DEPARTMENT OF WATER AFFAIRS & FORESTRY

# INKOMATI WATER AVAILABILITY ASSESSMENT

## MAIN REPORT

Report No. PWMA 05/X22/00/0808

June 2009

Water for Africa
Environmental, Engineering & Management Consultants (Pty) Ltd

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**DEPARTMENT OF WATER AFFAIRS AND FORESTRY**

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# SCHEDULE OF REPORTS

| | | |
|---|---|---|
| **This Report** ☞ | PWMA 05/X22/00/0808 | Main Report |
| | PWMA 05/X22/00/0908 | Water Requirements Volume 1<br>Water Requirements Volume 2: Assessment of Alien Vegetation |
| | PWMA 05/X22/00/1008 | Ecological Water Requirements |
| | PWMA 05/X22/00/1108 | Water Quality |
| | PWMA 05/X22/00/1208 | Infrastructure and Operating Rules Volume 1<br>Infrastructure and Operating Rules Volume 2: Appendices |
| | PWMA 05/X22/00/1308 | Rainfall Volume 1: Report<br>Rainfall Volume 2: Appendices |
| | PWMA 05/X22/00/1408 | Hydrology of Komati River Volume 1<br>Hydrology of Komati River Volume 2: Appendices |
| | PWMA 05/X22/00/1508 | Hydrology of Crocodile River Volume 1<br>Hydrology of Crocodile River Volume 2 Appendices |
| | PWMA 05/X22/00/1608 | Hydrology of Sabie River Volume 1<br>Hydrology of Sabie River Volume 2 Appendices |
| | PWMA 05/X22/00/1708 | Yield Modelling Volume 1<br>Yield Modelling Volume 2: Appendices |

# EXECUTIVE SUMMARY

## Introduction and purpose of the study

The Inkomati Water Management Area (WMA) shown in **Figure 1** is located in the north-eastern corner of South Africa and incorporates the catchments of the Komati, Crocodile and Sabie Rivers.

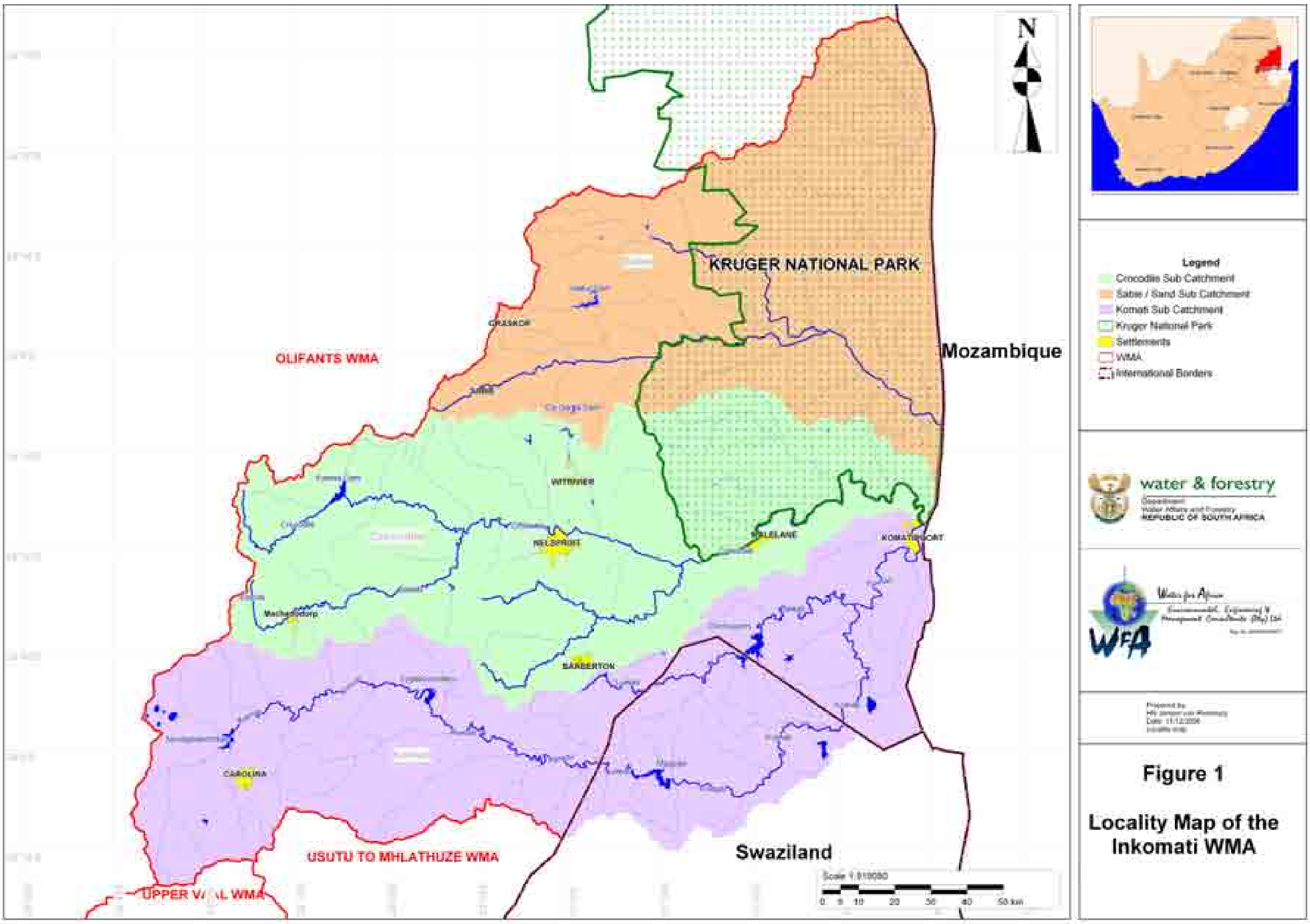


*Figure 1: Inkomati water management area (WMA)*

The Komati River rises in the south west corner of the WMA, flows through Swaziland then re-enters South Africa before flowing on into Mozambique. The Crocodile River, located in the centre of the WMA, joins the Komati River just before flowing into Mozambique, while the Sabie River forms a separate catchment in the North of the WMA, also flowing into Mozambique after flowing through the Kruger National Park. Once in Mozambique, the Sabie River joins the Komati River which at this point is referred to as the Incomati River. The Incomati River Basin is therefore an international river basin, shared by South Africa, Swaziland and Mozambique.

The Inkomati WMA is considered to be stressed, with water requirements in excess of the available water resources, especially if the water requirements of Mozambique and the ecological Reserve are taken into account. The result of this is that the ecological Reserve is not met and the cross-border flows into Mozambique have on occasions been less than specified in various international agreements. The assurance of water supply to the irrigation sector is also very low in some areas, especially the lower reaches of the Crocodile River.

A tool provided in the National Water Act (NWA) (Act 36 of 1998) is that of compulsory licensing, which allows the state to re-allocate the water resource in accordance with the water supply objectives and priorities given in the NWA and the National Water Resource Strategy (NWRS). In order to embark on such a re-allocation process, a thorough understanding of current water use and the currently available water resource is required. The purpose of this study is to provide this understanding and set up a water resource model which will facilitate water re-allocation.

The study consists of three main components, the first of which is to determine the water requirements and where possible the actual water use within the WMA. The requirements must be determined for present day use (to form a basis for re-allocation) while knowledge of past water use is also required for the calibration of the hydrological model. The second component of the study was to set up a hydrological model that accurately reflects the historic situation of the catchments in terms of water requirements and water availability. The third component of the study involved the setting up and verification of the Water Resources Yield Model (WRYM). The model has been used to make a first assessment of the water availability of the Inkomati WMA based on two water resource yield scenarios This main report is an extended summary report of all the main components of the Water Availability Assessment study. Where relevant the more detailed reports are referred to.

The **Komati River catchment** has a total surface area of 11 232 km$^2$ and is made up of four tertiary catchments, the Upper Komati (X11), Middle Komati (X12), Lower Komati (X13) and the Lomati (X14). Important tributaries of the Komati River include the Lomati River, Buffelspruit, Teespruit, Mtsoli River and the Gladdespruit. The Upper and Middle Komati catchments have similar landuse in that both catchments are rural in nature with agriculture as the main activity. These catchments are dominated by forestry in the high rainfall escarpment catchments and by water transfers from Nooitgedacht and Vygeboom Dams in the Upper Komati catchment for Eskom Power Stations in the Olifants WMA. The lower Komati and Lomati catchments are also rural in nature with agriculture the main activity. These catchments are dominated in the western mountainous areas by commercial forestry and in the downstream eastern catchments by significant areas of ‘controlled’ irrigation and by water transfers to the Mbuluzi and Kaap catchments. Controlled in this context refers to irrigation occurring within Irrigation Boards where crops and crop water requirements are defined and legislated usually as an annual water quota.

The **Crocodile River catchment** has a total surface area of 10 446 km$^2$ and is made up of four tertiary catchments, the Upper Crocodile (X21), Middle Crocodile (X22), Lower Crocodile (X24) and Kaap (X23). Important tributaries of the Crocodile River include the Kaap River, the Elands River in the Upper Crocodile and the Sand, Nelspruit and White Rivers in the Middle Crocodile. The Crocodile catchment is rural in nature with agriculture as the main activity while the high rainfall escarpment catchments of the Upper and Middle Crocodile and Kaap catchment have significant areas of commercial forestry. The Upper

Crocodile is relatively undeveloped with small domestic and irrigation demands. The Middle Crocodile catchment has significant areas of controlled irrigation and urban demands. The Kaap catchment is dominated in the lower eastern catchment by significant areas of controlled irrigation. Water is transferred into the Kaap River catchment from the Lomati and Shiyalongubu Dams for urban (Umjindi Local Municipality) and agricultural (Louws Creek Irrigation Board) users. The lower Crocodile has large areas of controlled irrigation and smaller urban/domestic demands. Water is transferred from the Sabie River to the Nsikazi North Water Supply Scheme for domestic users in the Lower Crocodile.

The **Sabie River catchment** has a total surface area of 6 315 $km^2$ and is made up of three tertiary catchments, the Sabie (X31), Lower Sabie (X33) and Sand (X32). Important tributaries of the Sabie River include the Mac-Mac, Marite and Whitewaters Rivers in the Sabie catchment and the Sand River. The Sabie catchment is mostly rural in nature with agriculture and silviculture the main activities, while the lower Sabie is almost entirely within the Kruger National Park where the water use is negligible but the sustainable flow of the lower Sabie is crucial to sustaining the ecological functioning of the Park. The high rainfall escarpment catchments in the Upper Sabie have large areas of commercial forestry. The Sabie catchment is relatively well developed with significant irrigation demands. Water is transferred from the Sabie catchment to rural settlements in the lower Crocodile River (Nsikazi North). The Sand River catchment has localized irrigation that appears to use all the dry season base flows often causing the Sand River to stop flowing completely.

## Infrastructure

The water storage and supply infrastructure within the Inkomati catchments and the associated operating rules relevant to the setting up and running of the water resources models is documented in a separate report referred to as the **Infrastructure and Operating Rules Report** (PWMA 05/X22/00/1208).

The report describes the following components:

- Water storage infrastructure, i.e. dams
- Operating rules of dams and systems
- Water transfer schemes
- Irrigation schemes
- Domestic water supply schemes
- Water supply to industry and mine

The report focuses mainly of the production of geographic information system (GIS) maps that show the location and layout of dams and water supply schemes. These maps are provided as an Appendix to the **Infrastructure and Operating Rules Report**.

Significant dams within the Inkomati WMA are listed in the tables below.

**Summary of Significant Dams in the Komati River catchment**

| Dam | Natural MAR (million $m^3$/a) | Full supply capacity | | Full supply area ($km^2$) |
|---|---|---|---|---|
| | | Million $m^3$ | % MAR | |
| Maguga | 749.4 | 332.0 | 44% | 10.4 |
| Driekoppies | 241.7 | 251.0 | 104% | 18.7 |
| Vygeboom | 258.4 | 83.3 | 32% | 6.7 |
| Nooitgedacht | 67.4 | 78.2 | 116% | 7.6 |
| Shiyalongubo | 14.3 | 7.4 | 52% | 2.7 |
| Lomati | 11.7 | 5.1 | 44% | 0.57 |
| Sand River* | 4.9 | 49.0 | 1 000% | 7.0 |
| Masibikela* | 2.8 | 9.1 | 325% | 3.0 |
| Mbambiso | 7.0 | 10.0 | 143% | 1.7 |

** Off-channel storage dam*

**Summary of Significant Dams in the Crocodile River catchment**

| Dam | Natural MAR (million $m^3$/a) | Full supply capacity | | Full supply area ($km^2$) |
|---|---|---|---|---|
| | | Million $m^3$ | % MAR | |
| Kwena | 118.5 | 158.9 | 134% | 12.5 |
| Ngodwana | 59.6 | 10.0 | 17% | 1.0 |
| Witklip | 19.8 | 12.7 | 64% | 1.9 |
| Klipkopjes | 18.7 | 11.9 | 64% | 2.3 |
| Longmere | 24.9 | 4.3 | 17% | 1.0 |
| Primkop | 40.6 | 2.0 | 5% | 0.4 |

**Summary of Significant Dams in the Sabie River catchment**

| Dam | Natural MAR (million $m^3$/a) | Full supply capacity | | Full supply area ($km^2$) |
|---|---|---|---|---|
| | | Million $m^3$ | % MAR | |
| Inyaka | 79.9 | 125.0 | 156% | 8.1 |
| Maritsane | 33.2 | 2.0 | 6% | 0.1 |
| Da Gama | 20.3 | 13.6 | 67% | 1.3 |

## Hydrology

The hydrology of the Inkomati WMA was analysed and documented in three sections, each dealing with the main sub-catchments of the Inkomati WMA, namely, the Komati, Crocodile and Sabie River catchments. Details regarding catchment hydrology and the process of calibrating the catchments are contained in the following **Hydrology reports;** Komati River (PWMA 05/X22/00/1408), Crocodile River (PWMA 05/X22/00/1508) and Sabie River (PWMA 05/X22/00/1608) catchments. The results and conclusions of these hydrological analyses are documented below.

## Hydrology statistics compared with previous studies: Komati River catchment

| Incremental catchment | Calibration record | Natural MAR (million $m^3$/a) | | |
|---|---|---|---|---|
| | | WAAS | Other studies | % Difference |
| Komati catchment | 1921 – 1988 (1) | 1346.9 | 1419.7 | -5.1% |
| | 1920 – 1989 (2) | 1351.6 | 1365.6 | -1.0% |
| | 1921 - 1995 (3) | 1336.1 | 1385.1 | -3.5% |
| | 1920 – 2004 (4) | 1356.8 | | |
| X11 | 1920 – 1989 (2) | 347.4 | 359.6 | -3.4% |
| | 1920 – 2004 (4) | 341.9 | | |
| X12 | 1920 – 1989 (2) | 302.6 | 316.2 | -4.3% |
| | 1920 – 2004 (4) | 301.9 | | |
| X13 | 1920 – 1989 (2) | 387.8 | 388.5 | -0.2% |
| | 1920 – 2004 (4) | 396.6 | | |
| X14 | 1920 – 1989 (2) | 313.8 | 301.3 | 4.1% |
| | 1921 - 1995 (3) | 308.0 | 347.9 | -11.5% |
| | 1920 – 2004 (4) | 316.4 | | |

Note: (1) JIBS report, 1995
(2) WR90 report, 1994
(3) Maguga Dam Basin Study, 1998
(4) VRSAU report, 1999, Hydrology of the Komati catchment upstream of Swaziland

## Hydrology statistics compared with previous studies: Crocodile River catchment

| River / Location | Calibration record | Natural MAR (million $m^3$/a) | | |
|---|---|---|---|---|
| | | WAAS | Other studies | % Difference |
| Total Crocodile catchment | 1921 - 1988<br>1920 – 1989<br>1920 – 2004 | 1123.0<br>1122.0<br>1136.2 | 1226.4^<br>1236.4* | -8.4<br>-9.2 |
| Upper Crocodile catchment | 1920 – 1989<br>1920 – 2004 | 469.4<br>467.3 | 507.9* | -7.5 |
| Middle Crocodile catchment | 1920 – 1989<br>1920 – 2004 | 350.6<br>362.4 | 418.1* | -16 |
| Kaap Catchment | 1920 - 1988<br>1920 – 1989<br>1920 – 2004 | 202.8<br>202.7<br>204.2 | 220.1^<br>206.0* | -8<br>-2 |
| Lower Crocodile Catchment | 1921 - 1988<br>1920 – 1989<br>1920 – 2004 | 98.0<br>97.0<br>106.6 | 113.25^<br>104.4* | -14<br>-7 |

* WR 90 – Surface Water Resources of South Africa, Appendix B, Volume VI
^ JIBS, 1995, Runoff Hydrology, Appendix 13

**Hydrology statistics compared with previous studies: Sabie River catchment**

| River / Location | Calibration record | Natural MAR (million $m^3/a$) | | |
|---|---|---|---|---|
| | | WAAS | Other studies | % Difference |
| Total Sabie catchment | 1921 – 1988(1) | 658.0 | 752.6 | -13% |
| | 1920 - 1989(2) | 658.0 | 732.0 | -10% |
| | 1920 - 2004(3) | 675.8 | | |
| Upper Sabie catchment | 1921 – 1988(1) | 520.0 | 595.8 | -13% |
| | 1920 - 1989(2) | 520.0 | 584.6 | -12% |
| | 1920 - 2004(3) | 527.3 | | |
| Sand catchment | 1921 – 1988(1) | 131.0 | 153.7 | -15% |
| | 1920 - 1989(2) | 131.0 | 136.2 | -4% |
| | 1920 - 2004(3) | 136.0 | | |

(1) JIBS, 1995 – Appendix 13; Runoff Hydrology
(2) WR90, 1994 – Surface Water Resources of South Africa
(3) Inkomati WAAS, 2008 – Inkomati Water Availability Assessment study.

The following conclusions and recommendations were drawn from this hydrological analysis:

- The rainfall data, produced from the rainfall analysis, is considered acceptable and could be used with confidence to calibrate the WRSM2000 model. The number of rain gauges that remain operational is a cause for concern and consideration should be given to re-opening old reliable stations and or the establishment of new gauges.
- Good to reasonable calibrations were obtained at most flow gauges. The observed flow data at some gauges does require review and should be undertaken by the Inkomati Catchment Management Agency (ICMA). The patched flows record should be assessed and if accepted used to update the DWAF flow records to prevent duplication of this process in future studies.
- Dry season flows were under simulated at a number of gauges in the Crocodile River catchment. The reason for this under simulation appears to be related to landuse data and the methodology used to determine streamflow reduction due to afforestation which only becomes apparent in highly afforested catchments.
- The reservoir balances and flows in the White River catchments are seriously flawed and require attention to improve confidence in the flow information for this catchment.
- The MAR of the updated naturalized hydrology for the Komati catchment decreased by up to 5 % when compared with previous studies. This is an acceptable change and the natural flows created for all the quinary catchments in the study area can be used with confidence in further analyses.
- The MAR of the updated naturalized hydrology for the Crocodile catchment decreased by between 7 and 14 % when compared with previous studies. This is an acceptable change and the natural flows created for all the quinary catchments in the study area can be used with confidence in further analyses.
- The Sand River (X32) catchment was calibrated at only one gauge which is not adequate for a catchment of this size and complexity. Additional gauges in the wetter

headwater catchments are required to improve the confidence in the calibration of this catchment.

- The MAR of the updated naturalized hydrology for the Sabie catchment decreased 10 to 13 % when compared with previous studies. This is an acceptable change and the natural flows created for all 58 quinary catchments in the study area can be used with confidence in further analyses. Of concern, and requiring further investigation, is the over 20 % decrease in the MAR of the Inyaka Dam catchment. This decrease needs to be confirmed by reviewing the dam balance record for Inyaka Dam. The record was too short and unreliable to be of any value to this study.

## Water Quality

The major impacts on the water quality in the **Komati River catchment** are associated with diffuse sources including agricultural fertilizers, agricultural insecticides, pesticides and fungicides; sewage run-off and atmospheric deposition; and point sources which include mining effluent, domestic sewage effluent and industrial effluent and organic pollutants.

In the Upper Komati region (Nooitgedacht Dam to Vygeboom Dam) water quality appears to be in a good condition as the land use activity is minimal. In the river reach between Vygeboom Dam and Swaziland, the water quality appears to be fairly good. The main water quality issues observed are elevated concentrations of the nutrients (phosphate, ammonia, nitrates) and slightly elevated salt concentrations at Hoogenoeg. As the middle Komati is more densely populated with a higher number of urban settlements, the water quality observed could be attributed to sewage effluent discharges and increased organic pollution. The water quality in the lower Komati River appears to be significantly impacted with increased concentrations being observed for most water quality variables at the last three monitoring stations. As the Komati River flows through Swaziland it is bordered by intensive agricultural activity (within very close proximity) and this continues into South Africa which has resulted in the deterioration of the water quality. The available data shows that the main water quality issues appear to be related to nutrients and salinisation.

The **Crocodile River catchment** is dominated by agricultural activities (pasture, dry land or irrigated cultivation), irrigation, forestry production, and rural and urban settlements. There are also some mining activities in the Kaap River while the South African Pulp and Paper Industry (SAPPI) Mill in the Elands River is a major source of pollutants. The construction of weirs and dams in the upper Crocodile catchment to accommodate the increasing trout farming near the towns of Dullstroom and Machadodorp has led to a loss of wetlands and an overall threat to the status of the river. The encroachment of alien vegetation in this region, namely wattle, eucalyptus and poplar trees, also poses a problem to the availability and quality of water. The middle region of the Crocodile River is densely populated as it runs through the major towns of Nelspruit, Kaapmuiden and Malelane. The most important stresses and impacts in this part of the catchment are attributed to domestic and industrial land uses. The area is also characterised by commercial farming such as sugar cane, fruit orchards, vegetables and tobacco cultivation. The lower Crocodile River catchment forms the southern boundary of the

Kruger National Park with a number of tourist lodges built on the bank of the river which has a negative effect on the quality of the water (increased nutrients). Citrus and sugar cane farming is also abundant in the area.

In general, the water quality in the upper Crocodile River catchment appears to be in a good to fair condition, with the exception of the Elands River sub-catchment. The area is of concern as it reflects escalated concentrations of salts (and major ions) and nutrients. The increased nutrients can be attributed to the greater number of communities located along this tributary (Machadodorp, Waterval Boven) which inevitably leads to an increased sewage effluent and organic pollution from domestic origin. The impacts of intense agriculture and afforestation in the middle Crocodile River are observed at Karino and Weltevrede, where elevated concentrations of nutrients and salts are observed. The lower Crocodile River poses the greatest problem in the catchment as a notable increase in the concentrations of most of the variables is observed at these monitoring stations. The quality of water in this region is much poorer in comparison to the upper and middle reaches of the river.

Overall, the water quality in the upper Sabie River region can be described as being in a good condition. The monitoring stations near the two dams revealed that the quality of water in these tributaries is in a good state with the exception of ammonia concentrations. The lower Sabie River region poses the greatest concern as a notable increase in the concentrations of most of the variables is observed at these monitoring stations. The lower Sabie and Sand River catchments are predominantly within the Kruger National Park and hence strict conservation measures are implemented in this region. However, the unprotected upstream areas are vulnerable to increasing urbanisation and other land uses. The Sand River is densely populated with several rural communities. This results in an increased waste output and organic pollution in the rivers. Another threat to the quality of water in this region is overgrazing by livestock which causes extensive erosion of the river banks and in-stream sedimentation problems.

## Water requirements and use

Water requirements within the Inkomati WMA documented in this report is for the year 2004. Future water requirements were not addressed specifically as part of this study but allocations in term of international agreements were addressed. For more details on water use and the background as to how the information on water requirements was obtained refer to the **Water Requirements report** (PWMA 05/X22/00/0908).

By far the largest water user in the Inkomati WMA is the irrigation sector and it is important therefore to obtain good estimates of the water allocations to this sector as well as the actual water use. Within the context of this report, irrigation water requirements are based on a theoretical calculation of how much water is required, based on crop areas, crop types, the efficiency of irrigation systems and climatic conditions. The irrigation model used to estimate the crop water requirements is the Water Quality Model (WQT) model. Allocated water use was based on various sources of information, such as:

- the irrigation schedules of irrigation boards,

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- the Interim IncoMaputo Agreement, and
- estimates of lawful use based on satellite imagery (where irrigation falls outside of irrigation boards).

Where a discrepancy between estimates was found, the higher of the two estimates was used.

The tables below summarise the water requirements, transfers out of the catchment and stream flow reduction for the two water resource yield scenarios considered in this study, namely, the best estimate of current day (2004) water requirements and the allocated water requirements within each study area.

**Summary of water requirements for the best estimate scenario**

| User group | Komati (including Swaziland) | Crocodile | Sabie |
|---|---|---|---|
| **Cross border flows** | 35 | 28 | 0 |
| **Transfers out** | 223(1) | 0 | 0 |
| **Industrial** | 1 | 22 | 0 |
| **Domestic** | 21 | 59 | 20 |
| **Irrigation(1)** | 492 | 514 | 100 |
| **Total** | **772** | **623** | **120** |
| **Afforestation (SFRA)** | 117 | 157 | 90 |

Notes: (1) Transfers for Eskom (101) and for irrigation (122) in the Mbuluzi catchment

(2) Cross border flows based on the Pigg's Peak agreement

**Summary of water requirements in the Inkomati WMA for the water allocation scenario**

| User group | Komati (including Swaziland) | Crocodile | Sabie |
|---|---|---|---|
| **International** | 62 | 50 | 0 |
| **Transfer out** | 132(1) | 0 | 0 |
| **Industrial** | 2 | 27 | 0 |
| **Domestic** | 50 | 58 | 27 |
| **Irrigation** | 641(2) | 482 | 98 |
| **Total** | **887** | **617** | **125** |
| **Afforestation (SFRA)** | 117 | 157 | 90 |

Notes: (1) Allocation to Eskom is not achievable with current infrastructure.

(2) Includes transfer of 122 million $m^3$ to irrigators in the Mbuluzi catchment.

(3) Cross border flows based on the IIMA agreement

## Ecological Water Requirements

Water resource planning requires recognition of the ecological Reserve and hence estimates of Ecological Water Requirements (EWRs) are required. A comprehensive Reserve determination has been completed in the Komati catchment while similar studies are in progress in the Crocodile and Sabie River catchments. The preliminary results from the Crocodile and Sabie catchments have been used to develop EWRs for these catchments, while in the Komati catchment the Reserves have been extrapolated to each node in the system. A node in this case represents a sub-catchment that is typically a sub-division of the quaternary catchments as defined by the WR90 study (WRC, 1994). The extrapolation process has been developed recently and the Komati catchment is the first in which it has been applied. The methodology used for this extrapolation is summarised in the **Ecological Flow Requirements report** (PWMA 05/X22/00/1008) submitted as part of this study. For more detail about the methodology refer to the draft report prepared for the WRC by Kleynhans et al, (WRC, 2008).

The extrapolated Reserves for the Komati sub-catchments and the interim reserves for the Crocodile and Sabie catchments are provided in **Appendix G** of the **Yield Model Report** (PWMA 05/X22/00/1708). Similar extrapolations still need to be carried out as for the Crocodile and Sabie catchments.

## Water availability assessment

The ultimate purpose of setting up a water resource model for the Inkomati WMA is to provide water availability input, in the form of a model, as one of the many interdependent activities into a process that will formalise Integrated Water Resources Management (IWRM) and ultimately develop an allocation schedule for the WMA. The determination of water availability rests on two closely associated modelling processes. The first is the hydrological modelling process that determines the natural runoff from the catchments while the second modelling process is the yield model which simulates water use within sub-catchments comprising the Inkomati CMA given the natural runoff and storage characteristics of dams in the catchment. These simulations have been used to reconcile water use with water availability. The yield model that has been set up as part of this study is the Water Resources Yield Model known as the WRYM (DWAF, 2008).

Water availability and system yield was determined in the following three separate steps or processes:

1. The historic yields of all significant dams or systems of dams were determined, assuming upstream abstractions for each scenario.
2. Stochastic analyses were then carried out on the major systems using 201 stochastic hydrology sequences for each quinary catchment and long-term yield curves derived at key points in the system.
3. Since the concept of historic and long-term yields only really apply to a defined system and not a catchment as a whole, the water availability (balance) for the whole catchment was estimated and is reported on in terms of demand versus supply and assurances of supply to each user sector. Details of the demand versus supply (and assurance) for every defined user was determined for each scenario and for each catchment and provided as an Appendix to the Yield Modelling report. The results are summarized in this executive summary as follows:

**Results of water availability assessment for the Komati River catchment**

| Water User | Demand (Million $m^3$/annum) | Supply (Million $m^3$/annum) | Assurance of supply (%) |
|---|---|---|---|
| **Scenario 1: Best estimate of current day (2004) water use** | | | |
| International | 34.7 | 34.7 | 100% |
| Strategic | 105.1 | 105.1 | 100% |
| Industrial and mining | 0.6 | 0.6 | 100% |

| | | | |
|---|---|---|---|
| Urban / domestic | 21.3 | 21.1 | 99% |
| Controlled Irrigation (SA) | 388.1 | 355.2 | 92% |
| Controlled Irrigation (Swazi) | 56.6 | 56.6 | 100% |
| Uncontrolled Irrigation (all) | 47.9 | 46.6 | 97% |
| Transfers to Mbuluzi / Kaap | 130.3 | 129.8 | 100% |
| **Total** | **784.6** | **749.7** | **96%** |
| **Scenario 2: Allocated water use** | | | |
| International | 61.5 | 61.5 | 100% |
| Strategic | 105.1 | 101.2 | 96% |
| Industrial and mining | 2.4 | 2.4 | 100% |
| Urban / domestic | 50.3 | 48.7 | 97% |
| Treaty Irrigation (SA) | 380.5 | 325.9 | 86% |
| Treaty Irrigation (Swaziland) | 261.2 | 256.2 | 98% |
| Transfers to Kaap | 8.5 | 7.9 | 93% |
| **Total** | **869.5** | **803.8** | **92%** |
| **Scenario 3: Allocated water use with reserve** | | | |
| International | 61.5 | 61.5 | 100% |
| Strategic | 105.1 | 94.8 | 90% |
| Industrial and mining | 2.4 | 2.1 | 87% |
| Urban / domestic | 50.3 | 47.5 | 94% |
| Treaty Irrigation (SA) | 380.5 | 320.6 | 84% |
| Treaty Irrigation (Swaziland) | 261.2 | 251.4 | 96% |
| Transfers to Kaap | 8.5 | 6.8 | 82% |
| Ecological Reserve at X13K-2 | 227.7 | 227.7 | 100% |
| **Total** | **1097.2** | **1012.4** | **92%** |

## Results of water availability assessment for the Crocodile River catchment

| Water User | Demand (million $m^3/a$) | Supply (million $m^3/a$) | Assurance of supply (%) |
|---|---|---|---|
| **Scenario 1: Current day (2004) water use** | | | |
| International | 28.4 | 28.4 | 100% |
| Strategic | 0.0 | 0.0 | - |
| Industrial | 22.4 | 22.4 | 100% |
| Urban / domestic | 48.5* | 48.5 | 100% |
| Irrigation (controlled) | 420.2 | 394.0 | 94% |
| Irrigation (uncontrolled) | 94.0 | 55.8 | 59% |
| **Total** | **613.5** | **547.9** | **89%** |
| **Scenario 2: Allocated water use** | | | |
| International | 50.5 | 50.5 | 100% |
| Strategic | 0.0 | 0.0 | - |
| Industrial | 26.6 | 26.6 | 100% |
| Urban / domestic | 46.3* | 46.3 | 100% |
| Irrigation (Treaty allocation) | 482.2 | 431.9 | 90% |
| **Total** | **605.6** | **555.3** | **92%** |
| **Scenario 3: Allocated water use with reserve** | | | |
| International | 50.5 | 50.5 | 100% |
| Strategic | 0.0 | 0.0 | - |
| Industrial | 26.6 | 26.6 | 100% |
| Urban / domestic | 46.3* | 43.8 | 95% |
| Irrigation (Treaty allocation) | 482.2 | 355.8 | 74% |
| Ecological Reserve at X24H-2 | 204.6 | 204.6 | 100% |
| **Total** | **810.2** | **681.3** | **84%** |

* Barberton and Nsikazi North requirements are supplied from Lomati (X14) and Sabie (X31) catchments and are not accounted for in this table.

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**Results of water availability assessment for the Sabie River catchment**

| Water User | Demand (million $m^3$/a) | Supply (million $m^3$/a) | Assurance of supply (%) |
|---|---|---|---|
| **Scenario 1: Current day (2004) water use** | | | |
| International | 0.0 | 0.0 | - |
| Strategic | 0.0 | 0.0 | - |
| Industrial | 0.0 | 0.0 | - |
| Urban / domestic | 20.2 | 20.2 | 100% |
| Irrigation | 100.1 | 83.2 | 83% |
| Transfers to Crocodile (East) | 6.5 | 6.5 | 100% |
| **Total** | **126.8** | **109.9** | **87%** |
| **Scenario 2: Allocated water use** | | | |
| International | 0.0 | 0.0 | - |
| Strategic | 0.0 | 0.0 | - |
| Industrial | 0.0 | 0.0 | - |
| Urban / domestic | 27.1 | 25.1 | 100% |
| Irrigation: Controlled | 23.2 | 23.2 | 100% |
| Irrigation: Uncontrolled | 74.3 | 58.4 | 79% |
| Transfers to Crocodile (East) | 8.0 | 8.0 | 100% |
| **Total** | **132.6** | **116.7** | **88%** |
| **Scenario 3: Allocated water use with reserve** | | | |
| International | 0.0 | 0.0 | - |
| Strategic | 0.0 | 0.0 | - |
| Industrial | 0.0 | 0.0 | - |
| Urban / domestic | 27.1 | 26.4 | 97% |
| Irrigation: Controlled | 23.2 | 20.0 | 86% |
| Irrigation: Uncontrolled | 74.3 | 49.5 | 67% |
| Transfers to Crocodile (East) | 8.0 | 7.6 | 95% |
| Ecological Reserve* | 209.3 | 206.4 | 99% |
| **Total** | **341.9** | **309.9** | **91%** |

* Ecological Reserve requirement for Sabie River (X31) is 167 million $m^3$/annum and for Sand River is 43 million $m^3$/annum

## Conclusions and recommendations

The hydrology and yield models set up as part of this WAAS provide much more detail than was available in previous models of the Inkomati WMA, with catchment and hence model discretisation at quinary or sub-quaternary scale.

The main conclusions from the hydrology review and extension are that the rapidly reducing numbers of rain gauges that remain operational are a cause for great concern and consideration should be given to re-opening old reliable stations and or the establishment of new gauges. The model calibrations were however adequate in most cases, the exception being in the White River catchment where a meaningful calibration against observed data could not be obtained due to the exceptionally poor observed data. The other important conclusion relating to flow gauges is that there are insufficient flow gauges in the Sand catchment of the Sabie system in order to model the complexity of this catchment adequately. The hydrology derived from this study, the most detailed and comprehensive to date, does not deviate significantly from previous studies, with the exception of the hydrology of the Inyaka

Dam where the MAR is now estimated to be 20% less than in previous studies. This has serious implications for the water availability for Inyaka Dam and the Sabie River catchments.

The WRYM setup for the river systems in the study area provides a useful tool for allocation planning and compulsory licencing. The use of the WRYM model for operational purposes is however limited since it does not model the complex operating rules that are applied within the Komati and Crocodile River catchments. Detailed yield analyses of the catchments of the Inkomati WMA were undertaken during this study using the WRYM, with limited analysis of the Incomati catchment in the Mozambican portion of the Incomati River Basin, using information that was readily available. The overall conclusion reached for the whole study area is that despite the large increase in water use since previous detailed studies (JIBS, 1995), the catchments are not **currently** unduly stressed and users are receiving their water at acceptable levels of assurance. This is largely due to the completion of the Maguga and Inyaka Dams since the last detailed study. The results of this study reinforce the conclusions of the KOBWA analysis (KOBWA, 2005) in the case of the Komati catchment and the Framework Towards a Water Allocation Plan (DWAF, 2007) in the case of the WMA. The yields of the Sabie catchments as well as the Coromana Dam, as derived from this study, are however significantly lower than other studies. This can be attributed to the lower estimated runoff from the Sabie catchment.

The following recommendations based on this water availability Assessment are:

- Additional flow gauges are required in the Sand catchments (X32) of the Sabie drainage catchment.
- The state of the observed flows and reservoir records in the White River catchments in the Crocodile drainage catchment are inadequate and this problem needs to be resolved in order to improve the hydrology of this area.
- There are now insufficient rain gauges in the Inkomati WMA to extend the hydrology into the future. Previously reliable gauges which have been shut down must be reinstated if the hydrology in the study area is to be improved upon in the future.
- The system models setup as part of this study should be upgraded to model the actual operation of the catchments more realistically. This recommendation applies especially to the Komati and Crocodile River systems where complex restriction rules and water banking are applied. In the Sabie system the fractal allocation rules for the Sand River catchment should be applied. These processes could possibly be modeled with the Water Resources Planning Model but other models that are already being used in these catchments to do such analyses should also be considered.
- The Crocodile and Sabie systems should be updated when the ecological Reserves have been finalized and extrapolated to hydro-nodes.

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# MAIN REPORT FOR THE INKOMATI WAAS

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# ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| DWAF | National Department of Water Affairs and Forestry |
| ESKOM | Electricity Supply Commission |
| EWR | Ecological water requirements |
| GIS | Geographic Information System |
| IB | Irrigation Board |
| IIMA | Interim Incamaputa Agreement |
| ISP | Internal Strategic Perspective |
| KOBWA | Komati Basin Water Authority |
| LM | Local municipality |
| MAP | Mean Annual Precipitation |
| MAR | Mean Annual Runoff |
| MCM | Million $m^3$ |
| NWRS | National Water Resource Strategy |
| RQS | DWAF D: Resource Quality Services |
| RWQO | Resource Water Quality Objectives |
| SAPPI | South Africa Pulp and Paper Industry |
| TPTC | Tripartite Permanent Technical Committee |
| TWQR | Target Water Quality Ranges |
| WAAS | Water Availability Assessment Study |
| WARMS | Water Use Authorization and Registration Management System |
| WMA | Water Management Area |
| WQT | Water Quality Model |
| WR90 | The Water Resources (Hydrology) of South Africa |
| WRC | Water Research Commission |
| WRSM | Water Resource Simulation Model |
| WRPM | Water Resources Planning Model |
| WRYM | Water Resources Yield Model |
| WSS | Water supply scheme |

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# 1. INTRODUCTION

The Inkomati Water Management Area (WMA) shown in **Figure 1.1** is located in the north-eastern corner of South Africa and incorporates the catchments of the Komati, Crocodile and Sabie Rivers.

The Komati River rises in the south west corner of the WMA, flows through Swaziland then re-enters South Africa before flowing on into Mozambique. The Crocodile River, located in the centre of the WMA, joins the Komati River just before flowing into Mozambique, while the Sabie River forms a separate catchment in the North of the WMA, also flowing into Mozambique after flowing through the Kruger National Park. Once in Mozambique, the Sabie River joins the Komati River which at this point is referred to as the Incomati River. The Incomati River Basin is therefore an international river basin, shared by South Africa, Swaziland and Mozambique.

The Inkomati WMA is considered to be stressed, with water requirements in excess of the available water resources, especially if the water requirements of Mozambique and the ecological Reserve are taken into account. The result of this is that the ecological Reserve is not met and the cross-border flows into Mozambique have on occasions been less than specified in various international agreements. The assurance of water supply to the irrigation sector is also very low in some areas, especially the lower reaches of the Crocodile River.

A tool provided in the National Water Act (NWA) (Act 36 of 1998) is that of compulsory licensing, which allows the state to reallocate the water resource in accordance with the water supply objectives and priorities given in the NWA and the National Water Resource Strategy (NWRS). In order to embark on such a reallocation process, a thorough understanding of current water use and the currently available water resource is required. The purpose of this study is to provide this understanding and set up a water resource model which will facilitate water reallocation.

The study consists of three main components, the first of which is to determine the water requirements and where possible the actual water use within the WMA. The requirements must be determined for present day use (to form a basis for re-allocation) while knowledge of past water use is also required for the calibration of the hydrological model. The second component of the study was to set up a hydrological model that accurately reflects the historic situation of the catchments in terms of water requirements and water availability. The third component of the study involved the setting up and verification of the Water Resources Yield Model (WRYM). The model has been used to make a first assessment of the water availability of the Inkomati WMA based on two water resource yield scenarios This main report is an extended summary report of all the main components of the Water Availability Assessment study. Where relevant the more detailed reports are referred to.

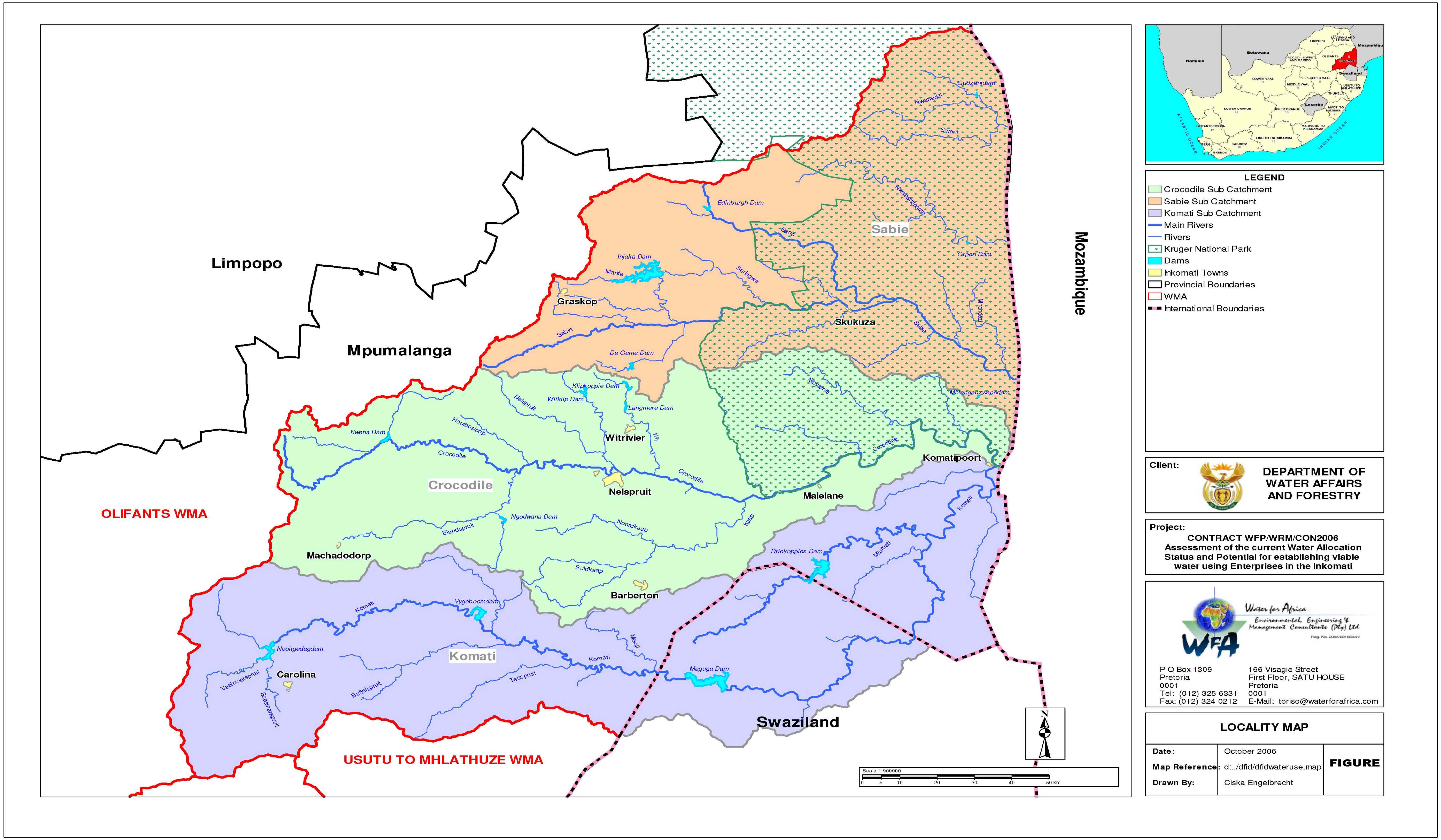


**Figure 1.1 Inkomati WMA locality map**

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# 2. THE INCOMATI CATCHMENT

## 2.1 The study area

Strictly speaking, the study area of the Inkomati Water Availability Assessment Study (IWAAS) is the Inkomati WMA which consists of those portions of the Komati, Crocodile and Sabie River catchments that fall within South Africa. However, it is important to understand the location of the study area within the context of the drainage basin of which it forms a part, as well as in relation to international boundaries. The neighboring countries of Swaziland and Mozambique form part of the drainage basin and influence the availability of water to South Africa within the basin.

The drainage basin as a whole is generally referred to as the Incomati River Basin, derived from the Incomati River which is the name given to the river after the confluence of the Crocodile and Komati Rivers as shown in **Figure 2.1**.

Since the confluence of these two rivers is just upstream of the South African/Mozambican border, the Incomati River is for all practical purposes located in Mozambique, but receives runoff from the Komati, Crocodile and Sabie Rivers. This report has been structured to report on the four main catchments comprising the Incomati River Basin, namely, the Komati, Crocodile and Sabie catchments, as well the portion of the Basin located within Mozambique.

## 2.2 Infrastructure

The **Infrastructure and Operating Rules Report** (PWMA 05/X22/00/1208) is a supporting report which documents the infrastructure within the Inkomati catchments and the associated operating rules relevant to the setting up and running of the water resources models.

The report describes the following components:

- Water storage infrastructure, i.e. dams
- Operating rules of dams and systems
- Water transfer schemes
- Irrigation schemes
- Domestic water supply schemes
- Water supply to industry and mine

The report focused mainly of the production of geographic information system (GIS) maps that show the location and layout of dams and water supply schemes. These maps are provided as an Appendix to the **Infrastructure and Operating Rules Report**.

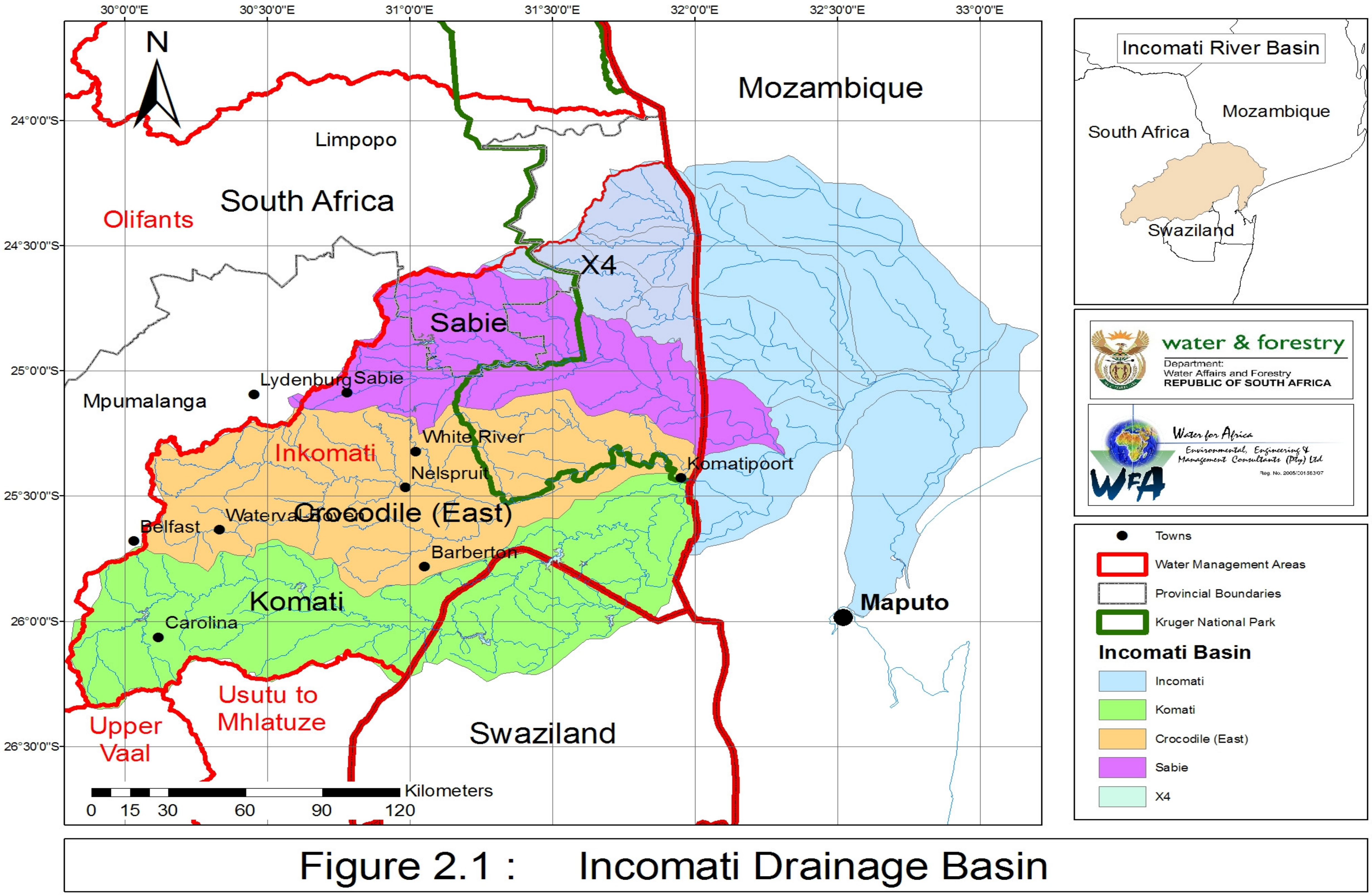

Figure 2.1 : Incomati Drainage Basin

**Figure 2.1: Incomati Drainage Basin**

### 2.2.1 Dams

There are several significant dams in the Inkomati WMA (including Swaziland's portion of the Komati River catchment), and over 90 dams with a capacity greater than 50 000 m$^3$. The details of the major dams are provided in **Tables 2.1**, **2.2** and **2.3**.

*Table 2.1 Summary of Significant Dams in the Komati River catchment*

| Dam | Natural MAR (million m$^3$/a) | Full supply capacity | | Full supply area (km$^2$) |
|---|---|---|---|---|
| | | Million m$^3$ | % MAR | |
| Maguga | 749.4 | 332.0 | 44% | 10.4 |
| Driekoppies | 241.7 | 251.0 | 104% | 18.7 |
| Vygeboom | 258.4 | 83.3 | 32% | 6.7 |
| Nooitgedacht | 67.4 | 78.2 | 116% | 7.6 |
| Shiyalongubo | 14.3 | 7.4 | 52% | 2.7 |
| Lomati | 11.7 | 5.1 | 44% | 0.57 |
| Sand River* | 4.9 | 49.0 | 1 000% | 7.0 |
| Masibikela* | 2.8 | 9.1 | 325% | 3.0 |
| Mbambiso | 7.0 | 10.0 | 143% | 1.7 |

** Off-channel storage dam*

*Table 2.2 Summary of Significant Dams in the Crocodile River catchment*

| Dam | Natural MAR (million m$^3$/a) | Full supply capacity | | Full supply area (km$^2$) |
|---|---|---|---|---|
| | | Million m$^3$ | % MAR | |
| Kwena | 118.5 | 158.9 | 134% | 12.5 |
| Ngodwana | 59.6 | 10.0 | 17% | 1.0 |
| Witklip | 19.8 | 12.7 | 64% | 1.9 |
| Klipkopjes | 18.7 | 11.9 | 64% | 2.3 |
| Longmere | 24.9 | 4.3 | 17% | 1.0 |
| Primkop | 40.6 | 2.0 | 5% | 0.4 |

*Table 2.3 Summary of Significant Dams in the Sabie River catchment*

| Dam | Natural MAR (million m$^3$/a) | Full supply capacity | | Full supply area (km$^2$) |
|---|---|---|---|---|
| | | Million m$^3$ | % MAR | |
| Inyaka | 79.9 | 125.0 | 156% | 8.1 |
| Maritsane | 33.2 | 2.0 | 6% | 0.1 |
| Da Gama | 20.3 | 13.6 | 67% | 1.3 |

### 2.2.2 Canals

There is only one major canal system in the study area and that is the CDC canal that can divert up to 9.7 $m^3/s$ from the Komati River to irrigators in Swaziland. There are numerous smaller canal systems found within the Komati, Crocodile and Sabie River catchments which divert run-of-river flows to irrigators. The canals in the Sand River catchment in the Sabie catchment are in a bad state of repair and in need of refurbishment.

### 2.2.3 Hydropower

Hydropower in the study area is very limited and the only significant plant is the recently completed installation at the Maguga Dam. Releases from the Maguga Dam for the generation of hydropower are synchronised to meet the requirements of downstream irrigators by using balancing storage just downstream of the dam and is therefore a non-consumptive use. Hydropower in the study area is summarised in **Table 2.4** and can generally be considered as a non-consumptive water use.

*Table 2.4 Hydropower stations per drainage basins*

| Drainage Basin | Operational Installations | Total generating capacity (MW) |
|---|---|---|
| Komati | 4 | 17 – 19* |
| Crocodile | 6 | 4.5 |
| Sabie | 1 | 0.5 |
| **Total** | **11** | **22 – 24*** |

* Peak capacity

### 2.2.4 Operating rules

There are five major systems within the study area with complex operating rules that warrant documenting since they influence the model setups for assessing the water resource availability. These are:-

- The Nooitgedacht/Vygeboom system in the upper Komati River catchment
- The Maguga/Driekoppies system in the lower Komati River catchment
- The Crocodile River system
- The Inyaka Dam system, and
- The Sand River system.

The operating rules for each system are summarised in the following sections.

***Nooitgedacht/Vygeboom system***

The Komati sub-system is part of the Integrated Vaal River System that must be operated as an integrated system irrespective of who owns or operates the individual components. The primary objective of the operation of the Integrated Vaal River System is to maintain the assurance of supply to all water users receiving water from the system. This is achieved by transferring water between subsystems with the aim of balancing the draw-down of the reservoirs during drought periods, and preventing spillage and wastage from the system during wet periods.

The operation of the two major dams is such that the priority of supply is from Vygeboom Dam and the incremental runoff from the Gemsbokhoek catchment, while the remainder of the demand is supplemented from Nooitgedacht Dam. This implies that the downstream dam, Vygeboom, is emptied first to limit spills from the subsystem and to capture as much runoff as possible from the dam's incremental catchment. Supplementing the yield of the system, the Gladdespruit canal diverts water from the Gladdespruit and Popanyane rivers to Vygeboom Dam.

***Maguga/Driekoppies system***

The management and operation of the water resources of Swaziland is controlled largely from the Maguga Dam, while the Maguga and Driekoppies dams are used to regulate releases to irrigators in the Lomati and lower Komati sub-catchments. The fact that the Maguga Dam is located in Swaziland and that Mozambique is located downstream of this area makes the management of this system particularly complex. The dams are operated on an equal drawdown rule so that the dams spill and empty simultaneously, with a buffer level set below which irrigators are restricted to 70% of their allocation.

***Crocodile River system***

The operation of the Crocodile River catchment focuses mainly on the needs of the irrigation sector, which is to be expected since irrigation is by far the largest water use sector in the catchment. The main control is the regulation of the flow in the Crocodile River via releases from the Kwena Dam. Decisions on water supply to users in the Crocodile River catchment are currently made in May each year based on how much water can be supplied to users without the dam failing in that year. The operating policy of the Department of Water Affairs (DWAF) Mpumalanga Regional Office is to supply water for the year at a very high level of assurance. Thus, while the volume of water to be supplied to irrigators might change from year to year, the assurance of that supply is always very high. It is important to note that the Kwena Dam only supplements the supply to water users abstracting from the Crocodile River. The operating rule is that irrigators will make use of run-of-river flows before releases are made from Kwena Dam.

The day-to-day management of releases from the Kwena Dam and abstractions from the Crocodile River are currently determined by the Crocodile Major Irrigation Board, by means of a spreadsheet mass balance model. However, a more complex system which includes a real-time hydrological model and hydrodynamic modeling of river flow is being set up by DWAF and should be operational by mid 2009.

***Inyaka Dam system***

By far the most significant flow regulating feature within the Sabie River catchment is the Inyaka Dam, which was constructed primarily to ensure sustainable flow through the Kruger

National Park. In order to achieve this, a complex operating procedure was developed and is documented in a suite of reports (DWAF, 2003). The basis for making releases from Inyaka Dam for the ecological Reserve is to utilise flow measured from a representative undeveloped catchment to trigger releases. A new gauge was constructed at Emmet on the Sabie River just downstream of the confluence with the Mac-Mac River for this purpose. The system has, however, never been operated as envisaged for a number reasons, the main limiting factor being the lack of sufficiently skilled staff. The other reason is that the Inyaka Dam has not yet been operated even close to its maximum supply capability and hence the need to operate the dam efficiently has not arisen.

***Sand River system***

The Champagne, Edinburgh, Dingleydale and New Forest irrigation schemes in the Sand River catchment are supplied by means of diverting run-of-river flows into canals. A problem identified in the past is that the irrigators often divert all the flow leaving nothing for the ecological Reserve. The Inyaka Dam and Bushbuckridge Transfer Scheme were intended to solve this problem by transferring water into the Sand River catchment to supplement the ecological requirements, at least as an interim measure. The proposed long term solution was to apply the 'fractal allocation' principle (DWAF, 2003) that requires irrigators to release a defined percentage of the flow past their abstraction works. The system has never been operated in this manner and the Sand River irrigators continue to divert flows up to the maximum capacity of the canals.

## 2.3 Catchment discretisation

Existing yield models that have been used in the Inkomati WMA to date operate at a fairly course level of resolution and are not appropriate for the licensing of individual users. It was therefore a requirement of this study to substantially improve the level of resolution of the yield model. The discretisation process is described in **Section 6** of the Komati, Crocodile and Sabie hydrology reports of this study. The process is not repeated in this report other than to add that the yield model need not necessarily be limited to the quinary catchments defined for the hydrological analysis and if necessary extra nodes may be added. The quinary catchment areas are provided in **Appendix B** of the **Yield Modelling Report** (PWMA 05/X22/00/1708) in **Tables B1, B2** and **B3** for the Komati, Crocodile and Sabie catchments respectively.

# 3. HYDROLOGY

This section summarises the hydrology of the Komati, Crocodile (east) and Sabie catchments within the Inkomati WMA. For more details regarding catchment hydrology and the process of calibrating the catchments refer to the **Hydrology reports;** Komati River (PWMA 05/X22/00/1408), Crocodile River (PWMA 05/X22/00/1508) and Sabie River (PWMA 05/X22/00/1608) catchments.

## 3.1 Komati River Hydrology

### 3.1.1 Introduction

The total area of the Komati River catchment is 11 232 km$^2$ and is made up of four tertiary catchments, the Upper Komati (X11), Middle Komati (X12), Lower Komati (X13) and the Lomati (X14). Important tributaries of the Komati River include the Lomati River, Buffelspruit, Teespruit, Mtsoli River and the Gladdespruit. The process of generating the incremental natural hydrology for the defined sub-catchments of the Komati River catchment is summarised in this Main Report while detailed information is provided in the **Komati Hydrology Report.**

The Upper and Middle Komati catchments have similar landuse in that both catchments are rural in nature with agriculture as the main activity. These catchments are dominated by forestry in the high rainfall escarpment catchments and by water transfers from Nooitgedacht and Vygeboom Dams in the Upper Komati catchment for Eskom Power Stations in the Olifants WMA. The lower Komati and Lomati catchments are also rural in nature with agriculture the main activity. These catchments are dominated in the western mountainous areas by commercial forestry and in the downstream eastern catchments by significant areas of 'controlled' irrigation and by water transfers to the Mbuluzi and Kaap catchments. Controlled in this context refers to irrigation occurring within Irrigation Boards where crops and crop water requirements are defined and legislated usually as an annual water quota.

The Komati catchment falls within the Mpumalanga Province and has no major towns. Smaller towns include Carolina, Badplaas, Ekulindeni and Elukwatini in the Upper and Middle Komati and Tonga, Driekoppies and domestic users in Swaziland in the Lower Komati and Lomati catchments. **Figure 1.1** shows the locality of the Komati or X1 catchment within the Inkomati WMA.

Water related infrastructure in the Komati catchment is dominated by four major supply dams and the related diversion infrastructure. In the upper Komati catchment the Nooitgedacht and Vygeboom Dams are operated as a system and in the lower Komati and Lomati catchments, the Maguga and Driekoppies Dams are operated as a system.

### 3.1.2 Rainfall

There is a separate report, Inkomati WAAS Rainfall Report (DWAF, 2007; PWMA 05X22/00/1308) that describes the process of identifying and patching rainfall records. In summary the rainfall in the study area occurs mainly in the summer months from October to March and the Mean Annual Precipitation (MAP) varies between 554 mm/anum in the drier eastern part of the catchment to 1 272 mm/annum in the wetter escarpment and mountain catchments of the Komati. The mean annual Symons pan evaporation (MAE) is in the order of 1430 mm/annum. Most of the rainfall data was obtained from the Rain Information Management System that has been developed by the DWAF.

A total of 269 stations in and around the Inkomati WMA were identified of which 150 gauges were selected to be validated before they were used in the simulation of rainfall runoff. The main selection criteria for patching were that stations had at least 15 years of data and that there were adequate gauges with records up to September 2005. A total of 56 gauges were selected and patched for the hydrology update of the Komati catchment. MAP values were calculated for all quinary catchments using the gridded MAP surface from the Agrohydrology Atlas (Schulze, 2002). A comparison of quaternary catchment MAP's from this study with the WR90 MAP's showed that for most catchments the MAP's are similar and the differences do not exceed 2%.

### 3.1.3 Catchment developments

The Komati catchment is mainly agricultural in nature, with significant areas under cultivation, either dryland or irrigated. The predominant crop in the Upper and Middle Komati catchments is maize, with sugar cane the main crop in the Lower Komati and Lomati catchments. There are significant commercial forest plantations in the high rainfall sub-catchments of all the tertiary catchments. The current day (2004) area of forestry is 1200 $km^2$ and is mostly pine (73 %) with the remainder being eucalyptus. At 2004 development levels the streamflow reduction from forestry is estimated to be 117 million $m^3$/annum. The area covered by Alien Invasive plants (AIPs) has been estimated to be about 321 $km^2$. The WRSM2000 model for the Komati catchment was calibrated without the AIP information as reliable information was not initially available.

There is limited mining activity in the Komati catchment. There are however, concerns about the impact on water quality from small coal mines upstream of Nooitgedacht Dam and from abandoned mines in the Mtsoli catchment and the headwater catchments of the Lower Komati.

Numerous small dams are scattered over the catchment and are used mainly for irrigation and stock watering. There are also a significant number of natural pans in the upper reaches of the Nooitgedacht catchment. The pans form endoreic areas that reduce the Nooitgedacht Dam catchment area by an estimated 119 $km^2$ to a net catchment area of 1 475 $km^2$. Groundwater abstractions in the Komati catchment are not significant but are likely to be under reported.

Irrigation is not significant in the Upper and Middle Komati catchments but is common and widespread in the lower reaches of the Lower Komati and Lomati catchments. There is no controlled irrigation upstream of the Muguga Dam in the Komati catchment and upstream of Driekoppies Dam in the Lomati catchment. The main irrigation schemes are the Komati

Irrigation Board and Mhlume Water scheme in the Lower Komati catchment and the Lomati Irrigation Board in the lower Lomati catchment. All the schemes are supported by releases from the Maguga and Driekoppies Dams. The Lomati and Komati Irrigation Board's comprise 30 294 ha with a total requirement of 280 million $m^3$/annum.

A significant volume of water is transferred from the Nooitgedacht/Vygeboom system of the Upper Komati catchment to power stations in the Olifants WMA and from the Maguga/Driekoppies system of the Lower Komati catchments to irrigators in the Mbuluzi catchment in Swaziland.

### 3.1.4 Calibrations and natural flows

During the inception phase of this study, 18 flow gauges and 4 reservoir records were selected for further investigation of their suitability for use in the WRSM2000 model configured for the study area. As a result of the review 13 flow gauges as shown in **Figure 3.1** were selected for calibrating the Komati catchment. Limited patching of unreliable, incomplete and missing flow data was undertaken.

The aim of the calibration was to generate monthly flow records that were equivalent to the observed record. In general the following Pitman parameters were adjusted to improve the calibration:

ST – Soil moisture capacity (mm)

FT – Sub-surface flow at full soil moisture capacity (mm/month)

TL – Lag in surface flow (months).

The hydrology for the Komati catchment as a whole was extended to 2004 (previously available to 1995) and represents 85 years of record extending from 1920 to 2004. Good to reasonable calibrations were obtained at X1R001, X1H017 and at X1R003 in the Upper Komati. Reasonable calibrations were obtained at X1H016 and X1H001 in the Middle Komati and at GS26 in the Lower Komati. Obtaining reasonable calibrations at X1H003 and at X2H036 was difficult as both gauges have structural limitations and are probably underestimating higher flows. A good calibration was obtained at GS11 in the Upper Lomati whereas a poor calibration was obtained X1H014 as the gauge underestimates flow due to an upstream diversion for hydropower.

The statistics for the calibration points are summarized in **Table 3.1** and compared with results from previous studies for the same period. Comparing with previous studies for the same periods, the Mean Annual Runoff (MAR) for the total Komati River catchment, this latest estimate of the natural hydrology results in a decrease in MAR of between 1% and 5 %.

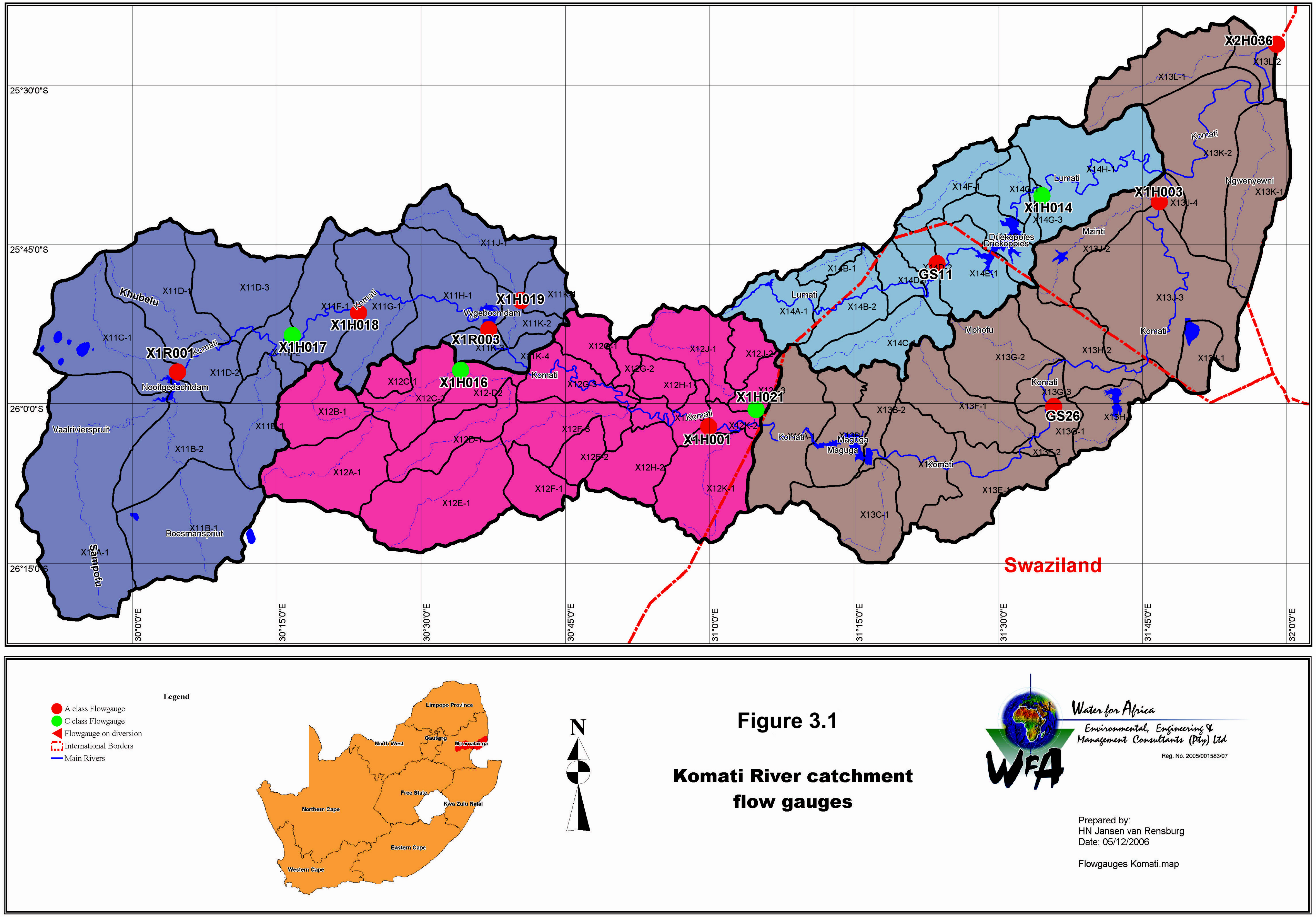


**Figure 3.1 Komati River catchment flow gauges**

## Table 3.1 Updated hydrology statistics compared with previous studies

| Gauge | Incremental catchment | Calibration record | Natural MAR (million m³/a) | | |
|---|---|---|---|---|---|
| | | | WAAS | Other studies | % Difference |
| X1R001 | Komati River at Nooitgedacht Dam | 1921 – 1989(1) | 65.6 | 78.5 | -16.4% |
| | | 1920 – 1989(2) | 65.7 | 64.1 | 2.5% |
| | | 1921 - 1995(3) | 68.3 | 59.9 | 14.0% |
| | | 1920 – 1994(4) | 64.9 | 66.3 | -2.1% |
| | | 1920 – 2004 (5) | 67.4 | | |
| X1H018 | Komati River at Gemsbokhoek | 1920 – 1989(2) | 158.9 | 162.6 | -2.3% |
| | | 1920 – 1994(4) | 157.4 | 159.1 | -1.1% |
| | | 1920 – 2004 (5) | 158.6 | | |
| X1R003 | Komati River at Vygeboom Dam | 1921 – 1989(1) | 261.6 | 264.2 | -1.0% |
| | | 1920 – 1989(2) | 261.7 | 269.0 | -2.7% |
| | | 1921 - 1995(3) | 265.0 | 242.2 | 9.4% |
| | | 1920 – 1994(4) | 258.3 | 260.5 | -0.8% |
| | | 1920 – 2004 (5) | 258.4 | | |
| X1H001 | Komati River at Hoogenoeg | 1921 – 1989(1) | 550.9 | 550.5 | 0.1% |
| | | 1920 – 1989(2) | 553.1 | 573.9 | -3.6% |
| | | 1921 - 1995(3) | 556.0 | 531.1 | 4.7% |
| | | 1920 – 1994(4) | 544.4 | 552.1 | -1.4% |
| | | 1920 – 2004(5) | 545.8 | | |
| X1R005 | Komati River at Maguga Dam | 1921 – 1989(1) | 749.3 | 788.3 | -4.9% |
| | | 1921 - 1995(3) | 752.5 | 766.4 | -1.8% |
| | | 1920 – 2004(5) | 749.4 | | |
| X1H003 | Komati River at Tonga | 1921 - 1989(1) | 1015.9 | 1029.5 | -1.3% |
| | | 1921 - 1995(3) | 1011.2 | 1004.7 | 0.6% |
| | | 1920 - 2004(5) | 1022.1 | | |
| X1R004 | Lomati River at Driekoppies Dam | 1921 - 1995(3) | 236.1 | 260.7 | -9.4% |
| | | 1920 – 2004 (5) | 241.7 | | |
| | Lomati River at Vlakbult | 1921 – 1989(1) | 312.8 | 354.5 | -11.8% |
| | | 1920 – 1989(2) | 313.8 | 301.3 | 4.1% |
| | | 1921 - 1995(3) | 308.0 | 347.9 | -11.5% |
| | | 1920 – 2004 (5) | 316.4 | | |
| X2H036 | Komati River at Komatipoort (includes Crocodile) | 1920 – 1989(2) | 2473.1 | 2602.0 | -5.0% |
| | | 1920 – 2004 (5) | 2494.1 | | |
| **Total** | **Komati catchment** | **1921 – 1988(1)** | **1346.9** | **1419.7** | -5.1% |
| | | **1920 – 1989(2)** | **1351.6** | **1365.6** | -1.0% |
| | | **1921 - 1995(3)** | **1336.1** | **1385.1** | -3.5% |
| | | **1920 – 2004 (4)** | **1356.8** | | |
| | **X11** | **1920 – 1989(2)** | **347.4** | **359.6** | -3.4% |
| | | **1920 – 2004 (4)** | **341.9** | | |
| | **X12** | **1920 – 1989(2)** | **302.6** | **316.2** | -4.3% |
| | | **1920 – 2004 (4)** | **301.9** | | |
| | **X13** | **1920 – 1989(2)** | **387.8** | **388.5** | -0.2% |
| | | **1920 – 2004 (4)** | **396.6** | | |
| | **X14** | **1920 – 1989(2)** | **313.8** | **301.3** | 4.1% |
| | | **1921 - 1995(3)** | **308.0** | **347.9** | -11.5% |
| | | **1920 – 2004 (4)** | **316.4** | | |

Note: (1) JIBS report, 1995
(5) WR90 report, 1994
(6) Maguga Dam Basin Study, 1998
(7) VRSAU report, 1999, Hydrology of the Komati catchment upstream of Swaziland
(8) WAAS Report; Hydrology of the Komati catchment

### 3.1.5 Conclusions and recommendations

From the hydrological analysis of the Komati River catchment the following conclusions and recommendations were drawn:

- The rainfall data produced from the rainfall analysis is considered acceptable and could be used with confidence to calibrate the WRSM2000 model. The number of rain gauges that remain operational is a cause for concern and consideration should be given to re-opening old reliable stations and or the establishment of new gauges.
- Good to reasonable calibrations were obtained at most flow gauges. The observed flow data at some gauges does require review and should be undertaken by the Inkomati Catchment Management Agency (ICMA). The patched flows record should be assessed and if accepted used to update the DWAF flow records to prevent duplication of this process in future studies.
- The MAR of the updated naturalized hydrology for the Komati catchment decreased by up to 5 % when compared with previous studies. This is an acceptable change and the natural flows created for all the quinary catchments in the study area can be used with confidence in further analyses.
- The results from the verification and validation tests of the stochastic flows indicated that the stochastically generated flows are acceptable with only minor discrepancies. The stochastic flows are considered plausible and realistic and can be used with confidence for further water resources analysis of the Komati River catchment.

## 3.2 Crocodile River hydrology

### 3.2.1 Introduction

The total area of the Crocodile River catchment is 10 446 $km^2$ and is made up of four tertiary catchments, the Upper Crocodile (X21), Middle Crocodile (X22), Lower Crocodile (X24) and Kaap (X23). Important tributaries of the Crocodile River include the Kaap River, the Elands River in the Upper Crocodile and the Sand, Nelspruit and White Rivers in the Middle Crocodile. The process of generating the incremental natural hydrology for the defined sub-catchments of the Crocodile River catchment is summarised in this Main Report while detailed information is provided in the **Crocodile Hydrology Report.**

The Crocodile catchments is rural in nature with agriculture as the main activity while the high rainfall escarpment catchments of the Upper and Middle Crocodile and Kaap catchments have significant areas of commercial forestry. The Upper Crocodile is relatively undeveloped with small domestic and irrigation demands. The Middle Crocodile catchment has significant areas of controlled irrigation and urban demands. The Kaap catchments are dominated in the lower eastern catchments by significant areas of controlled irrigation. Water is transferred into the

Kaap catchment from the Lomati and Shiyalongubu Dams for urban (Umjindi Local Mumicipality) and agricultural (Louws Creek Irrigation Board) users. The lower Crocodile has significant areas of controlled irrigation and smaller urban/domestic demands. Water is transferred from the Sabie canal in the Sabie catchment to the Nsikazi North Water Supply Scheme (WSS) for domestic users in the Lower Crocodile.

The Crocodile catchment falls entirely within the Mpumalanga Province and has the major urban centres of Nelspruit (provincial capital), Kanyamazane and White River in the Middle Crocodile catchment and Barberton in the Kaap catchment. Smaller towns include Dullstroom, Machadorp and Watervalboven in the Upper Crocodile and Matsulu, Malelane and Hectorspruit in the Lower Crocodile catchment. **Figure 1.1** shows the locality of the Crocodile or X2 catchment within the Inkomati WMA.

Water related infrastructure in the Crocodile catchment is dominated by Kwena Dam and four smaller supply dams. Located in the upper Crocodile catchment, the Kwena Dam is operated by the Crocodile Major Irrigation Board to augment the water availability to downstream users within the Crocodile system. In the middle Crocodile the Witklip Dam in the Sand River catchment and the Klipkopje, Longmere and Primkop Dams in the White River catchment are operated to provide water to the town of White River and irrigators located in these tributary catchments.

### 3.2.2 Rainfall

There is a separate report, **Inkomati WAAS Rainfall Report** (DWAF, 2007; PWMA 05X22/00/1308) that describes the process of identifying and patching rainfall records. In summary the rainfall in the study area occurs mainly in the summer months from October to March and the MAP varies between 470 mm/annum in the drier eastern part of the catchment to 1310 mm/annum in the wetter escarpment and mountain catchments of the upper and middle Crocodile and Kaap catchments. The mean annual Symons pan evaporation (MAE) is in the order of 1470 mm/annum. Most the rainfall data was obtained from the Rain Information Management System or Rain IMS that has been developed by the DWAF.

A total of 269 stations in and around the Inkomati WMA were identified of which 150 gauges were selected to be validated before they were used in the simulation of rainfall runoff. The main selection criteria for patching were that stations had at least 15 year of data and that there were adequate gauges with records up to September 2005. A total of 61 rainfall stations were selected and patched for the hydrology update of the Crocodile catchment. The MAP values were calculated for all quinary catchments using the gridded MAP surface from the **Agrohydrology Atlas** (Schulze, 2002). A comparison of quaternary catchment MAP's from this study with the WR90 MAP's showed that for most catchments the MAP's are similar and differences do not exceed 10 %.

### 3.2.3 Catchment developments

The Crocodile catchment is mainly agricultural in nature, with significant areas of the study area under cultivation, both dryland and irrigated. The main crops in the Upper Crocodile are maize and vegetables, while vegetables are the main crop in Middle Crocodile and sugar cane is the dominant crop in the Lower Crocodile and Kaap catchments. There are significant commercial forest plantations in the high rainfall sub-catchments of all the tertiary catchments except the drier Lower Crocodile catchment. With a total area of 1940 km$^2$, the forestry is mainly pine (62 %) and eucalyptus. The streamflow reduction from forestry is estimated to be 157 million m$^3$/annum at 2004 development level. The area covered by Alien Invasive plants (AIPs) has been estimated to be about 295 km$^2$. The WRSM2000 model for the Crocodile catchment was calibrated without the AIP information as reliable information was not initially available.

There is limited mining in the area and industrial requirements are dominated by Sappi paper mill in the Upper Crocodile and the TSB sugar mill at Malelane in the Lower Crocodile. Sappi obtains water from local sources (Ngodwana Dam) within the Ngodwana catchment (X21H) while the sugar mill abstracts water from the lower Crocodile River.

There are numerous small dams scattered over the catchment that are used mainly for irrigation and stock watering. Groundwater abstractions in the Crocodile catchment are not significant but are likely to be under reported.

Irrigation is not significant in the Upper Crocodile catchments but widespread in the Middle and Lower Crocodile and Kaap catchments. The main irrigation scheme is the Crocodile Major Irrigation Board, with numerous smaller schemes within the Kaap, Elands, Nelspruit and White River catchments. These schemes are supported by releases from Kwena, Witklip, Klipkopje, Primkop and Longmere Dams. The allocated area for all Irrigation Boards within the Crocodiel River catchment s is 45 303 ha with an annual allocation of approximately 400 million m$^3$/annum.

The Crocodile catchment receives minor water transfers from the Lomati catchment for the Umjindi Local Municipality and the Louws Creek Irrigation Board in the Kaap catchment as well as from the Sabie catchment for rural settlement at Nsikazi North.

### 3.2.4 Calibrations and natural flows

During the inception phase of this study, 18 flow gauges and 5 reservoir records were selected for further investigation of their suitability for use in the WRSM2000 model configured for the study area. As a result of the review 16 flow gauges and 2 reservoir records, shown in **Figure 3.2**, were selected for calibrating the Crocodile catchments. Limited patching of unreliable, incomplete and missing flow data was undertaken.

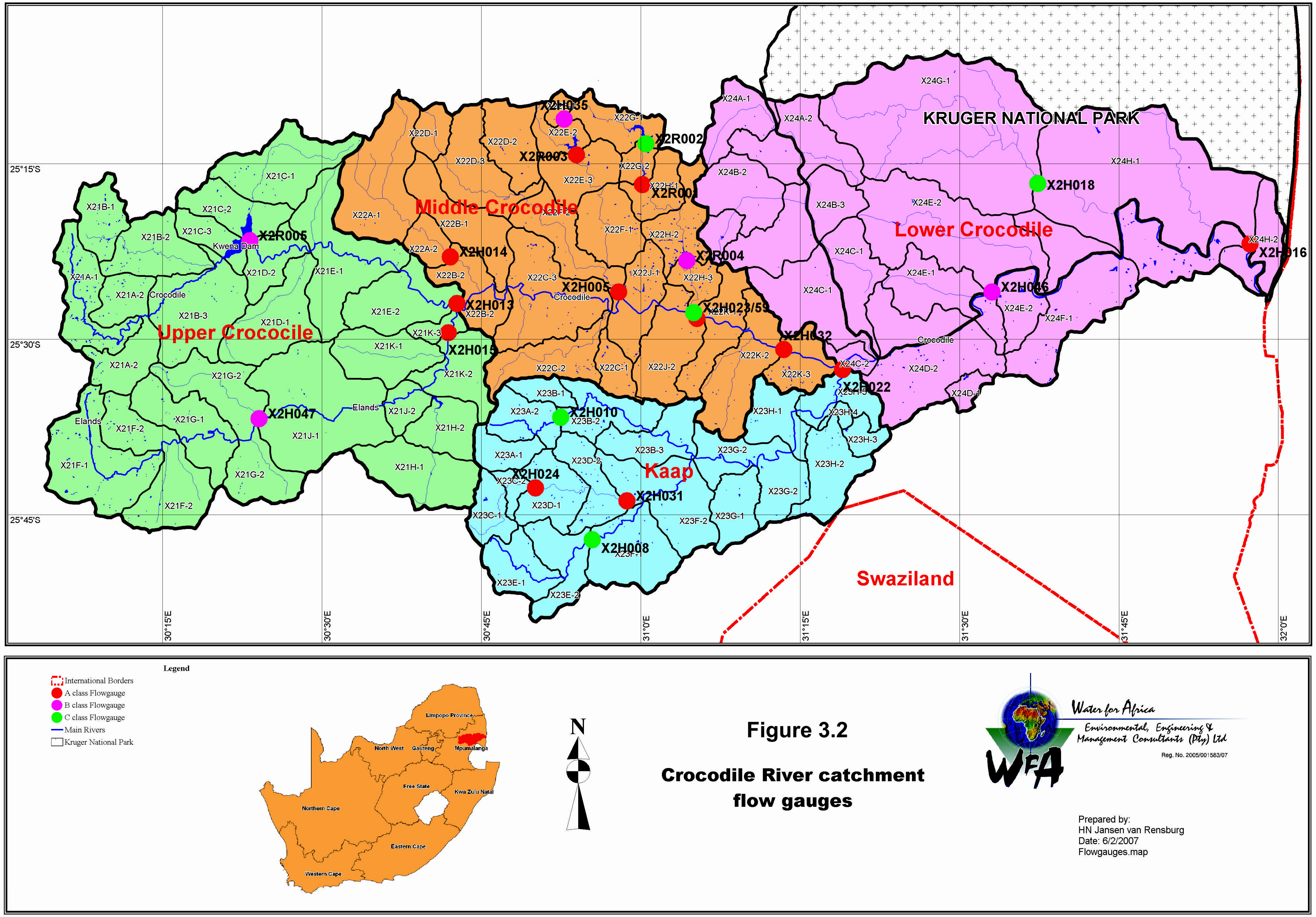


**Figure 3.2** Crocodile River catchment flow gauges

The aim of the calibration was to generate monthly flow records that were equivalent to the observed record. In general the following Pitman parameters were adjusted to improve the calibration:

ST – Soil moisture capacity (mm)

FT – Sub-surface flow at full soil moisture capacity (mm/month)

TL – Lag in surface flow (months).

The hydrology for the Crocodile River catchment as a whole was extended to 2004 and represents 85 years of record extending from 1920 to 2004. Good to reasonable calibrations were obtained at X2R005 and X2H013 in the Upper Crocodile. Reasonable calibrations were obtained at X2H011 and X2H015 in the Elands catchment, at X2H014 in the Houtbosloop catchment and at X2H035, X2R003 in the Sand River and Nelspruit catchments. At X2H005 in the Nels River catchment the calibration was more difficult and dry season flows are under simulated.

The gauges in the White River catchment all have all considered inaccurate and were not used to calibrate the WRSM2000. The calibrations at the middle Crocodile gauges of X2H006 and X2H032 were undertaken in conjunction with each other. While the calibrations are reasonable, both these gauges are known to underestimate low flows.

Reasonable to good calibrations were obtained at X2H010, X2H024 and X2H008 in the Upper Kaap tributary catchments. Obtaining reasonable calibrations at X2H031 in the lower Suidkaap and at X2H022 in the lower Kaap was more difficult and low flows are under simulated for developed flows. Reasonable calibrations were obtained at X2H046 and X2H016 in the Lower Crocodile catchments; however dry season flows are underestimated for developed conditions.

Most of the gauges that underestimate dry season flows appear to do so for the period up to the early 1980's after which the simulation improves. It is possible that the land use information up to 1980 is inaccurate. In addition all the gauges are downstream of heavily afforested catchments and the under simulation of dry season flows could be consequence of the methods used to estimate streamflow reduction. The dry season simulations do improve when observed flows are naturalized at X2H005, X2H032, X2H022 and X2H016.

The statistics for the calibration points are summarized in **Table 3.2** and compared with results from previous studies for the same period. The MAR for the total Crocodile River catchment decreased between 7 % and 14 % when compared with previous studies for the same period.

## Table 3.2 Updated hydrology statistics compared with previous studies

| Gauge | River / Location | Calibration record | Natural MAR (million m³/a) | | |
|---|---|---|---|---|---|
| | | | WAAS | Other studies | % Difference |
| X2R005 | Crocodile River at Kwena Dam | 1921 – 1988<br>1920 - 1989<br>1920 - 2004 | 116.7<br>117.2<br>118.4 | 121.8^<br>127.8* | -6<br>-8 |
| X2H013 | Upper Crocodile River at Montrose | 1921 – 1988<br>1920 - 1989<br>1920 - 2004 | 194.4<br>194.6<br>197.7 | 215.8^<br>225.2* | -10<br>-13.5 |
| X2H015 | Elands River at Lindenau | 1921 – 1988<br>1920 - 1989<br>1920 - 2004 | 269.8<br>269.7<br>264.5 | 257.0^<br>283.8* | +5<br>-5 |
| X2H014 | Houtbosloop at Sudwalaskraal | 1920 – 1989<br>1920 - 2004 | 65.0<br>65.8 | 71.5* | -9 |
| X2R003 | Upper Sand River at Witklip Dam | 1921 - 1988<br>1920 – 2004 | 19.7<br>19.8 | 25.5^ | -23 |
| X2H005 | Nels River at Boschrand | 1921 - 1988<br>1920 – 1989<br>1920 – 2004 | 123.8<br>123.7<br>125.4 | 161.0^<br>153.5* | -23.0<br>-19.0 |
| X2H006 | Middle Crocodile River at Karino | 1921 - 1988<br>1920 – 1989<br>1920 – 2004 | 798.2<br>797.8<br>802.9 | 821.7^<br>897.7* | -3<br>-11 |
| X2H032 | Middle Crocodile River at Weltevrede | 1921 – 1988<br>1920 – 2004 | 813.3<br>818.6 | 893.0^ | -9 |
| X2H010 | Upper Noordkaap River at Bellevue | 1921 - 1988<br>1920 – 1989<br>1920 – 2004 | 36.4<br>36.3<br>36.0 | 33.3^<br>32.1* | +9<br>+13 |
| X2H024 | Upper Suidkaap River at Glenthorpe | 1920 – 1989<br>1920 - 2004 | 26.2<br>25.9 | 25.4* | +4 |
| X2H031 | Suidkaap River at Bornmans Drift | 1920 – 1989<br>1920 - 2004 | 61.9<br>61.5 | 53.9* | +15 |
| X2H008 | Queens River at Sassenheim | 1921 - 1988<br>1920 – 1989<br>1920 - 2004 | 30.2<br>30.1<br>29.9 | 36.7^<br>36.7* | -18<br>-18 |
| X2H022 | Kaap River at Dalton | 1921 - 1988<br>1920 – 1989<br>1920 – 2004 | 202.8<br>202.7<br>204.2 | 220.1^<br>206.0* | -8<br>-2 |
| X2H046 | Lower Crocodile at Tenbosch | 1921 - 1988<br>1920 – 1989<br>1920 - 2004 | 1122.5<br>1121<br>1136.5 | 1224.5^<br>1236* | -8.3<br>-9.3 |
| X2H018 | Mbyamiti River at Kruger National Park | 1921 - 1988<br>1920 - 2004 | 14.3<br>15.3 | 13.7^ | +4.5 |
| **Total** | **Total Crocodile catchment** | **1921 - 1988<br>1920 – 1989<br>1920 – 2004** | **1123.0<br>1122.0<br>1136.2** | **1226.4^<br>1236.4*** | **-8.4<br>-9.2** |
| | **Upper Crocodile catchment** | **1920 – 1989<br>1920 – 2004** | **469.4<br>467.3** | **507.9*** | **-7.5** |
| | **Middle Crocodile catchment** | **1920 – 1989<br>1920 – 2004** | **350.6<br>362.4** | **418.1*** | **-16** |
| | **Kaap Catchment** | **1920 - 1988<br>1920 – 1989<br>1920 – 2004** | **202.8<br>202.7<br>204.2** | **220.1^<br>206.0*** | **-8<br>-2** |
| | **Lower Crocodile Catchment** | **1921 - 1988<br>1920 – 1989<br>1920 – 2004** | **98.0<br>97.0<br>106.6** | **113.25^<br>104.4*** | **-14<br>-7** |

* WR 90 – Surface Water Resources of South Africa, Appendix B, Volume VI
^ JIBS, 1995, Runoff Hydrology, Appendix 13

### 3.2.5 Conclusions and recommendations

From the hydrological analysis of the Crocodile River catchment the following conclusions and recommendations are drawn:

- The rainfall data produced from the rainfall analysis was considered acceptable and could be used with confidence to calibrate the WRSM2000 model. The number of rain gauges that remain operational is a cause for concern and consideration should be

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given to re-opening old reliable stations and or the establishment of new gauges.

- Good to reasonable calibrations were obtained at most flow gauges. The observed flow data at some gauges requires review and should be undertaken by the ICMA. The patched flows record should be assessed and if accepted used to update the DWAF flow records to prevent duplication of this process in future studies.
- Dry season flows were under simulated at a number of gauges and while naturalization of the observed record does improve the simulation the reasons for the under simulation appear to be related to landuse data and the methodology used to determine streamflow reduction due to afforestation. Heavily forested quinary catchments in the Crocodile catchment could be selected to verify these methodologies.
- The reservoir balances and flows in the White River catchments are seriously flawed and require attention to improve confidence in the flow information for this catchment.
- The MAR of the updated naturalized hydrology for the Crocodile catchment decreased by between 7 and 14 % when compared with previous studies. This is an acceptable change and the natural flows created for all the quinary catchments in the study area can be used with confidence in further analyses.
- The results from the verification and validation tests of the stochastic flows indicated that the stochastically generated flows are acceptable with only minor discrepancies. The stochastic flows are considered plausible and realistic and can be used with confidence for further water resources analysis of the Crocodile River catchment.

## 3.3 Sabie River Hydrology

### 3.3.1 Introduction

The total area of the Sabie River catchment is 6 315 km$^2$ and is made up of three tertiary catchments, the Sabie (X31), Lower Sabie (X33) and Sand (X32). Important tributaries of the Sabie River include the Mac-Mac, Marite and Whitewaters Rivers in the Sabie catchment and the Sand River. The process of generating the incremental natural hydrology for the defined sub-catchments of the Sabie River catchment is summarised in this Main Report while detailed information is provided in the **Sabie Hydrology Report.**

The Sabie catchments is mostly rural in nature with agriculture and silviculture the main activities, while the lower Sabie is almost entirely within the Kruger National Park where the water use is negligible but the sustainable flow of the lower Sabie is crucial to sustaining the ecological functioning of the Park. The high rainfall escarpment catchments in the Upper Sabie have large areas of commercial forestry. The Sabie catchment is relatively well developed with significant irrigation demands. Water is transferred from the Sabie catchment to rural settlements in the lower Crocodile River (Nsikazi North). The Sand River catchment has localized irrigation that appears to use all the dry season baseflows often causing the Sand River to stop flowing completely.

The Sabie River catchment falls mostly within the Mpumalanga Province and has no major urban centres. Small towns include Sabie, Graskop and Hazyview and numerous smaller settlements. Much of the upper Sand River catchment is located within the Limpopo Province and the catchment has numerous rural settlements spread across it. **Figure 1.1** shows the locality of the Sabie or X3 catchment within the Inkomati WMA.

Water related infrastructure in the Sabie catchment is dominated by Inyaka Dam in the Marite catchment and Da Gama Dam in the Whitewaters catchment. There is an extensive system of canals and pipes distributing water from these sources to irrigators and domestic users within the Sabie and Sand River catchments. The Bushbuckridge Water Supply Scheme supplies water from Inyaka Dam to most domestic users within these catchments. Inyaka Dam also makes releases to support the ecological water requirements of the lower Sabie catchments.

### 3.3.2 Rainfall

There is a separate report, **Inkomati WAAS Rainfall Report** (DWAF, 2007) that describes the process of identifying and patching rainfall records. In summary, the rainfall in the study area occurs mainly in the summer months from October to March and the MAP varies between 470 mm/annum in the drier eastern sub-catchment to 445 mm/annum in the wetter escarpment and mountain catchments of the Sabie River. The mean annual Symons pan evaporation (MAE) is in the order of 1500 mm/annum. Most of the rainfall data was obtained from the Rain Information Management System or Rain IMS that has been developed by the DWAF.

A total of 41 rainfall stations were selected within (or in close proximity to) the Sabie River catchment and patched to use in the hydrology update of the Sabie River catchment. The MAP values were calculated for all quinary catchments using the gridded MAP surface from the **Agrohydrology Atlas** (Schulze, 2002). A comparison of quaternary catchment MAP's from this study with the WR90 MAP's showed that for most catchments the MAP's are similar and differences do not exceed 4 %.

### 3.3.3 Catchment developments

The portion of the Sabie River catchment which lies outside of Kruger National Park are agricultural in nature, with significant areas of the study area under cultivation, either dryland or irrigated. The predominant irrigated crop in the Sabie and Sand catchments is citrus. There are significant commercial forest plantations in the high rainfall sub-catchments of the Sabie catchment, in particular the headwater catchments of the Upper Sabie, Marite and Whitewater catchments. Forestry in the Sand River catchment is less significant. The area of afforestation in 2004 was estimated at 853 km$^2$ of which 93 % is in the Sabie catchment. The forestry is mainly pine (61 %) and eucalyptus. The streamflow reduction from forestry is mainly in the Sabie catchments and is estimated to be 86 million m$^3$/a at 2004 development levels. The area covered by Alien Invasive plants (AIPs) has been estimated to be about 205 km$^2$. The WRSM2000 model for the Sabie catchment was calibrated without the AIP information as reliable information was not available at the time of calibration.

There are small dams in the Sabie River catchment that are used mostly for irrigation, stock and game watering. Groundwater abstractions for domestic and stock watering are not significant but are likely to be under reported.

Irrigation is significant and widespread in the Sabie catchment. The main irrigation schemes are located within the Sabie Irrigation Board and the Whitewaters Irrigation Board. The Sabie scheme is supplied via a canal which diverts run-of-river flow out of the Sabie River while irrigators within the Whitewaters Irrigation Board are supplied from the Da Gama Dam. Abstractions for irrigation in the Sand River are mostly run of river supported by releases from the small supply dams of Edinburgh and Orinoco.

There is limited mining in the area and no significant industrial demands.

### 3.3.4 Calibrations and natural flows

During the inception phase of this study, 13 flow gauges were selected for further investigation of their suitability for use in the WRSM2000 model configured for the study area. As a result of the review 11 flow gauges, shown in **Figure 3.3,** were selected for calibrating the WRSM200 model setup of the Sabie River catchment. Limited patching of unreliable, incomplete and missing flow data was undertaken.

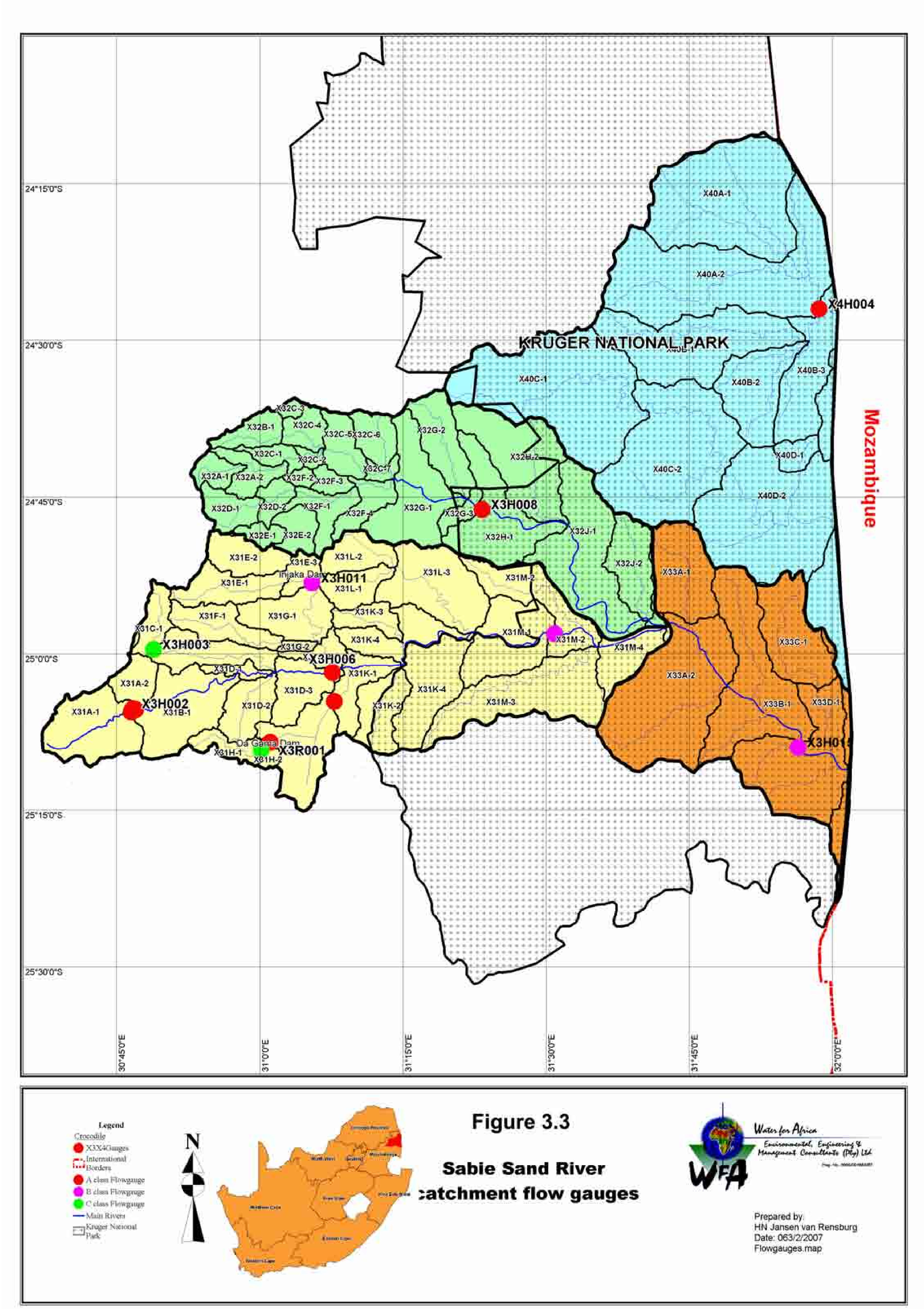
The aim of the calibration was to generate monthly flow records that were equivalent to the observed record. In general the following Pitman parameters were adjusted to improve the calibration:

ST – Soil moisture capacity (mm)

FT – Sub-surface flow at full soil moisture capacity (mm/month)

TL – Lag in surface flow (months).

**Figure 3.3 Sabie River catchment flow gauges**



The hydrology of the Sabie River catchment was extended to 2004 and represents 85 years of record extending from 1920 to 2004. Good to reasonable calibrations were obtained at X3H001, X3H003, X3H006 and X3H021 in the Sabie catchment, at X3H008 in the Sand catchment and at X3H015 in the Lower Sabie. Reasonable calibrations at X3H002 in the Klein Sand, X3H011 in the Marite and X3H004 in the Whitewaters catchments were harder to obtain with the simulated gross yield curves much higher than desired for good calibrations. Some of the gauges in the Sabie catchments have problems measuring higher flows with records missing for significant periods during periods such as the 2000 and 1995 floods.

The statistics for the calibration points are summarized in **Table 3.3** and compared with results from previous studies for the same period. The MAR for the Sabie River catchment decreased between 10 % and 13 % when compared with previous studies for the same period. The MAR for the important Inyaka Dam catchment decreased over 20% when compared with previous studies.

### 3.3.5 Conclusions and recommendations

From the hydrological analysis of the Sabie River catchment the following conclusions and recommendations are drawn:

- The rainfall data produced from the rainfall analysis was considered acceptable and could be used with confidence to calibrate the WRSM2000 model. The number of rain gauges that remain operational is a cause for concern and consideration should be given to re-opening old reliable stations and or the establishment of new gauges.
- Good to reasonable calibrations were obtained at most flow gauges. The observed flow data at some gauges does require review and should be undertaken by the ICMA. The patched flows record should be assessed and if accepted used to update the DWAF flow records to prevent duplication of this process in future studies.
- Gross yields were over simulated at a number of gauges and while naturalization of the observed record does improve the simulation the reasons for the over simulation appear to be related to landuse data.
- The Sand River catchment was calibrated at only one gauge which is not adequate for a catchment of this size and complexity. Additional gauges in the wetter headwater catchments are required to improve the confidence in the calibration of this catchment. While calibration information from headwater gauges in the Sabie catchment can provide some information for the Sand headwater catchments the information is not directly transferable as the two catchments are not that similar.
- The MAR of the updated naturalized hydrology for the Sabie catchment decreased 10 to 13 % when compared with previous studies. This is an acceptable change and the natural flows created for all 58 quinary catchments in the study area can be used with confidence in further analyses.
- Of concern and requiring further investigation is the over 20 % decrease in the MAR of the Inyaka Dam catchment. This decrease needs to be confirmed by reviewing the dam balance record for Inyaka Dam. The record was too short and unreliable to be of any value to this study.

- The results from the verification and validation tests of the stochastic flows indicated that the stochastically generated flows are acceptable with only minor discrepancies. The stochastic flows are considered plausible and realistic and can be used with confidence for further water resources analysis of the Sabie River catchment.

**Table 3.3 Updated hydrology statistics compared with previous studies**

| Gauge | River / Location | Calibration record | MAR (million m³/a) | | |
|---|---|---|---|---|---|
| | | | WAAS | Other studies | % Difference |
| X3H001 | Sabie River at Sabie | 1921 – 1988(1) | 80.0 | 84.7 | -6% |
| | | 1920 - 2004(3) | 80.2 | | |
| X3H002 | Klein Sabie River at Sabie | 1921 – 1988(1) | 13.7 | 18.3 | -25% |
| | | 1920 - 2004(3) | 13.5 | | |
| X3H003 | Mac-Mac River at Geelhoutboom | 1921 – 1988(1) | 31.4 | 33.3 | -6% |
| | | 1920 - 2004(3) | 31.5 | | |
| X3H006 | Sabie River at Perrys Farm | 1921 – 1988(1) | 279.4 | 317.5 | -12% |
| | | 1920 - 1989(2) | 280.0 | 306.0 | -8% |
| | | 1920 - 2004(3) | 278.0 | | |
| X3H011 | Marite River at Inyaka | 1921 – 1988(1) | 78.0 | 99.4 | -22% |
| | | 1920 - 1989(2) | 78.0 | 104.5 | -25% |
| | | 1920 - 2004(3) | 80.0 | | |
| X3H004 | Noordsand River at De Rust | 1921 – 1988(1) | 47.3 | 49.1 | -6% |
| | | 1920 - 1989(2) | 47.3 | 46.9 | -1% |
| | | 1920 - 2004(3) | 47.9 | | |
| X3H008 | Sand River at Exeter | 1921 – 1988(1) | 114.0 | 154.3 | -26% |
| | | 1920 - 1989(2) | 114.0 | 118.1 | -3% |
| | | 1920 - 2004(3) | 116.0 | | |
| X3H015 | Sabie River at Lower Sabie Rest Camp [KNP] | 1920 - 1989(2) | 660.0 | 729.6 | -10% |
| | | 1920 - 2004(3) | 672.3 | | |
| **Total** | **Total Sabie catchment** | **1921 – 1988(1)** | **658.0** | **752.6** | **-13%** |
| | | **1920 - 1989(2)** | **658.0** | **732.0** | **-10%** |
| | | **1920 - 2004(3)** | **675.8** | | |
| | **Upper Sabie catchment** | **1921 – 1988(1)** | **520.0** | **595.8** | **-13%** |
| | | **1920 - 1989(2)** | **520.0** | **584.6** | **-12%** |
| | | **1920 - 2004(3)** | **527.3** | | |
| | **Sand catchment** | **1921 – 1988(1)** | **131.0** | **153.7** | **-15%** |
| | | **1920 - 1989(2)** | **131.0** | **136.2** | **-4%** |
| | | **1920 - 2004(3)** | **136.0** | | |

*(3)* JIBS, 1995 – Appendix 13; Runoff Hydrology
*(4)* WR90, 1994 – Surface Water Resources of South Africa
(3) Inkomati WAAS, 2008 – Inkomati Water Availability Assessment study.

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# 4. WATER QUALITY

## 4.1 Introduction

Currently the major stresses facing the WMA are the high water demands for irrigation, afforestation, industry, transfer out of the catchment for Eskom and rapidly increasing domestic water demands. The water shortages experienced in the area have led to competition for the available water resources among user sectors. Furthermore, the major dams in the study area change the flow regime and impact on the water quality. Having water of the right quality is just as important as having enough water. It is therefore vital that the water resources of this WMA are managed in an integrated manner to achieve a balance between meeting water demands (quality and quantity) and what is available.

To achieve the above, a holistic assessment is required in order to inform development planning that will ensure a balance between environmental sustainability and different forms of developmental initiatives. According to the NWRS, the central objective of managing water resources is to ensure that water is used to support equitable social and economic transformation and development. Key to this is also balancing the need for sustainability. A water quality assessment of the Inkomati WMA was therefore carried out as part of this WAAS with the aim of providing a water quality perspective of the WMA. This will inform the development of the catchment management strategy and the development of a water allocation plan for the Inkomati WMA.

## 4.2 Water quality data analysis

### 4.2.1 Methodology

The water quality status is presented in this section in graphical form. Software used for data manipulation included Microsoft Office Excel for basic statistical analyses and graphical presentation. The data has been plotted from the most upstream monitoring station to the downstream station, providing an indication of status along the river length.

The data sets obtained have been represented in these plots in the form of box and whisker diagrams, which depicts the data distribution as 5th, 25th, 50th, 75th and 95th percentile values.

The water quality status along the river was compared to the most stringent user Target Water Quality Ranges (TWQR) as specified in the **South African Water Quality Guidelines** (DWAF, 1996) for the identified water quality variables. Currently no Resource Water Quality Objectives (RWQOs) have been set for the water resources in the Inkomati WMA. The water quality status assessment has been based on the routine monitoring conducted by DWAF in recent years and it must be borne in mind that this is a high level qualitative assessment of historical water quality in the Inkomati WMA making use of the data available to the study team.

### 4.2.2 Identification of key variables

The original data obtained from DWAF included a comprehensive list of variables that are monitored within the X-drainage region of South Africa. This study focused on the following water quality variables which were selected based on the major land use activities (agriculture, urban development, settlements, industrial activity), current water quality issues in the catchment (eutrophication, salinisation) and water user requirements (power generation, industry, domestic, agriculture).

- Chloride (Cl)
- Electrical Conductivity (EC)
- Ammonia (NH4)
- Nitrate and nitrite (NO3 and NO2)
- Sodium (Na)
- Phosphorus (PO4) (Inorganic)
- Sulphate (SO4)
- pH
- Magnesium (Mg)
- Total Alkalinity

### 4.2.3 Water quality guidelines

RWQOs for the Komati, Crocodile and Sabie Rivers had not been determined at the start of this study. Thus it was necessary for the purposes of this assessment to establish a benchmark against which water quality could be measured to identify where the issues of water quality concern exist. The **South African Water Quality Guidelines** (DWAF, 1996) was used as the target guideline criteria. These serve as the primary source of information for determining the water quality requirements of different users and for the protection and maintenance of the health of aquatic ecosystems.

The most stringent applicable TWQR amongst the user groups (most stringent user requirement) per identified variable was selected as the target concentration against which the current water quality status was compared. The **South African Water Quality Guidelines** (DWAF, 1996) used for the assessment are listed in **Table 4.1**.

**Table 4.1 DWAF water quality guidelines to assess water quality status**

| Water quality | Most stringent user requirement | Water quality guideline concentration (TWQR) |
|---|---|---|
| Chloride | Industrial: Category 1 | 20 mg/l |
| Ammonia | Aquatic ecosystem | ≤0.007 mg/l N |
| Electrical conductivity (EC) | Industrial: Category 1 | 15 mS/m |
| Nitrate | Domestic: Class 0 | 6 mg/l N |
| pH | Domestic: Class 0 | 6 - 9 pH units |
| Phosphorus (inorganic) | Aquatic ecosystem | <0.005 mg/l N |
| Sodium | Irrigation | ≤70 mg/l |
| Sulphate | Industrial: Category 1 | 30 mg/l |
| Magnesium | Domestic: Class 0 | 30 mg/l |
| Alkalinity | Industrial: Category 1 | 50 mg/l $CaCO^3$/l |

## 4.3 Identification of key monitoring points

### 4.3.1 Komati River catchments

From the information received from the DWAF's Resource Quality Services (RQS) Directorate, 58 monitoring stations were identified along the length of the Komati River. These stations are located from the Upper Komati, starting from Nooitgedacht Dam down to the Lower Komati where the Komati River flows into Mozambique. Data for the monitoring stations in Swaziland was not obtained from DWAF.

The water quality data received was not very comprehensive as monitoring at some of the stations ceased several years ago whilst at other stations monitoring is inconsistent resulting in scattered data, which is not representative of the entire monitoring period. Therefore, of the 58 monitoring stations along the Komati River only ten stations with reliable data that covered sufficiently long periods were selected for this study and are tabulated in **Table 4.2** and depicted in **Figure 4.1**.

**Table 4.2 Komati River monitoring points selected for water quality assessment**

| Monitoring ID | Monitoring point name | Location feature | Number of samples | Duration of monitoring |
|---|---|---|---|---|
| 102931 | X1H001 – at Hooggenoeg | Komati River | 507 | Oct 1977 – Feb 2007 |
| 102933 | X1H003 – at Tonga | Komati River | 1272 | March 1977 – March 2007 |
| 102937 | X1H017 – at Waterval | Komati River | 20 | Dec 1979 – April 2002 |
| 102938 | X1H018 – at Gemsbokhoek | Komati River | 323 | April 1977 – Feb 2007 |
| 102947 | X1H033 – Nooitgedacht Dam d/s weir | Komati River | 96 | March 1983 – July 2004 |
| 102948 | X1H036 – Vygeboom Dam d/s weir | Komati River | 147 | March 1982 – Jan 2007 |
| 102949 | X1H042 – at Komatipoort | Komati River | 343 | Jan 1993 – Feb 2007 |
| 102950 | X1R001 – Nooitgedacht Dam | Dam/Barrage | 233 | March 1968 – Sept 2006 |
| 102951 | X1R003 – Vygeboom Dam | Dam/Barrage | 129 | March 1975 – Dec 2006 |
| 102979 | X2H036 – at Komatipoort | Komati River | 973 | Oct 1982 – Jan 2007 |

### 4.3.2 Crocodile River catchment

DWAF's RQS database has a total of 56 monitoring stations in the Crocodile River catchment. These stations are located from the Kwena Dam to the confluence with the Komati River at Komatipoort. The monitoring stations are located on the Crocodile River and on some major tributaries. The water quality data received was not very comprehensive as monitoring at some of the stations ceased several years ago whilst at other stations monitoring is inconsistent resulting in scattered data, which is not representative of the entire monitoring period. Only 17 stations had reliable, consistent data over a long monitoring period (greater than five years monitoring). **Table 4.3** lists the monitoring stations and include the duration of the monitoring period. The locations of the monitoring stations are depicted in **Figure 4.2**.

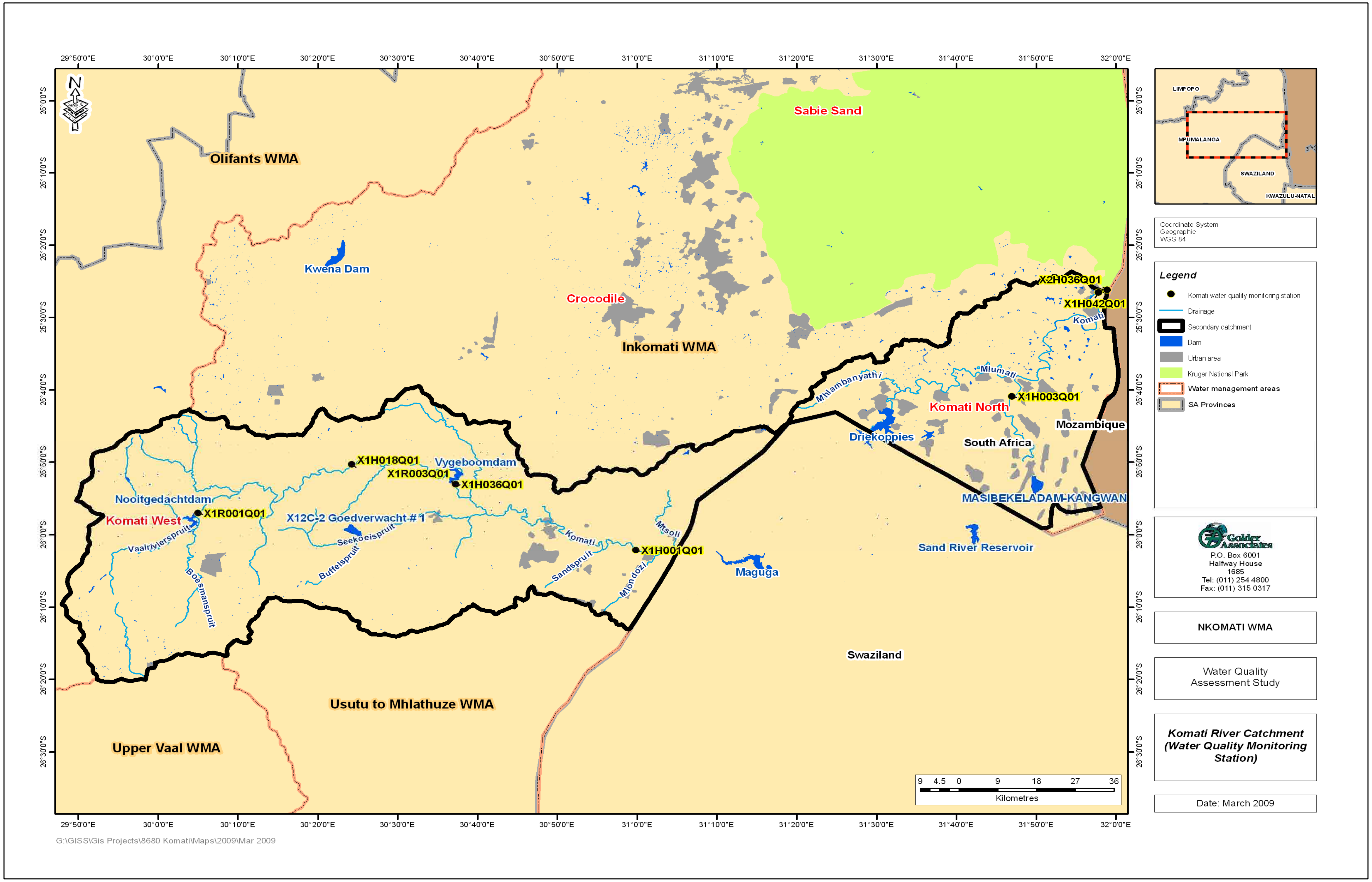


**Figure 4.1 Location of monitoring points along the Komati River used in the assessment**

**Table 4.3 Crocodile catchment monitoring points selected for water quality assessment**

| Monitoring ID | Monitoring point name | Location feature | Number of samples | Duration of monitoring |
|---|---|---|---|---|
| 102953 | X2H006 – at Karino | Crocodile River | 610 | March 1962 – Nov 2006 |
| 102955 | X2H010 – at Bellevue | North Kaap River | 433 | Oct 1963 – Nov 2006 |
| 102956 | X2H011 – at Geluk | Elands River | 630 | March 1972 – Sept 2006 |
| 102958 | X2H013 – at Montrose | Crocodile River | 1246 | April 1966 – Dec 2006 |
| 102960 | X2H014 – at Sudwalaskraal | Houtbosloopspruit | 530 | Aug 1966 – Nov 2006 |
| 102961 | X2H015 – at Lindenau | Elands River | 1267 | March 1972 – Nov 2006 |
| 102963 | X2H016 – at Ten Bosch | Crocodile River | 1856 | Feb 1970 – Dec 2006 |
| 102964 | X2H017 – at Thankerton | Crocodile River | 1184 | Nov 1969 – Dec 2006 |
| 102965 | X2H022 – at Dalton | Kaap River | 994 | June 1962 – Dec 2006 |
| 102974 | X2H031 – at Bornmansdrift | South Kaap River | 490 | Aug 1966 – Nov 2006 |
| 102975 | X2H032 – at Weltevrede | Crocodile River | 1466 | March 1972 – Dec 2006 |
| 102986 | X2H046 – at Riverside | Crocodile River | 927 | Oct 1986 – Dec 2006 |
| 102987 | X2H048 – at Malelane Bridge | Crocodile River | 372 | Oct 1983 – Aug 2006 |
| 102991 | X2H065 – Longemere Dam d/s weir | Wit River | 413 | July 1977 – Nov 2006 |
| 102993 | X2H068 – Witklip Dam d/s weir | Sand River | 112 | July 1977 – Oct 2006 |
| 102994 | X2H070 – Kwena Dam d/s weir | Crocodile River | 224 | Oct 1983 – Sept 2006 |
| 103006 | X2R005 – Kwena Dam | Dam/Barrage | 158 | Oct 1984 – Sept 2006 |

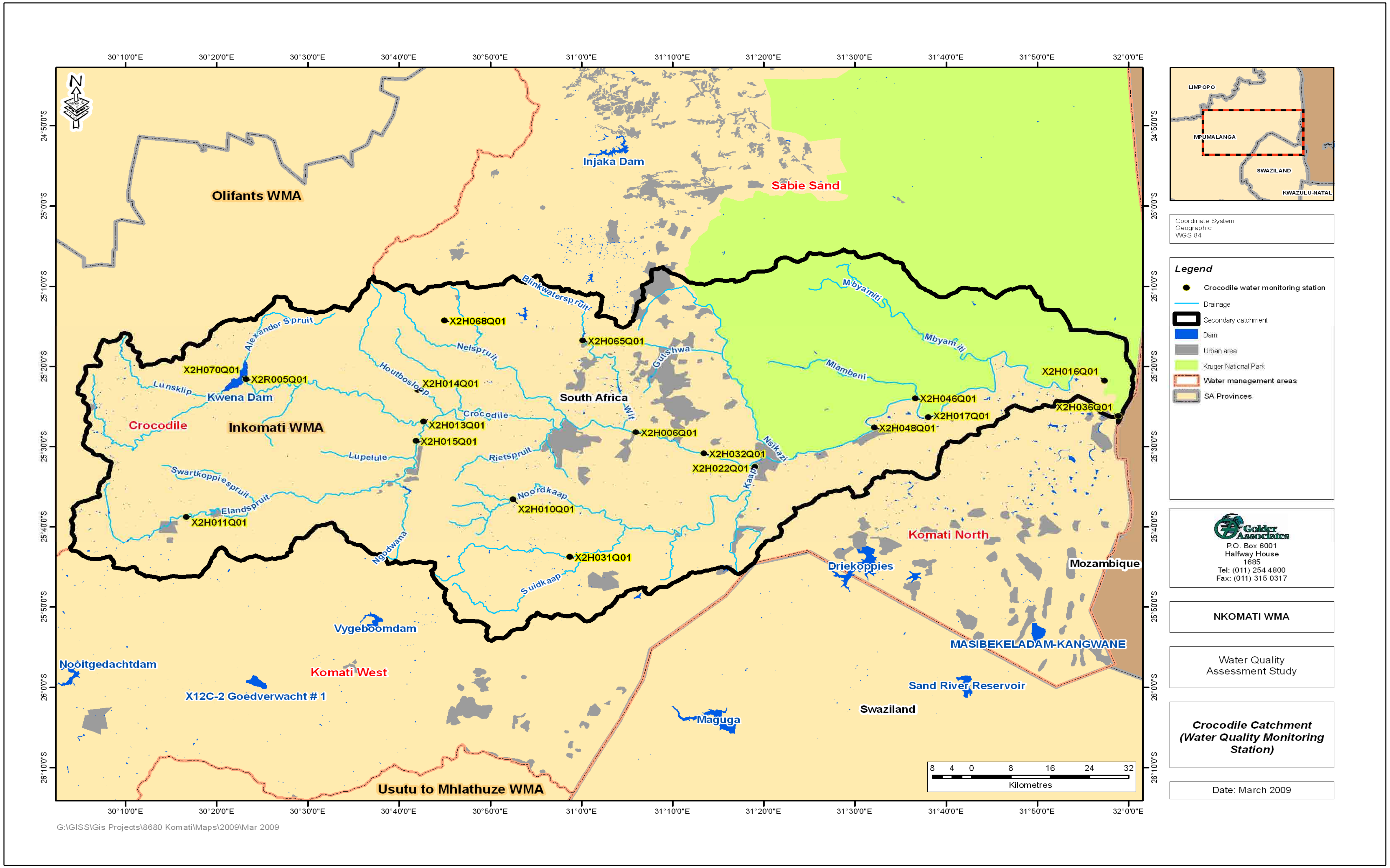


**Figure 4.2** Location of monitoring points used in the assessment on rivers of the Crocodile catchment

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### 4.3.3. Sabie River catchment

The DWAF's RQS database has a total of 105 monitoring stations in the Sabie River catchments. The monitoring stations are located on the Sabie and Sand Rivers and on some major tributaries. However, the majority of these stations were not monitored at all or their monitoring data was inconsistent and outdated as regular monitoring ceased in the late 1990s. Only 11 stations that had reliable, recent and consistent data over a long monitoring period (greater than five years monitoring) were chosen for this study. **Table 4.4** lists these monitoring stations and the duration of the monitoring period. The locations of the monitoring points used for the water quality assessment are shown in **Figure 4.3**.

**Table 4.4 Sabie catchment monitoring points selected for water quality assessment**

| Monitoring ID | Monitoring point name | Location feature | Number of samples | Duration of monitoring |
|---|---|---|---|---|
| 103007 | X3H001 – at Sabie | Sabie River | 517 | April 1966 – Dec 2006 |
| 103008 | X3H002 – at Little Sabie | Sabie River | 533 | April 1966 – Dec 2006 |
| 103009 | X3H003 – at Geelhoutboom | Mac-Mac River | 490 | April 1966 – Dec 2006 |
| 103011 | X3H004 – at De Rust | North Sand River | 825 | Nov 1969 – Dec 2006 |
| 103012 | X3H006 – at Perry's Farm | Sabie River | 898 | Nov 1969 – Dec 2006 |
| 103014 | X3H008 – at Exeter | Sand River | 466 | July 1977 – Dec 2006 |
| 103015 | X3H011 – at Inyaka Dam | Marite River | 966 | April 1979 – Dec 2006 |
| 103016 | X3H012 – at Phabene | Sabie River | 396 | Nov 1983 – Dec 2006 |
| 103019 | X3H015 – at Lower Sabie rest camp in KNP | Sabie River | 1191 | Oct 1983 – Dec 2006 |
| 103020 | X3H019 – right canal from Da Gama Dam | White Waters River | 132 | Feb 1998 – Dec 2006 |
| 103024 | X3R001 – Da Gama Dam | White Waters River | 171 | March 1975 – Dec 2006 |

## 4.4 Summary and conclusions

### 4.4.1 Komati River catchment

The Komati River Catchment is characterised by substantial commercial farming and rural and urban settlements. The commercial farming encompasses the planting of crops, mostly sugar cane and citrus but also forests such as wattle, pine and eucalyptus. The catchment also includes major water transfers from the Vygeboom and Nooitgedacht Dams to the Eskom power stations.

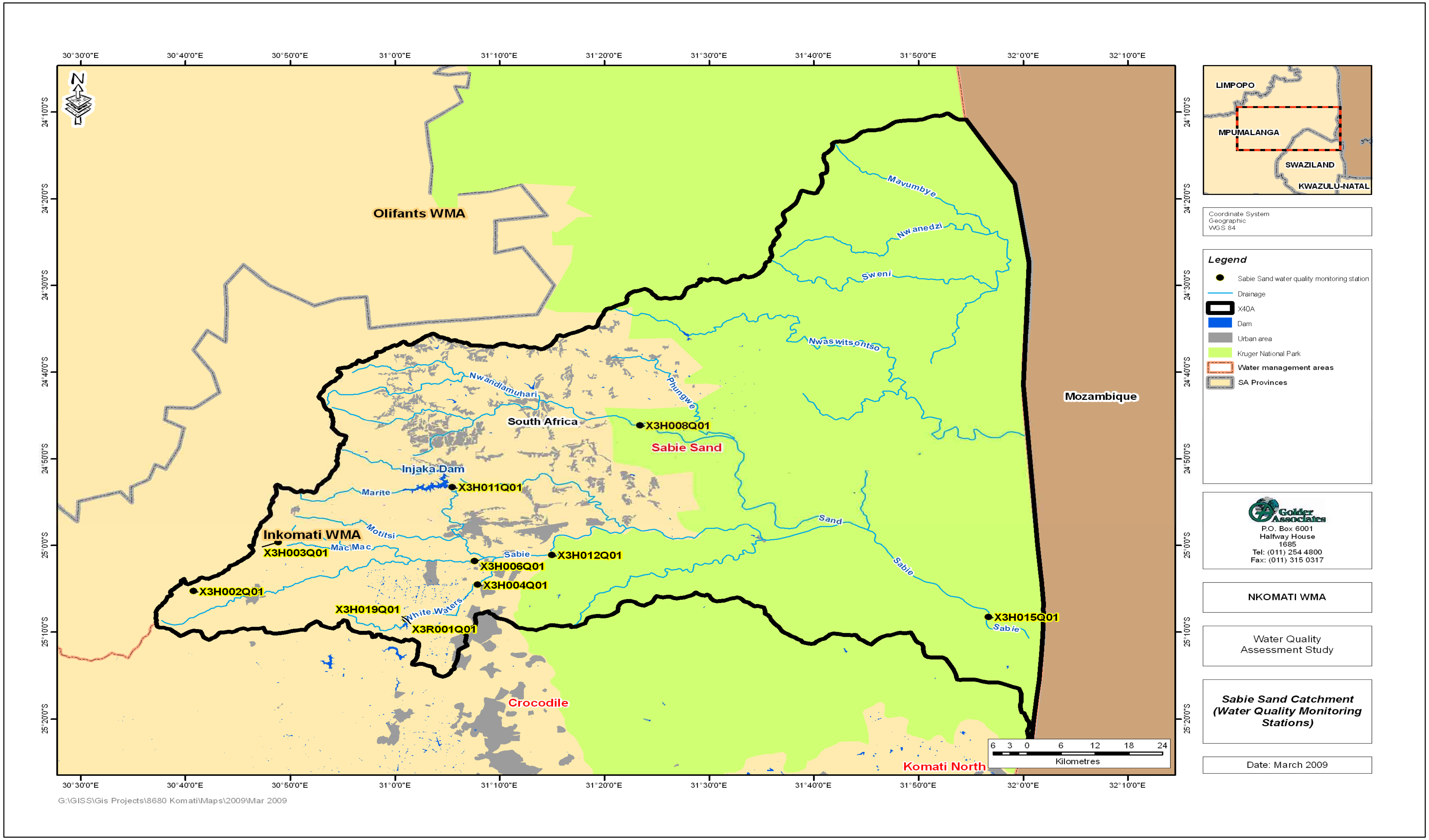


**Figure 4.3** Location of monitoring points used in the assessment on rivers of the Sabie catchment

The major impacts on the water quality in the catchment are associated with diffuse sources including agricultural fertilizers, agricultural insecticides, pesticides and fungicides; sewage run-off and atmospheric deposition; and point sources which include mining effluent, domestic sewage effluent and industrial effluent and organic pollutants (DWAF, 2006).

In the Upper Komati region (Nooitgedacht Dam to Vygeboom Dam) water quality appears to be in a good condition as the land use activity is minimal. The main impacts are related to dry land farming and forestry. The catchment is characterised by few agricultural practices and Carolina and Badplaas being the only major settlement areas close by. Wattle, eucalyptus and pine are the only farming activities in this region. The slight increases in electrical conductivity, pH, alkalinity and sulphate readings in this region could be due to atmospheric deposition and coal mining in the area.

In the river reach between Vygeboom Dam and Swaziland, the water quality appears to be fairly good. There is minimal land use activity and hence the water quality is fairly un-impacted. This region also experiences higher rainfall which is a contributing factor to the good quality observed in the river. The land use is characterised mainly by extensive grazing, limited cultivated land and a few settlements. The surrounding area of the Gladdespruit confluence with the Komati River is characterised by citrus and maize farming activities. The main water quality issues observed are elevated concentrations of the nutrients (phosphate, ammonia, nitrates) and slightly elevated salt concentrations at Hoogenoeg. As the middle Komati is more densely populated with a higher number of urban settlements, the water quality observed could be attributed to sewage effluent discharges and increased organic pollution. A further impact in the catchment is the water quality problem related to the changes in the river discharge due to the transfers from the Vygeboom and Nooitgedacht Dams by Eskom.

The water quality in the lower Komati River appears to be significantly impacted with increased concentrations being observed for most water quality variables at the last three monitoring stations, namely X1H003, X1H042 and X2H036. As the Komati River flows through Swaziland it is bordered by intensive agricultural activity (within very close proximity) and this continues into South Africa. This part of the catchment is characterised by intensive agricultural activity and intensive irrigation. This has resulted in the deterioration of the water quality. The available data shows that the main water quality issues appear to be related to nutrients and salinisation.

### 4.4.2 Crocodile River catchment

The Crocodile River catchment is dominated by agricultural activities (pasture, dry land or irrigated cultivation), irrigation, forestry production, and rural and urban settlements. There are also some mining activities in the Kaap River while the South African Pulp and Paper Industry (SAPPI) Mill in the Elands River is a major source of pollutants. The lower Crocodile region (Crocodile East) is occupied by the Kruger National Park. In recent times there has been an increase in urban development in the Crocodile River catchment which has led to concerns regarding the loss of natural habitats and increased pollution and waste (WRC, 2001).

The construction of weirs and dams in the upper Crocodile catchment to accommodate the increasing trout farming near the towns of Dullstroom and Machadodorp has led to a loss of wetlands and an overall threat to the status of the river. The encroachment of alien vegetation in this region, namely wattle, eucalyptus and poplar trees, also poses a problem to the availability and quality of water. The middle region of the Crocodile River is densely populated as it runs through the major towns of Nelspruit, Kaapmuiden and Malelane. The most important stresses and impacts in this part of the catchment are attributed to domestic and industrial land uses. The area is also characterised by commercial farming such as sugar cane, fruit orchards, vegetables and tobacco cultivation. The lower Crocodile River catchment forms the southern boundary of the Kruger National Park with a number of tourist lodges built on the bank of the river which has a negative affect on the quality of the water (increased nutrients). Citrus and sugar cane farming is also abundant in the area.

In general, the water quality in the upper Crocodile River catchment appears to be in a good to fair condition, with the exception of the Elands River sub-catchment. The area is of concern as it reflects escalated concentrations of salts (and major ions) and nutrients. The increased nutrients can be attributed to the greater number of communities located along this tributary (Machadodorp, Waterval Boven) which inevitably leads to an increased sewage effluent and organic pollution from domestic origin. Another contributing factor is the increasing trout farming activities in the area which is negatively impacting on the quality of water. A major contributing factor to the increasing salt concentrations observed is the effluent discharge from the SAPPI Paper Mill in the catchment.

The middle Crocodile River catchment is characterised by increased urbanisation and industrial activity. The river flows through the major towns of Nelspruit, Kaapmuiden and Malelane Commercial farming activities are also characteristic in these parts of the catchment and water is abstracted from the river for irrigation purposes. The impacts of these land use activities are observed at Karino and Weltevrede, where elevated concentrations of nutrients and salts are observed.

The lower Crocodile River poses the greatest problem in the catchment as a notable increase in the concentrations of most of the variables is observed at these monitoring stations. The lower eastern region of the Crocodile River is expected to be of conservation standards as it forms part of the boundary to the Kruger National Park. However, the quality of water in this region is much poorer in comparison to the Crocodile West region. The contributing factors could be the great number of tourist lodges built along the bank of the river which results in an increase in nutrient concentrations. Irrigation of the citrus and sugar cane farming results in low flows which in turn impacts negatively on the overall water quality.

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### 4.4.3 Sabie catchment

Overall, the water quality in the upper Sabie River region can be described as being in a good condition. The monitoring stations near the two dams revealed that the quality of water in these tributaries is in a good state with the exception of ammonia concentrations. The lower Sabie River region poses the greatest concern as a notable increase in the concentrations of most of the variables is observed at these monitoring stations.

The dominant land uses in the Sabie River catchment are forestry production, agricultural, industrial, irrigation and domestic (South African River Health Programme Report, WRC, 2001). The upper section of the Drakensberg Escarpment is covered with mountain grasslands with extensive forests in gorges and slopes and the lower escarpment is considered a bushveld area. The increasing alien vegetation is a risk to the availability of water in these areas. Trout farming is also becoming a popular activity in these areas. A number of small towns such as Sabie and Graskop are located in this region of the catchment. The area is also characterised by commercial farming such as banana plantations and madumbi (similar to sweet potato) and the minimal industrial activities are located along the Klein Sabie River area.

The lower Sabie and Sand River catchments are dominated by a large number of rural settlements. The activities of the local communities include subsistence and small scale farming of livestock and fruit. However, much of the lower catchment area falls within the Kruger National Park where conservation and eco-tourism are the most prominent activities.

The higher escarpment area of the upper Sabie River catchment is in a good state with increasing degradation observed further downstream. This can be attributed to the invasion of alien vegetation and the forestry activities in the area. Trout (especially in the Mac-Mac River) has also become a threat to the health of the river as it competes with indigenous fish species and hence affects the concentration of nutrients in the river. Furthermore, the diversion of water into dams and weirs for trout farming activities leads to a decrease in water flows. The sewage output from the various small towns such as Sabie and Graskop also lowers the quality of water in that region. In addition, sawdust from a local sawmill has a negative impact on the water quality. Organic contaminants are leached into the river during rainfall events which leads to an increase in the pH of the water (River Health Programme Report, WRC, 2001). Irrigation of the banana plantations and small fruit orchards in the area may also impact negatively on the water flows and quality.

The lower Sabie and Sand River catchments are predominantly within the Kruger National Park and hence strict conservation measures are implemented in this region. However, the unprotected upstream areas are vulnerable to increasing urbanisation and other land uses. The Sand River is densely populated with several rural communities. This results in an increased waste output and organic pollution in the rivers. Another threat to the quality of water in this region is overgrazing by livestock which causes extensive erosion of the river banks and in-stream sedimentation problems (River Health Programme Report, WRC, 2001).

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# 5. WATER REQUIREMENTS AND USE

## 5.1 Introduction

This section documents all the current water requirements within the Inkomati WMA. Current within the context of this report is the year 2004. Future water requirements were not addressed specifically as part of this study. For more details on water use and the background as to how the information on water requirements was obtained refer to the **Water Requirements report** (PWMA 05/X22/00/0908).

## 5.2 Domestic water requirements

Domestic water use within the Inkomati WMA is limited compared to other more developed catchments in South Africa. This is due to the limited urban development. **Table 5.1** lists the best estimate of domestic water requirements in the major catchments of the Inkomati WMA and the significant towns and rural settlements in those catchments.

**Table 5.1 2004 Domestic water requirements**

| Catchment | Water requirement (million $m^3/a$) | City, town or settlement |
|---|---|---|
| **Komati River catchment** | | |
| Upper Komati (X11; X12) | 4.8 | Carolina, Badplaas, Elukwatini, Ekulendini |
| Swaziland (X13) | 3.8 | Piggs Peaks, small towns and villages |
| Lomati (X14) | 4.9 | Driekoppies, Nyathi, Langeloop |
| Lower Komati (X13) | 7.8 | Tonga, Masibekela, Magudu, Komatipoort |
| **Sub-Total** | **21.3** | |
| **Crocodile River catchment** | | |
| Upper Crocodile (X21) | 1.7 | Machadorp, Waterval Boven, Dullstroom |
| Middle Crocodile (X22) | 13.5 | Nelspruit, White River |
| Kaap River (X23) | 3.9 | Barbeton |
| Lower Crocodile (X24) | 39.8 | Nsikasi (North and South), Matsulu, Malalane, Hectorspruit, Marloth Park, Kaapmuiden |
| **Sub-total** | **58.9** | |
| **Sabie River catchment** | | |
| Sabie (X31) | 8.9 | Sabie, Graskop, Hazyview, Hoxani |
| Sand (X32) | 11.3 | Bushbuckridge, numerous villages in the Sand catchment |
| **Sub-total** | **20.2** | |
| **Total** | **100.5** | |

## 5.3 Industrial and mining water requirements

There are a number of large industrial water users in the Inkomati WMA while water use by the mining sector is insignificant. The industrial users are all located in the Komati and Crocodile catchments. There are no significant mining or industrial water users in the Sabie catchments, in the Swaziland portion of the Komati River catchments or in the Lomati (X14) catchments. There are several saw mills in the upper Sabie River that negatively impact on water quality. The current day (2004) industrial and mining use is summarized in **Table 5.2**.

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**Table 5.2 2004 Industrial and mining water requirements**

| Catchment | Water requirement (million $m^3$/a) | Industry / mine |
|---|---|---|
| Komati | 0.5<br>0.1 | Sugar mill in the lower Komati<br>Mining in the upper Komati |
| Crocodile | 13.4<br>9.0 | SAPPI in the Elands catchment<br>Sugar mill in the lower Crocodile |
| Sabie | 0.0 | |
| **TOTAL** | **23.0** | |

## 5.4 Irrigation water requirements

By far the largest water user in the Inkomati WMA is the irrigation sector. It is important therefore to obtain good estimates of the water allocations to this sector as well as the actual water use. The difference between the allocation and actual use is important to understand and quantify as it has large implications, from the calibration of hydrological models through to the allocation of the limited water resources within the Inkomati WMA. Within the context of this report, irrigation water requirements are based on a theoretical calculation of how much water is required, based on crop areas, crop types, the efficiency of irrigation systems and climatic conditions. The irrigation model used to estimate the crop water requirements is the Water Quality Model (WQT) model, details of which can be found in the WRYM User Manual (DWAF, 2008). For a number of reasons, the actual water use does not always correspond to the theoretical water requirements or the allocated amount. Some of the reasons applicable in the Inkomati WMA are as follows:

- There is insufficient water available to supply all irrigators with their theoretical requirement.
- The theoretical water requirement assumes a so-called optimum crop water requirement which requires a high level of management to monitor. If water is cheap, as it is in much of the WMA, irrigators could over-irrigate if the water is available.
- In cases where water usage is controlled by an irrigation board, irrigators are more likely to be irrigating according to their quota or allocation and not according to a theoretical requirement.

For the purposes of this study, two estimates of irrigation demand have been made. These are as follows:

- A theoretical calculation using the WQT model (DWAF, 2008) and irrigated areas (and crop types) obtained from the validation study (DWAF, 2006).
- Allocated water use based on various sources of information. Where a discrepancy between estimates was found, the higher of the two estimates was used.

The various sources of allocated water use include:

- Scheduled water use of irrigation boards; since most of the irrigation within the WMA falls within irrigation boards, this accounts for most of the irrigation within the WMA.
- Irrigation allocated in terms of the Komati Basin Treaty (JWC, 1984).
- Irrigation allocated in terms of the Interim Inkomati Water Use Agreement (TPTC,

–

2004).

Current day (2004) irrigation water requirements and allocations are given in **Tables 5.3** and **5.4** respectively.

**Table 5.3 Crop areas and est. water requirements (WQT model) in the Inkomati WMA**

| Catchment | Irrigated area (km$^2$) | Dominant crops type | Crop water requirements (million m$^3$/annum) |
|---|---|---|---|
| **Komati River catchment** | | | |
| X11 | 29 | Maize | 14 |
| X12 | 8 | Maize | 4 |
| X13 | 359 | Sugarcane | 444 |
| X14 | 116 | Sugarcane | 126 |
| **Sub-total** | **512** | | **588** |
| **Crocodile River catchment** | | | |
| X21 | 39 | Citrus | 21 |
| X22 | 211 | Cash crops | 149 |
| X23 | 98 | Sugarcane | 92 |
| X24 | 163 | Sugarcane | 192 |
| **Sub-total** | **511** | | **454** |
| **Sabie River catchment** | | | |
| X31 | 103 | Citrus | 82 |
| X32 | 25 | Vegetables | 17 |
| **Sub-total** | **128** | | **99** |
| **TOTAL** | **1151** | | **1141** |

**Table 5.4 Allocations to irrigators in the Inkomati WMA**

| Catchment | Irrigation allocation (million m$^3$/annum) | Comment |
|---|---|---|
| Komati | 641 | Interim Inkomati Water Use Agreement (IIMA). Essentially the same as other allocations. |
| Crocodile | 482<br>(307) | South Africa's allocation in terms of scheduled area and application rates plus existing lawful use.<br>IIMA allocation is 307 million m$^3$/a. |
| Sabie | 98 | IIMA |
| **TOTAL** | **1221** | |

## 5.5 Streamflow reduction due to Afforestation

Forestry in the escarpment areas of the Inkomati WMA provides an important economic input to the WMA. The area of forestry appears to have increased significantly in some areas in recent years. Very few new licences for afforestation have been issued for many years by DWAF and hence it is uncertain whether the increased area is due to unlawful development or simply improved techniques in measuring the afforested areas. **Table 5.5** summarises the current day (2004) afforestation in the major catchments as well as the estimated streamflow reduction.

**Table 5.5 Afforested area and estimated streamflow reduction in the Inkomati WMA**

| Catchment | Afforestation area ($km^2$) | Streamflow reduction (million $m^3$/annum) |
|---|---|---|
| X11 | 256 | 31 |
| X12 | 461 | 39 |
| X13 | 189 | 18 |
| X14 | 297 | 29 |
| **Komati sub-total** | **1203** | **117** |
| X21 | 587 | 51 |
| X22 | 900 | 66 |
| X23 | 443 | 40 |
| X24 | 11 | 0 |
| **Crocodile sub-total** | **1941** | **157** |
| X31 | 797 | 86 |
| X32 | 56 | 4 |
| **Sabie sub-total** | **853** | **90** |
| **TOTAL** | **3997** | **364** |

## 5.6 Transfers out of catchments

When dealing with the transfer of water from one catchment to another it is important to distinguish between the types of transfer. In this study transfers have been divided into transfers ‘out’ of the Inkomati WMA to adjacent WMAs, transfers into the WMA from adjacent WMAs, transfers out of the tertiary catchments but within the WMA and transfers between quinary catchments within each of the Komati, Crocodile and Sabie catchments. From a water requirement point view, only transfers out of the WMA constitute an additional requirement that has not already been assigned to one of the user sectors described above. These additional requirements only occur in the Komati River catchment and are described in **Table 5.6**.

**Table 5.6 Transfers out of the Inkomati WMA**

| Transfer scheme | Location | 2004 transfer (million $m^3$/a) | Description |
|---|---|---|---|
| Nooitgedacht/Vygeboom System to Olifants WMA (1962 – 2004) | Upper Komati | 101 | Nooitgedacht/Vygeboom Dams to Eskom p/s. |
| Komati River to Mbuluzi (1980 – 2004) | Swaziland downstream of Maguga Dam | 122 | From Komati River at CDC weir for irrigation in the Mbuluzi [W60]. |
| **TOTAL** | | **223** | |

## 5.7 Cross border flows

The Pigg’s Peak Agreement (JWC, 1992), signed in 1991, was an interim trilateral agreement stipulating that a minimum flow of 2 $m^3$/s (averaged over a three day period) should be recorded at Ressano Garcia. The more recent Interim IncoMaputo Water Use Agreement (TPTC 2002), states that a minimum flow of 2.6 $m^3$/s is required at Ressano Garcia for environmental purposes. This is assumed to be split 55% and 45% between the Komati and Crocodile Rivers respectively (KOBWA, 2005). In addition to this, the IIMA also lists the existing water use by the three basin states. In the case of Mozambique, it lists requirements of 29 million $m^3$/a and 1 million $m^3$/a respectively for irrigation and domestic use in the Incomati River upstream of the confluence of the Sabie River. These users have no other source of water other than the cross border flows from South Africa at Ressano Garcia and hence there is a realistic expectation that in addition to the stated minimum ecological flow requirements that these users must be supplied from South Africa. Assuming the 55% / 45% split between the Crocodile and Komati catchments, the minimum flows required from each sub-basin are:

Komati: 62 million $m^3$/a or 1.95 $m^3$/s

Crocodile: 50 million $m^3$/a or 1.6 $m^3$/s

It must be stressed that the IIMA is an interim agreement which is open to interpretation. Hence the cross border flows used in this study should be seen as a realistic estimate of the international requirements and not a binding commitment by South Africa at this stage.

## 5.8 Conclusions

**Tables 5.7** and **5.8** summarise the water requirements, transfers out of the catchment and stream flow reduction for the two water resource yield scenarios considered in this study, namely, the best estimate of current day (2004) water requirements and the allocated water requirements within each study area.

**Table 5.7 Summary of water requirements for best estimate scenario**

| User group | Komati (including Swaziland) | Crocodile | Sabie |
|---|---|---|---|
| **Cross border flows** | 35 | 28 | 0 |
| **Transfers out** | 223(1) | 0 | 0 |
| **Industrial** | 1 | 22 | 0 |
| **Domestic** | 21 | 59 | 20 |
| **Irrigation(1)** | 492 | 514 | 100 |
| **Total** | **772** | **623** | **120** |
| **Afforestation (SFRA)** | 117 | 157 | 90 |

Notes: (1) Transfers for Eskom (101) and for irrigation (122) in the Mbuluzi catchment

(2) Cross border flows based on the Piggs Peak agreement

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**Table 5.8 Summary of water requirements in the Inkomati WMA for water allocation scenario**

| User group | Komati (including Swaziland) | Crocodile | Sabie |
|---|---|---|---|
| **International** | 62 | 50 | 0 |
| **Transfer out** | 132(1) | 0 | 0 |
| **Industrial** | 2 | 27 | 0 |
| **Domestic** | 50 | 58 | 27 |
| **Irrigation** | 641(2) | 482 | 98 |
| **Total** | **887** | **617** | **125** |
| **Afforestation (SFRA)** | 117 | 157 | 90 |

Notes: (1) Allocation to Eskom is not achievable with current infrastructure.

(3) Includes transfer of 122 million $m^3$ to irrigators in the Mbuluzi catchment.

(3) Cross border flows based on the IIMA agreement

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# 6. ECOLOGICAL FLOW REQUIREMENTS

The Inkomati WMA is considered to be stressed, meaning that water requirements are in excess of the available water resources, particularly when the water requirements of Mozambique and the ecological Reserve are taken into account. As a result, the ecological Reserve is not met and the cross-border flows into Mozambique have on occasion been less than those specified in the various international agreements. The assurance of water supply to the irrigation sector is also very low in some areas, such as the lower reaches of the Crocodile Rivers.

Water resource planning does however require recognition of the ecological Reserve and estimates of Ecological Water Requirements (EWRs) are required. A comprehensive Reserve determination has been completed in the Komati catchment while similar studies are in progress in the Crocodile and Sabie River catchments. The preliminary results from the Crocodile and Sabie catchments have been used to develop EWRs for these catchments, while in the Komati catchment the Reserves have been extrapolated to each node in the system. A node in this case represents a sub-catchment that is typically a sub-division of the quaternary catchments as defined by the WR90 study (WRC, 1994). The extrapolation process has been developed recently and the Komati catchment is the first in which it has been applied. The methodology used for this extrapolation is summarised in the **Ecological Flow Requirements report** (PWMA 05/X22/00/1008) submitted as part of this study. For more detail about the methodology refer to the draft report prepared for the WRC by Kleynhans et al, (WRC, 2008).

The Reserves used in the WRYM model set ups for the Inkomati Water Availability Assessment study are summarised for each area in **Table 6.1**.

The extrapolated Reserves for the Komati sub-catchments and the interim reserves for the Crocodile and Sabie catchments are provided in **Appendix G** of the **Yield Model Report** (PWMA 05/X22/00/1708). Similar extrapolations still need to be carried out as for the Crocodile and Sabie catchments.

## Table 6.1 Inkomati WMA reserve sites

| Sites | Ecological Status | Natural MAR million $m^3/a$ | EWR (PES) million $m^3/a$ | % MAR |
|---|---|---|---|---|
| **Komati River reserves (Approved, comprehensive)** | | | | |
| K1-Gevonden | B/C | 180.0 | 35.9 | 19.9 |
| K2-Kromdraai | C | 525.0 | 86.8 | 16.5 |
| M1-Silingani *** | C | 857.0 | 222.6 | 26.0 |
| K3-Tonga* | D | 1007.0 | 146.2 | 14.5 |
| G1-Vaalkop | C/D | 37.7 | 25.5 | 67.6 |
| T1-Teespruit | C | 60.6 | 36.6 | 60.4 |
| L1-Kleindoringkop | C/D | 322.0 | 30.5 | 9.5 |
| **Crocodile reserves (Interim, in progress)** | | | | |
| C EWR 1 | A/B | 9.9 | 4.2 | 42.4 |
| C EWR 2 | B | 55.8 | 27.0 | 48.4 |
| C EWR 3 | B/C | 169.9 | 91.4 | 53.8 |
| C EWR 4 | C | 754.1 | 263.4 | 34.9 |
| C EWR 5 | C | 1006.2 | 267.7 | 26.6 |
| C EWR 6 | C | 1063.1 | 249.9 | 23.5 |
| C EWR 7 | C | 169.0 | 34.5 | 20.4 |
| **Sabie reserves (Interim, in progress)** | | | | |
| S EWR 1 | B/C | 140.0 | 54.0 | 38.6 |
| S EWR 2 | C | 262.0 | 63.3 | 24.2 |
| S EWR 3 | A/B | 496.0 | 187.0 | 37.7 |
| S EWR 4 | B | 65.8 | 29.6 | 45.0 |
| S EWR 5 | B/C | 157.1 | 43.2 | 27.5 |
| S EWR 6 | C | 45.0 | 13.7 | 30.4 |
| S EWR 7 | C | 28.9 | 9.7 | 33.6 |
| S EWR 8 | B | 133.6 | 39.3 | 29.4 |

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# 7. YIELD MODEL SETUP

## 7.1 Introduction

The ultimate purpose of setting up a water resource model for the Inkomati WMA is to provide water availability input, in the form of a model, as one of the many interdependent activities into a process that will formalise Integrated Water Resources Management (IWRM) and ultimately develop an allocation schedule for the WMA. The determination of water availability rests on two closely associated modelling processes. The first is the hydrological modelling process that determines the natural runoff from the catchments. The hydrology of the Komati, Crocodile and Sabie catchments have been reported on in three separate reports.

The second modelling process is the yield model which simulates water use within sub-catchments comprising the Inkomati CMA given the natural runoff and storage characteristics of dams in the catchment. These simulations have been used to reconcile water use with water availability. The yield model that has been set up as part of this study is the Water Resources Yield Model known as the WRYM (DWAF, 2008).

### 7.1.1 Overview of the Water Resources Yield Model

The yield analysis of the Inkomati River system was undertaken using the WRYM. The WRYM was developed by DWAF for the purpose of modelling complex water resource systems and is used together with other simulation models, pre-processors and utilities for the purpose of planning and operating the country's water resources.

The WRYM uses a sophisticated network solver in order to analyse complex multi-reservoir water resource systems for a variety of operating policies and is designed for the purpose of assessing a system's long- and short-term resource capability (or yield). Analyses are undertaken based on a monthly time-step and for constant development levels, i.e. the system configuration and modelled demands remain unchanged over the simulation period. The major strength of the model lies in the fact that it enables the user to configure most water resource system networks using basic building blocks, which means that the configuration of a system network and the relationships between its elements are defined by means of input data, rather than by fixed algorithms embedded in the complex source code of the model.

DWAF has developed a software system for the structured storage and utilisation of hydrological and water resource system network model information. The system, referred to as the WRYM Information Management System (IMS), serves as a user-friendly interface with the Fortran-based WRYM and substantially improves the performance and ease of use of the model. The IMS incorporates the WRYM data storage structure in a database and provides users with an interface which allows for system configuration and run result interpretation within a Microsoft Windows environment.

During the course of this Study, DWAF made available WRYM Release 7.4 and 7.5 which

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incorporated a number of new sub-models designed to support the explicit modelling of water resource system components required in water availability assessment studies. Detailed information in this regard may be obtained from the **Water Resources Yield Model (WRYM) User Guide** (DWAF, 2008).

### 7.1.2 Development of a representative system network model

Developing a representative network model for a water resource system involves a process whereby the modeller creates a synthetic representation of reality in the form of a schematic diagram. This is achieved by indicating the connectivity between and nature of the various components that make up the system in question. This process of synthesis, however, always implies a trade-off between the need to simulate the behaviour of individual system components at a sufficient level of detail, on the one hand, and practical modelling limitations on the other.

The process of developing a representative system network model therefore includes three main aspects:

(a) Identification of physical system features,

(b) Assessing the appropriate spatial resolution and

(c) Lumping and aggregation of system components until the appropriate spatial resolution is achieved.

### 7.1.3 Water Resource Yield Model system configuration testing

Great care was taken to ensure that the network configuration definition input into the WRYM was correct and accurately represented the intended configuration. There were four main processes which included:

- Extensive checking to verify that the sub-catchment hydrology data was applied correctly in the WRYM system. This involved comparing simulated node inflows with the net runoffs contained in the associated sub-catchment hydrology data sets.
- Simulated model results were checked against the known physical characteristics of system components, such as the full supply, dead storage and bottom levels of reservoirs.
- The system network connectivity was checked by undertaking mass balances at each node in the system to ensure that the defined linkages in the system definition are correct.
- Simulated model results were checked to ensure that the behaviour of the system does reflect the intended operating rules, including the following situations:
    - When reservoirs / dummy dams are full;
    - When reservoirs / dummy dams are empty;
    - During drawdown events;
    - When supply priorities control the flow of water.

Furthermore, an additional test was undertaken intended to compare the simulated behaviour of major dams with the historically monitored behaviour. The dam balances of dams were provided by the DWAF, Directorate: Hydrological Services. The tests were undertaken on the results of yield analysis and are discussed together with the results of that scenario.

In this regard it should be noted that, in general, a test such as the one described above is difficult to undertake since the water requirements imposed on a dam, as well as the catchment developments and land use upstream of the dam, generally vary significantly over the dam's lifetime while WRYM assumes constant demands over the simulation period.

## 7.2 Model description

### 7.2.1 General

The WRYM was configured for the Inkomati River systems using Version 3.5 of the WRYM-IMS, incorporating Version 7.5.6.4 of the WRYM. The configuration was based on the representative system network model of the Inkomati River systems and covers the whole of the Incomati River Basin, including Incomati River in Mozambique. Exhaustive tests were undertaken to ensure that the network configuration definition input into the WRYM was correct and accurately represented the intended configuration

System schematic diagrams of the WRYM configuration of the Incomati River systems are provided at the end of this report. It should be noted that these diagrams are representative of the current day scenario or Scenario 1 and that the network definition of the other scenarios are essentially the same and differ only with regard to the inclusion or exclusion of a particular system element or land use development.

The following sections provide more detail on the configuration of the WRYM for the Inkomati River system, particularly with regard to the selected basic run control settings, modelled sub-catchment areas, incremental runoffs, irrigation areas, operating rule definition, as well as the determination of the system yield.

### 7.2.2 Run control settings

The Run control settings in the WRYM are used to define general information on how the system will be analysed for a particular model run. For the yield analysis of the Incomati River systems, this includes the following:

- An analysis period of 85 years from the 1920 to the 2004 hydrological year (i.e. October 1920 to September 2005) was used. This corresponds with the selected Study period as well as with the updated and extended hydro-meteorological data sets developed during the hydrological analysis of the Study (described in the catchment hydrology and rainfall reports).
- The long-term stochastic yield analyses were undertaken using the PARAM.DAT-file developed as part of the stochastic streamflow analysis and based on 201 85-year stochastically generated streamflow sequences.

### 7.2.3 Sub-catchment areas and incremental runoffs

Information on the modelling of sub-catchment areas and incremental runoffs within the context of the WRYM representative network models are provided for each area in **Tables I1, I2** and **I3** in **Appendix I** in the **Yield Model Report** (PWMA 05/X22/00/1708) and are based on the updated and extended hydro-meteorological data sets developed during the hydrological analysis of the study areas (as described in the Hydrology reports). The information includes a description of the network element, node number and catchment area associated with the sub-catchment in question, as well as the reference number (i.e. the incremental (or "I") sub catchment number), in sequence as listed in the PARAM.DAT file and routing percentage of the associated hydrological data file set.

It should be noted that such a data file set is defined for each sub-catchment in the system and includes four time-series data files that cover the study period of 85 years from 1920 to 2004. These are:

- The *.INC-file, which contains monthly historical natural incremental runoff volumes (in units of million $m^3$);
- The *.IRR-file, which contains monthly reductions in runoff due to Alien invasive plants (AIPs) (in units of million $m^3$);
- The *.AFF-file, which contains monthly reductions in runoff due to commercial forestry and in-catchment alien vegetation (in units of million $m^3$);
- The *.RAN-file, which contains monthly historical rainfall (in units of mm).

### 7.2.4 Irrigation areas

As discussed in **section 5.4**, irrigation water requirements in the Inkomati WMA were modelled in two ways in the WRYM. The WQT irrigation model (SSI, 2006) was used throughout the study area to get an indication of the irrigation requirements. For 'controlled' irrigation areas within irrigation boards, the irrigation allocation, determined from the scheduled area and application rate, was used to estimate irrigation water requirements.

### 7.2.5 Flow diversions

For more information about flow diversions refer to **Section 5** and **Appendix H** of the **Yield Model Report** (PWMA 05/X22/00/1708) and to the WRYM User Guide (DWAF, 2008). While configuring the WRYM to include all the flow diversions, a limitation of the WRYM was identified that causes the model to go into an endless loop, due to the iterative nature of the flow diversion routine. Fixing the model was not possible within the allocated timeframes and it was decided that only the major flow diversions would be implemented in the Komati catchment, i.e. the Popenyane and Gladdespruit diversions. The impact of other flow diversions has been assessed as limited in the other catchments. Once the limitations are resolved the flow diversion efficiency analysis results can be incorporated into the model.

### 7.2.6 Penalty structures

The concept behind assigning penalties to users is to provide a mathematical representation of the priority of water allocation within a system with the aim of either modeling a catchment as it is operated in practice or to model scenarios of how the catchment operators or policy makers would like to see to catchment operated. The WRYM network solver is based on linear programming which minimizes the 'cost' at every time step. Cost in this context is defined by the sum of penalties incurred within the system that is calculated from the flow volume in each channel multiplied by the penalty. Similarly a value is placed on water in storage. Since a penalty is a cost, in order to assign a high priority to a user a large penalty is imposed on not supplying the user with his requirement and conversely low priority users are assigned a low penalty for non-supply. The minimum cost is obviously to supply all users with all their requirements all the time but this is not always possible and hence when there is insufficient water available to meet all demands, high priority users (assigned a high penalty of non-supply) receive their water in preference to low priority users (assigned a low penalty of non-supply).

**Table 7.1** summarises the generic channel penalty structures and reservoir penalty structures adopted for the Inkomati systems. Additional penalties were required in some cases to achieve the specific operation of sub-systems, such as the transfers to strategic users in the Olifants WMA from the upper Komati system.

**Table 7.1 Generic penalty structures**

| Description | Arc 1 | Arc 2 |
|---|---|---|
| **Channels** | | |
| General river reach | 0 | |
| Spill from farm dams | 1500 | |
| Irrigation | 0 | 200 |
| Urban | 0 | 300 |
| Industrial | 0 | 400 |
| Eskom | 0 | 500 |
| International | 0 | 600 |
| Ecological | 0 | 1000 |
| Return flows | 0 | 5000 |
| **Reservoirs** | | |
| **Spill zone** | **Storage zone** | **Dead storage** |
| 10000 | 10 | 10000 |

Note that within the WRYM the value associated with water in the spill zone is in fact a negative penalty, the idea being to set this sufficiently high that dams spill when their full supply level is exceeded. The storage zone and dead storage penalties on the other hand are positive. If the value of water in the storage zone is less than the penalty associated with non-supply then water is released from the storage zone to a user. The value associated with water in the dead storage zone must be set very high so that water is never supplied from this zone

## 7.3 Assumptions and limitations

Two types of water resource yield analyses were undertaken in this study. The historic yield analysis, where the maximum annual abstraction from each dam or system is determined assuming upstream abstractions as defined by the two water use scenarios, namely the best estimate of current day (2004) water use and the allocated water use. The second analysis was a stochastic analysis in which 201 possible hydrology sequences are used in the simulation scenarios rather than the single historical hydrology sequence. The purpose of the stochastic

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analysis is to obtain an indication of the assurance of supply of the historic yield.

The four key factors determining the yield of a dam are as follows:

- The natural hydrology of the dam's catchment.
- The water use upstream of the dam that will reduce the inflow into the dam and hence reduce the yield.
- The storage available in the dam.
- Pre-defined compensation releases from the dam which are not assumed to be part of the yield available from the dam.

The limitations in the accuracy of a yield analysis relate to the accuracy with which the information on the four key factors can be ascertained. Hydrology is not an exact science and this is probably the factor that has the most influence on the accuracy of a yield analysis. Inaccuracies in the estimates of upstream water use are also a major limitation on the accuracy of a yield analysis.

## 7.4 Model verification

### 7.4.1 Introduction

It is essential that any model be verified against observed data in order to check that it offers a reasonable mathematical representation of the real world. In the case of a yield model, it is generally set up to model the system as the catchment manager would like to see it operated and seldom as it is actually being operated. Hence the verification of such models requires some extra effort.

There are two approaches that can be taken to verify a yield model. Either the current day water demands can be replaced with historical water demands and the resulting flows in the system compared with the observed flows, or the yield can be checked against the hydrology model. While a comparison of models would not generally be accepted as adequate verification, it should be borne in mind that the hydrology model has been calibrated (and hence verified) against observed data and hence if a sufficiently similar 'current day' simulation can be obtained from both the yield and hydrology models this should provide adequate verification of the yield model. The Water Resource Simulation Model (WRSM 2000) hydrology model is structured in such as way to make 'current day' analysis relatively simple while it would be an extremely time consuming task to generate historical water use time series for the yield model. Hence verification has been carried out by comparing the current day simulations of the hydrology and yield models as far as possible.

### 7.4.2 Komati catchment

The Komati catchment yield model was verified at the following locations:

- Flows into Nooitgedacht Dam from the headwater catchments of the upper Komati.

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- Flows into Vyeboom Dam in the upper Komati.
- Flow at the Hoogenoeg weir upstream of Swaziland.
- Flows into Maguga Dam in the Komati in Swaziland.
- Flows into Driekoppies Dam in the Lomati catchment.

The verification was undertaken by comparing the modeled flows at the locations in question as obtained from the WRYM with that of the WRSM 2000 used in the earlier hydrological analysis. The results are provided in **Table 7.2** and show acceptable differences considering that the differences in operational modeling applied in the two models.

**Table 7.2 Verification results at keys points in the Komati catchment**

| Sub-catchment | Natural MAR (million m3) | | Difference | Plot reference In Appendix I |
|---|---|---|---|---|
| | WRSM2000 | WRYM | % | |
| Inflows to Nooitgedacht Dam | 70.36 | 70.48 | 0.2 | I.1 and I.2 |
| Inflows to Vygeboom Dam | 213.48 | 214.77 | 0.6 | I.3 and I.4 |
| Flows at Hoogenoeg | 367.09 | 364.58 | -0.7 | I.5 and I.6 |
| Inflows to Maguga Dam | 552.17 | 549.72 | -0.4 | I.7 and I.8 |
| Inflows to Driekoppies Dam | 206.52 | 207.03 | 0.2 | I.9 and I.10 |

### 7.4.3 Crocodile catchment

The Crocodile catchment yield model was verified at the following locations:

- Flows into Kwena Dam in the upper Crocodile.
- Flows from the upper Crocodile (X21) catchment.
- Flows from the middle Crocodile (X22) catchment.
- Flows from the Kaap (X23) catchment.
- Outflows from the lower Crocodile (X24) to the Komati River.

The verification was undertaken by comparing the modeled flows at the locations in question as obtained from the WRYM with that of the WRSM 2000 used in the hydrological analysis. The results are provided in **Table 7.3** and show acceptable differences considering that the differences in modeling approaches in the two models.

**Table 7.3 Verification results at keys points in the Crocodile catchment**

| Sub-catchment | Natural MAR (million m3) | | Difference |
|---|---|---|---|
| | WRSM2000 | WRYM | % |
| Inflows to Kwena Dam | 108.2 | 108.4 | 0.2 |
| Flows from upper Crocodile catchment | 373.1 | 377.6 | 1.2 |
| Flows from middle Crocodile catchment | 524.8 | 521.7 | -0.6 |
| Flows from Kaap catchment | 112.3 | 100.9 | 10.2 |
| Outflows from the Crocodile catchment | 590.3 | 542.4 | -8.1 |

### 7.4.4 Sabie catchment

The Sabie catchment yield model was verified at the following locations:

- Flows into Inyaka Dam in the upper Marite catchment.
- Flows into Da Gama Dam in the Whitewaters catchment.
- Flows from the Sabie (X31) catchments.
- Flows from the Sand (X32) catchments.
- Flows from the Lower Sabie (X33) catchments.

The verification was undertaken by comparing the modeled flows at the locations in question as obtained from the WRYM with that of the WRSM2000 for present day conditions. The results of the verification in **Table 7.4** show acceptable differences considering the differences in operational modeling applied in the two models.

**Table 7.4 Verification results at keys points in the Sabie catchment**

| Sub-catchment | Natural MAR (million m3) | | Difference |
|---|---|---|---|
| | WRSM2000 | WRYM | % |
| Inflows to Inyaka Dam (Marite catchment) | 65.0 | 65.1 | 0.0 |
| Inflows to Da Gama Dam (Whitewaters catchment) | 15.5 | 15.5 | 0.0 |
| Flows from the Sabie River catchment (X31) | 360.5 | 358.1 | 0.7 |
| Flows from the Sand River catchment (X32) | 119.9 | 119.9 | 0.0 |
| Flows from the Lower Sabie River catchment (X33) | 492.9 | 490.5 | 0.5 |

### 7.4.5 Incomati in Mozambique

The National Water Resources Development Plans and Joint Water Resources Development Study of Maputo, Mbuluzi and Inkomati River Basins (also known as the Three Basins Study) undertaken by BKS (BKS, 2003) was selected as the most recent and appropriate study to simulate the effects of this study on the Mozambique system. The study involved several scenario analyses which included the status quo and several proposed dam options. For each of these options different development levels, projected water requirements and EWR options were simulated.

The scenario selected as being most relevant for this study was Scenario 1, as defined in the Three Basins Study (BKS, 2003), that reflects the status quo situation of present day development levels (2002) and requirements inside Mozambique. Ecological water requirements were excluded and the scenario was one of a few that were used to calculate the historic firm yield of the proposed dams.

Only the Incomati section of this study will be influenced by updating the inflows from the Sabie, Crocodile and the Komati systems and no changes were made to the Maputo and Mbuluzi systems. The updating of inflows will affect the historic firm yield of the Corumana Dam as well as the volume and assurance of supply for downstream users and eventually the Incomati estuary. Therefore this report provides information for the Incomati catchment in

Mozambique only.

The WRYM setup files and the draft document was obtained from BKS and imported into the WRYM model. The network diagrams were reproduced using the network visualizer and are attached. The only verification that could be done on this systems was to relate all the requirements, inflows, the historic firm yield of the Corumana dam, and the assurance of supply to those quoted in the Three Basins report (BKS, 2003).

There were a number of discrepancies between the system setup results and the Three Basins report. These include the specified irrigation demand files and as well as the historical firm yield of the Corumana Dam. Discussions with BKS confirmed that the report provided was a draft that has not been finalised and that the information in the system setup files should be used. Therefore, no verification was undertaken and all information reported is based on WRYM system setup of the Three Basins study.

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# 8. WATER AVAILABILITY

## 8.1 Methodology

Water availability and system yield was determined in the following three separate steps or processes:

1. The historic yields of all significant dams or systems of dams were determined, assuming upstream abstractions as indicated in **section 5.8** for each scenario.
2. Stochastic analyses were then carried out on the major systems using 201 stochastic hydrology sequences for each quinary catchment and long-term yield curves derived at key points in the system.
3. Since the concept of historic and long-term yields only really apply to a defined system and not a catchment as a whole, the water availability (balance) for the whole catchment was estimated and is reported on in terms of demand versus supply and assurances of supply to each user sector. This was done using the historic hydrology only. Details of the demand versus supply (and assurance) for every defined user are provided for each scenario and for each catchment in **Appendix A** of at the end of this report.

## 8.2 Results of Water Availability assessment

### 8.2.1 Komati catchment

The long-term yield curve of the Nooitgedacht/Vygeboom system for scenario 1 indicates a 1 in 20 year yield of over 150 million $m^3$/a and a 1 in 100 year yield of approximately 120 million $m^3$/a. The Komati Basin Treaty (JWC, 1992) refers to high and low assurance allocations, the low assurance allocations being fully supplied only 70% of the time, which is much less that a 1:20 year yield. This system supplies water to Eskom, who is a high assurance user and the system can supply high assurance users at the level required with the current day transfer infrastructure.

The long-term yield curve of the Maguga/Driekoppies system for scenario 1 indicates a 1 in 20 year yield of over 620 million $m^3$/a and a 1 in 100 year yield of approximately 520 million $m^3$/a. While these yield estimates are useful for broad planning purposes, the yields are less then the allocations that have made from this system. The Komati Basin Treaty (JWC, 1992) refers to high and low assurance allocations, the low assurance allocations being fully supplied only 70% of the time, which is much less that a 1:20 year yield.

It must be concluded that it is not possible from the long-term stochastic curve alone to evaluate if the system is over or under-allocated within the context of the Treaty allocations. In order to achieve this more sophisticated models are required. As an interim measure, a historic yield analysis was carried out in which the assurance of supply to all users was determined. These analyses were carried out for all three scenarios, the full results are presented **in Tables A.1, A.2 and A.3 of Appendix A.** The results of these analyses were aggregated for each user sector and for each scenario in **Table 8.1**

**Table 8.1 Results of water availability assessment for the Komati catchment**

| Water User | Demand (Million $m^3$/annum) | Supply (Million $m^3$/annum) | Assurance of supply (%) |
|---|---|---|---|
| **Scenario 1: Best estimate of current day (2004) water use** | | | |
| International | 34.7 | 34.7 | 100% |
| Strategic | 105.1 | 105.1 | 100% |
| Industrial and mining | 0.6 | 0.6 | 100% |
| Urban / domestic | 21.3 | 21.1 | 99% |
| Controlled Irrigation (SA) | 388.1 | 355.2 | 92% |
| Controlled Irrigation (Swazi) | 56.6 | 56.6 | 100% |
| Uncontrolled Irrigation (all) | 47.9 | 46.6 | 97% |
| Transfers to Mbuluzi / Kaap | 130.3 | 129.8 | 100% |
| **Total** | **784.6** | **749.7** | **96%** |
| **Scenario 2: Allocated water use** | | | |
| International | 61.5 | 61.5 | 100% |
| Strategic | 105.1 | 101.2 | 96% |
| Industrial and mining | 2.4 | 2.4 | 100% |
| Urban / domestic | 50.3 | 48.7 | 97% |
| Treaty Irrigation (SA) | 380.5 | 325.9 | 86% |
| Treaty Irrigation (Swaziland) | 261.2 | 256.2 | 98% |
| Transfers to Kaap | 8.5 | 7.9 | 93% |
| **Total** | **869.5** | **803.8** | **92%** |
| **Scenario 3: Allocated water use with reserve** | | | |
| International | 61.5 | 61.5 | 100% |
| Strategic | 105.1 | 94.8 | 90% |
| Industrial and mining | 2.4 | 2.1 | 87% |
| Urban / domestic | 50.3 | 47.5 | 94% |
| Treaty Irrigation (SA) | 380.5 | 320.6 | 84% |
| Treaty Irrigation (Swaziland) | 261.2 | 251.4 | 96% |
| Transfers to Kaap | 8.5 | 6.8 | 82% |
| Ecological Reserve at X13K-2 | 227.7 | 227.7 | 100% |
| **Total** | **1097.2** | **1012.4** | **92%** |

### 8.2.2 Crocodile River catchment

The modelling approach adopted in this study assumed that the Kwena Dam would continue to supply the demands of downstream users until it empties, which, given the large demands in the system, would occur frequently. In reality, the Crocodile Major Irrigation Board reduces their water use during droughts to prevent failure of the dam. This mode of operation has been modeled successfully in several other studies, namely the ‘Framework for Water Allocation to Guide Compulsory Licencing’ (DWAF, 2007), the ecological Reserve study (in progress), and the establishment of Real-time operating rules in the Crocodile catchments using other models.

It is recommended that in order to improve on the modeling of the Crocodile catchments that models used in these other studies should be utilized, or that the WRPM be setup to model the system in a manner that more closely matches the actual operation.

The water availability assessments of the Crocodile River catchment based on the analyses of the three scenarios are summarized in **Appendix A** in **Tables A.4, A.5** and **A.6.** These results are aggregated for each user for each scenario in **Table 8.2.**

**Table 8.2 Results of water availability assessment for the Crocodile catchment**

| **Water User** | **Demand (million $m^3$/a)** | **Supply (million $m^3$/a)** | **Assurance of supply (%)** |
|---|---|---|---|
| **Scenario 1: Current day (2004) water use** | | | |
| International | 28.4 | 28.4 | 100% |
| Strategic | 0.0 | 0.0 | - |
| Industrial | 22.4 | 22.4 | 100% |
| Urban / domestic | 48.5* | 48.5 | 100% |
| Irrigation (controlled) | 420.2 | 394.0 | 94% |
| Irrigation (uncontrolled) | 94.0 | 55.8 | 59% |
| **Total** | **613.5** | **547.9** | **89%** |
| **Scenario 2: Allocated water use** | | | |
| International | 50.5 | 50.5 | 100% |
| Strategic | 0.0 | 0.0 | - |
| Industrial | 26.6 | 26.6 | 100% |
| Urban / domestic | 46.3* | 46.3 | 100% |
| Irrigation (Treaty allocation) | 482.2 | 431.9 | 90% |
| **Total** | **605.6** | **555.3** | **92%** |
| **Scenario 3: Allocated water use with reserve** | | | |
| International | 50.5 | 50.5 | 100% |
| Strategic | 0.0 | 0.0 | - |
| Industrial | 26.6 | 26.6 | 100% |
| Urban / domestic | 46.3* | 43.8 | 95% |
| Irrigation (Treaty allocation) | 482.2 | 355.8 | 74% |
| Ecological Reserve at X24H-2 | 204.6 | 204.6 | 100% |
| **Total** | **810.2** | **681.3** | **84%** |

* Barberton and Nsikazi North requirements are supplied from Lomati (X14) and Sabie (X31) catchments and are not accounted for in this table.

### 8.2.3 Sabie River catchment

The water availability assessment for the Sabie River catchment based on the analyses from the three scenarios, are summarized in **Appendix A** in **Tables A.7**, **A.8** and **A.9**. The results are aggregated for users for each scenario in **Table 8.3.**

The Sabie River catchment has limited storage with which to regulate flow and hence provide firm yield. The combined historic firm yield of the Inyaka and Da Gama dams is estimated at 62 million $m^3$/a while the total current requirement is estimated at 127 million $m^3$/a. Most of the irrigation requirements are however supplied from run-of-river and not from storage. Within the next few years all the domestic use within the Sand River catchment will be supplied from the Inyaka Dam, which will free up water for the ecological Reserve in this sub-catchment. In the Sand River catchments there are several small dams (Edinburgh, Orinoco, Acornhoek and Kasteel) with a combined storage capacity of 3.54 million $m^3$. Once the domestic supply from these dams has been replaced from the Inyaka Dam the yield of these dams could be used to improve the assurance of supply to downstream irrigators and the ecological reserve.

## Table 8.3 Results of water availability assessment for the Sabie catchment

| Water User | Demand (million $m^3$/a) | Supply (million $m^3$/a) | Assurance of supply (%) |
|---|---|---|---|
| **Scenario 1: Current day (2004) water use** | | | |
| International | 0.0 | 0.0 | - |
| Strategic | 0.0 | 0.0 | - |
| Industrial | 0.0 | 0.0 | - |
| Urban / domestic | 20.2 | 20.2 | 100% |
| Irrigation | 100.1 | 83.2 | 83% |
| Transfers to Crocodile (East) | 6.5 | 6.5 | 100% |
| **Total** | **126.8** | **109.9** | **87%** |
| **Scenario 2: Allocated water use** | | | |
| International | 0.0 | 0.0 | - |
| Strategic | 0.0 | 0.0 | - |
| Industrial | 0.0 | 0.0 | - |
| Urban / domestic | 27.1 | 25.1 | 100% |
| Irrigation: Controlled | 23.2 | 23.2 | 100% |
| Irrigation: Uncontrolled | 74.3 | 58.4 | 79% |
| Transfers to Crocodile (East) | 8.0 | 8.0 | 100% |
| **Total** | **132.6** | **116.7** | **88%** |
| **Scenario 3: Allocated water use with reserve** | | | |
| International | 0.0 | 0.0 | - |
| Strategic | 0.0 | 0.0 | - |
| Industrial | 0.0 | 0.0 | - |
| Urban / domestic | 27.1 | 26.4 | 97% |
| Irrigation: Controlled | 23.2 | 20.0 | 86% |
| Irrigation: Uncontrolled | 74.3 | 49.5 | 67% |
| Transfers to Crocodile (East) | 8.0 | 7.6 | 95% |
| Ecological Reserve* | 209.3 | 206.4 | 99% |
| **Total** | **341.9** | **309.9** | **91%** |

* Ecological Reserve req. for Sabie River (X31) is 167 mill $m^3$ and for Sand River is 43 mill $m^3$.

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# 9. CONCLUSIONS AND RECOMMENDATIONS

## 9.1 General conclusions

The hydrology and yield models set up as part of this WAAS provide much more detail than was available in previous models of the Inkomati WMA, with catchment and hence model discretisation at quinary or sub-quaternary scale.

The main conclusions from the hydrology review and extension are that the rapidly reducing numbers of rain gauges that remain operational are a cause for great concern and consideration should be given to re-opening old reliable stations and or the establishment of new gauges. The model calibrations were however adequate in most cases, the exception being in the White River catchment where a meaningful calibration against observed data could not be obtained due to the exceptionally poor observed data. The other important conclusion relating to flow gauges is that there are insufficient flow gauges in the Sand catchment of the Sabie system in order to model the complexity of this catchment adequately. The hydrology derived from this study, the most detailed and comprehensive to date, does not deviate significantly from previous studies, with the exception of the hydrology of the Inyaka Dam where the MAR is now estimated to be 20% less than in previous studies. This has serious implications for the water availability for Inyaka Dam and the Sabie River catchments.

The WRYM setup for the river systems in the study area provides a useful tool for allocation planning and compulsory licencing. The use of the WRYM model for operational purposes is however limited since it does not model the complex operating rules that are applied within the Komati and Crocodile River catchments. Detailed yield analyses of the catchments of the Inkomati WMA were undertaken during this study using the WRYM, with limited analysis of the Incomati catchment in the Mozambican portion of the Incomati River Basin, using information that was readily available. The overall conclusion reached for the whole study area is that despite the large increase in water use since previous detailed studies (JIBS, 1995), the catchments are not **currently** unduly stressed and users are receiving their water at acceptable levels of assurance. This is largely due to the completion of the Maguga and Inyaka Dams since the last detailed study. The results of this study reinforce the conclusions of the KOBWA analysis (KOBWA, 2005) in the case of the Komati catchment and the Framework Towards a Water Allocation Plan (DWAF, 2007) in the case of the WMA. The yields of the Sabie catchments as well as the Coromana Dam, as derived from this study, are however significantly lower than other studies. This can be attributed to the lower estimated runoff from the Sabie catchment.

The ecological Reserve has been determined comprehensively only within the Komati catchment while studies are in progress within the Crocodile and Sabie River catchments. The current level of water use within the Komati and Sabie catchments appears to be sustainable with users receiving water at acceptable levels of supply, assuming implementation of the Reserve and international requirements. The assurance of supply within the Crocodile River catchment will however be unacceptably low for irrigators, assuming implementation of the Reserve and International Requirements.

Other than the Kaap River catchment and the lower Crocodile River catchments, the WRYM simulations compared very well with the hydrology model (WRSM 2000) simulations and can be considered to be adequately verified. More attention needs to be given to the Kaap and Lower Crocodile to understand the reason for the discrepancies between the hydrology model and yield model.

## 9.2 Komati River catchment

The yield analyses carried out in the Komati River largely confirm the yields obtained from previous studies, namely the Vaal River Systems Analysis Update (DWAF, 2001) in the case of the upper system and the KOBWA analysis (KOBWA, 2005) in the case of the lower system.

The conclusion from this study deviates from the highly stressed view portrayed in the Internal Strategic Perspective (DWAF, 2004). The catchment is not stressed under the current water use regime and is in fact under utilised because Swaziland have not taken up its full allocation in terms of the IIMA and Komati Basin Treaty. Once Swaziland takes up its full allocation and the terms of the IIMA are fully implemented, the WRYM indicates that the catchment will be in approximately in balance.

The implementation of the ecological Reserve will reduce the assurance of supply to users in upper reaches of the catchment but the assurances are probably sufficiently high to ensure a sustainable agricultural industry in the Komati River catchment. Additional analyses need to be undertaken, however, to investigate the implementation of the ecological Reserve at a quaternary or quinary scale. In some cases the impact of these extrapolated ecological Reserves could be very severe and this needs to be weighed up against the economic impact on users. This particularly applies to the ecological Reserve downstream of the Vygeboom Dam, which if implemented at sub-catchment scale will have a severe impact on Eskom by substantially reducing the yield of the Nooitgedacht/Vygeboom system.

Note, however, that the ecological Reserve for the lower reaches of the Komati River (after the confluence of the Komati and Lomati Rivers) has not been approved by DWAF. The reason for this is that in ecological terms there is no longer a river, just a series of ponds created by the weirs constructed along this stretch of the river. The inclusion (or not) of a Reserve on this stretch of river will have a significant influence on the availability of water in the lower reaches of the Komati River.

The yield of the Komati River catchment is derived mainly from the Nooitgedacht/Vygeboom system and the Maguga/Driekoppies system. In determining the yield of these systems it is important to model an equal drawdown of the dams in these two systems since if either dam within a system empties before the other the yield so determined will be less than the maximum achievable. While equal drawdown can be modeled using the historic flow sequence, it is much more difficult to achieve this using stochastic hydrology since generic operating rules need to be developed that apply in all cases. The long-term yield curves developed for these two systems are not based on such an operating rule and are likely to underestimate the yield that could be obtained from the two systems if operated optimally.

## 9.3 Crocodile River catchment

The yield analyses carried out in the Crocodile River catchment, while useful in that they quantify the long-term yield available from the smaller dams in the White River area, fail to analyse the system as it is actually operated due to the limitations of the yield model. The Crocodile system is dominated by run-of-river abstractions that are supplemented by releases from the Kwena Dam. Quantifying the available resource in such a system is a complex problem that has been partially resolved by simply documenting the assurance of supply to all users for the various scenarios. These analyses confirm the stressed nature of the Crocodile River system with the ecological Reserve implemented (given the preliminary nature of the estimates used in this study) which will result in unacceptably low assurances of supply, especially to the irrigation sector. This situation needs to be reviewed when the final ecological Reserves become available.

## 9.4 Sabie River catchment

The main conclusion of the yield analyses carried out in the Sabie River catchment is that there is less water available than previously thought. While previous studies (DWAF, 2003) indicated that there was scope for additional irrigation development following completion of the Inyaka Dam, this study shows that the Inyaka Dam can meet its obligation to transfer 25 million $m^3$/annum to the Sand River catchment at a high level of assurance, but there is no remaining yield for irrigation development in the Sabie or Sand River catchments. This conclusion will require review once the ecological Reserves are finalized.

## 9.5 Incomati River catchment (Mozambique)

A reconnaissance level analysis of the Mozambican portion of the Incomati River Basin and comparison with previous studies showed that the average flows from South Africa to Mozambique are much less than previously assumed. This can be attributed largely to the increased water demands within South Africa. As a result of these decreased cross-border flows, the estimated yield of the Corumana Dam in the lower Sabie is substantially less than previously estimated. Although not analysed as part of this study, the yield of the proposed Moamba Majoor Dam can also be expected to decrease significantly.

## 9.6 Modelling issues

The yield analyses carried out as part of this Water Availability Assessment Study entailed the use of the WRYM IMS, which has been developed from the WRYM over the last several years and continues to be developed further based on feedback from users on this and other studies. In many instances, the Inkomati WAAS teams were some of the first modelers to thoroughly test new developments in the real world and hence this study is in a position to make recommendations to resolve or improve certain components of this model.

In general the model development team has been quick to respond to suggestions and some of the limitations described below may already be resolved.

- The Alien vegetation model is not operational in the IMS and the estimated

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streamflow reduction due to alien vegetation had to be estimated using WRSM2000.

- The groundwater module is not operational in stochastic mode and improvements still need to be researched and implemented.
- The F20 or streamflow reduction model is not operational and SFR from forestry had to be estimated using the WRSM2000 model. This is related to limitations in the groundwater module.
- The new diversion module cannot be solved in stochastic mode. All stochastic analyses had to be carried out without the diversions routines in place.
- The assurance of supply graphs need to be updated to allow duration curves to be plotted based on stochastic analyses. This will allow a water availability assessment based on stochastic rather than only historic hydrology.
- The results functionality of the IMS is not working properly and will have to be revised significantly.

## 9.7 Recommendations

The following recommendations based on this water availability Assessment are:

- Additional flow gauges are required in the Sand catchments (X32) of the Sabie drainage catchment.
- The state of the observed flows and reservoir records in the White River catchments in the Crocodile drainage catchment are inadequate and this problem needs to be resolved in order to improve the hydrology of this area.
- The reservoir records of the Nooitgedacth, Vygeboom and Inyaka Dams are inadequate resulting in uncertain hydrology for these catchments, and hence uncertain estimates of the water availability. Quality control measures need to be put in place to ensure that these records are correctly processed and archived.
- There are now insufficient rain gauges in the Inkomati WMA to extend the hydrology into the future. Previously reliable gauges which have been shut down must reinstated if the hydrology in the study area is to be improved upon in the future.
- The system models setup as part of this study should be upgraded to model the actual operation of the catchments more realistically. This recommendation applies especially to the Komati and Crocodile River systems where complex restriction rules and water banking are applied. In the Sabie system the fractal allocation rules for the Sand River catchment should be applied. These processes could possibly be modeled with the Water Resources Planning Model but other models that are already being used in these catchments to do such analyses should also be considered.
- It appears as if South African irrigators in the Komati River catchment could have developed beyond their allocation in terms of the IIMA and allocations made to the irrigation boards in terms of South Africa's NWA. The estimated over-allocation of 25 million $m^3/a$ does however lie within the range of uncertainty of estimates irrigation requirements and needs to be investigated in more detail.
- The Crocodile and Sabie systems should be updated when the ecological Reserves have been finalized and extrapolated to hydro-nodes.

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- An economic analysis needs to be undertaken, together with stakeholder participation, to decide at which nodes in the system ecological Reserves are to be implemented since it is not realistic to assume implementation at all nodes.
- The WRYM IMS should be upgraded to deal with the limitations noted in **section 9.6**.

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# APPENDIX A: TABLES

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# YIELD RESULTS FOR THE KOMATI CATCHMENT

## Table A.1 Results of the water availability assessment for Scenario 1

| Komati River Catchment | Scenario 1 - Best est of current day use IB allocations applied | | | | | |
|---|---|---|---|---|---|---|
| Water Use Categories | Channels | Demand | | Supply | | Ass |
| | | m3/s | MCM/a | m3/s | MCM/a | |
| **Cross border flows** | **639** | **1.100** | **34.71** | **1.100** | **34.71** | **100%** |
| **Strategic** | **509** | **3.3** | **105.09** | **3.3** | **105.09** | **100%** |
| **Industrial** | **-** | **0.017** | **0.56** | **0.018** | **0.56** | **100%** |
| - Nkomati Mine | 604 | 0.004 | 0.12 | 0.004 | 0.12 | 100% |
| - Komati Sugar Mill | 616 | 0.014 | 0.44 | 0.014 | 0.44 | 100% |
| **Domestic** | **-** | **0.798** | **21.31** | **0.784** | **21.09** | **99%** |
| - Carolina | 600 | 0.019 | 0.60 | 0.019 | 0.60 | 100% |
| - Badplaas [Buffelspruit] | 605 | 0.010 | 0.31 | 0.010 | 0.30 | 97% |
| - Elukwatini [Teespruit] | 606 | 0.049 | 1.56 | 0.048 | 1.51 | 96% |
| - Elukwatini [Komati R] | 607 | 0.049 | 1.56 | 0.048 | 1.51 | 96% |
| - Ekulindeni | 608 | 0.023 | 0.72 | 0.022 | 0.69 | 96% |
| - Swaziland Dom 1 | 609 | 0.061 | 1.92 | 0.059 | 1.85 | 96% |
| - Swaziland Dom 2 [Mhlume] | 610 | 0.061 | 1.92 | 0.061 | 1.92 | 100% |
| - Tonga, Masibekela | 612 | 0.232 | 7.32 | 0.232 | 7.32 | 100% |
| - Komatipoort | 615 | 0.015 | 0.48 | 0.015 | 0.47 | 99% |
| - Driekoppies | 613 | 0.108 | 3.41 | 0.108 | 3.41 | 100% |
| - Lomati | 614 | 0.048 | 1.51 | 0.048 | 1.51 | 100% |
| **Transfers** | **-** | **4.129** | **130.31** | **4.112** | **129.76** | **100%** |
| - Barberton [Lomati Dam to SuidK] | 618 | 0.123 | 3.87 | 0.115 | 3.64 | 94% |
| - X14B1 (Shiya Dam Louws Creek IB) | 389 | 0.146 | 4.61 | 0.139 | 4.37 | 95% |
| - X13G1 Mbuluzi tra for Irr (min-max) | 617 | 3.861 | 121.83 | 3.858 | 121.75 | 100% |
| **Irrigation (all)** | **-** | **15.61** | **492.63** | **14.53** | **458.42** | **93%** |
| **Irrigation SA (uncontrolled)** | **-** | **0.550** | **17.37** | **0.537** | **16.96** | **98%** |
| - X11A1 DD Irr | 211 | 0.016 | 0.49 | 0.016 | 0.50 | 101% |
| - X11A1 RoR Irr | 217 | 0.014 | 0.44 | 0.014 | 0.45 | 101% |
| - X11B1 DD Irr | 221 | 0.009 | 0.28 | 0.009 | 0.28 | 101% |
| - X11B1 RoR Irr | 225 | 0.015 | 0.48 | 0.015 | 0.46 | 97% |
| - X11B2 DD Irr | 229 | 0.008 | 0.27 | 0.009 | 0.27 | 101% |
| - X11C1 DD Irr | 233 | 0.019 | 0.60 | 0.019 | 0.60 | 101% |
| - X11D1 DD Irr | 237 | 0.017 | 0.54 | 0.017 | 0.54 | 101% |
| - X11D1 RoR Irr | 241 | 0.011 | 0.34 | 0.011 | 0.34 | 100% |
| - X11D2 RoR Irr | 247 | 0.004 | 0.12 | 0.004 | 0.12 | 103% |
| - X11D3 RoR Irr | 251 | 0.003 | 0.10 | 0.003 | 0.10 | 100% |
| - X11E1 RoR Irr | 255 | 0.002 | 0.06 | 0.002 | 0.06 | 100% |
| - X11G1 RoR Irr | 259 | 0.003 | 0.09 | 0.003 | 0.09 | 102% |
| - X11H1 DD Irr | 265 | 0.023 | 0.72 | 0.023 | 0.72 | 100% |
| - X11H1 RoR Irr | 269 | 0.024 | 0.75 | 0.024 | 0.75 | 100% |
| - X11J1 RoR Irr | 273 | 0.011 | 0.36 | 0.011 | 0.36 | 101% |
| - X11K1 DD Irr | 277 | 0.026 | 0.81 | 0.026 | 0.82 | 101% |
| - X11K2 DD Irr | 281 | 0.014 | 0.44 | 0.014 | 0.44 | 101% |
| - X11K2 RoR Irr | 285 | 0.118 | 3.71 | 0.109 | 3.45 | 93% |
| - X11K3 RoR Irr | 289 | 0.041 | 1.28 | 0.039 | 1.23 | 97% |
| - X11K4 RoR Irr | 293 | 0.062 | 1.96 | 0.060 | 1.90 | 97% |
| - X12A1 RoR Irr | 297 | 0.003 | 0.09 | 0.003 | 0.09 | 97% |
| Komati River Catchment | Scenario 1 - Best est of current day use IB allocations applied | | | | | |
| Water Use Categories | Channels | Demand | | Supply | | Ass |
| | | m3/s | MCM/a | m3/s | MCM/a | |
| - X12B1 DD Irr | 303 | 0.003 | 0.09 | 0.003 | 0.09 | 100% |
| - X12C2 RoR Irr | 307 | 0.001 | 0.03 | 0.001 | 0.03 | 100% |

| | | | | | | |
|---|---|---|---|---|---|---|
| - X12D1 RoR Irr | 311 | 0.006 | 0.18 | 0.005 | 0.17 | 96% |
| - X12D2 DD Irr | 315 | 0.004 | 0.13 | 0.004 | 0.13 | 100% |
| - X12D2 RoR Irr | 319 | 0.018 | 0.57 | 0.018 | 0.56 | 97% |
| - X12F3 RoR Irr | 323 | 0.018 | 0.56 | 0.017 | 0.54 | 97% |
| - X12G3 DD Irr | 327 | 0.011 | 0.36 | 0.011 | 0.36 | 101% |
| - X12G3 RoR Irr | 331 | 0.048 | 1.52 | 0.047 | 1.48 | 97% |
| **Irrigation Swaziland** | **-** | **2.761** | **87.12** | **2.733** | **86.24** | **99%** |
| - X13E1 RoR Irr | 335 | 0.247 | 7.80 | 0.237 | 7.49 | 96% |
| - X13G1 RoR Irr | 341 | 0.224 | 7.08 | 0.216 | 6.81 | 96% |
| - X13G2 RoR Irr | 345 | 0.048 | 1.51 | 0.045 | 1.41 | 94% |
| - X13G3 RoR Irr | 437 | 0.244 | 7.69 | 0.236 | 7.46 | 97% |
| - X14D2 RoR Irr | 379 | 0.029 | 0.92 | 0.029 | 0.92 | 100% |
| - X14E1 RoR Irr | 385 | 0.120 | 3.79 | 0.120 | 3.79 | 100% |
| - X14G2 RoR Irr | 389 | 0.056 | 1.76 | 0.056 | 1.76 | 100% |
| - X13H2 Mhlume Irr (min-max) | 642 | 1.793 | 56.59 | 1.793 | 56.60 | 100% |
| **Irrigation SA (controlled)** | **-** | **12.300** | **388.14** | **11.257** | **355.23** | **92%** |
| - X13J1 controlled (X13J1.ird) | 620 | 0.015 | 0.48 | 0.014 | 0.43 | 90% |
| - X13J2 controlled (X13J2.ird) | 621 | 0.184 | 5.80 | 0.053 | 1.66 | 29% |
| - X13J3 controlled (min-max) | 622 | 1.836 | 57.94 | 1.829 | 57.73 | 100% |
| - X13J4 controlled (min-max) | 623 | 0.190 | 5.99 | 0.189 | 5.97 | 100% |
| - X13K1 controlled (X13K1.ird) | 624 | 0.722 | 22.77 | 0.117 | 3.70 | 16% |
| - X13K2 controlled (min-max) | 640 | 4.518 | 142.58 | 4.507 | 142.24 | 100% |
| - X13L1 controlled (X13L1.ird) | 626 | 0.781 | 24.65 | 0.503 | 15.87 | 64% |
| - X13L2 controlled (min-max) | 641 | 1.127 | 35.56 | 1.124 | 35.48 | 100% |
| - X14F1 controlled (X14F1.ird) | 628 | 0.005 | 0.17 | 0.005 | 0.17 | 100% |
| - X14G1 controlled (min-max) | 629 | 0.395 | 12.45 | 0.394 | 12.43 | 100% |
| - X14G3 controlled (min-max) | 631 | 0.106 | 3.34 | 0.106 | 3.33 | 100% |
| - X14H1 controlled (min-max) | 632 | 2.422 | 76.42 | 2.415 | 76.21 | 100% |
| **Total Water Req. (MCM/a)** | - | - | **784.61** | - | **749.64** | **96%** |

## Table A.2 Results of the water availability assessment for Scenario 2

| Komati River Catchment | Scenario 2 - Allocated water use | | | | | |
|---|---|---|---|---|---|---|
| Water Use Categories | Channels | Demand | | Supply | | Assurance |
| | | m3/s | MCM/a | m3/s | MCM/a | |
| **Cross border flows** | **639** | **1.950** | **61.54** | **1.950** | **61.54** | **100%** |
| **Strategic** | **509** | **3.3** | **105.09** | **3.208** | **101.24** | **100%** |
| **Industrial** | **-** | **0.077** | **2.42** | **0.077** | **2.43** | **100%** |
| - Nkomati Mine* | 643 | 0.063 | 1.99 | 0.063 | 1.99 | 100% |
| - Komati Sugar Mill | 616 | 0.014 | 0.43 | 0.014 | 0.44 | 103% |
| **Domestic** | **-** | **1.593** | **50.27** | **1.542** | **48.7** | **97%** |
| - Carolina | 600 | 0.019 | 0.60 | 0.019 | 0.60 | 100% |
| - Badplaas [Buffelspruit] | 605 | 0.010 | 0.31 | 0.009 | 0.29 | 94% |
| - Elukwatini [Teespruit] | 606 | 0.051 | 1.60 | 0.046 | 1.46 | 91% |
| - Elukwatini [Komati R] | 607 | 0.051 | 1.60 | 0.046 | 1.46 | 91% |
| - Ekulindeni | 608 | 0.023 | 0.72 | 0.021 | 0.67 | 93% |
| - Swaziland Dom 1* | 644 | 0.637 | 20.10 | 0.598 | 18.86 | 94% |
| - Swaziland Dom 2 [Mhlume] | 610 | 0.061 | 1.92 | 0.061 | 1.9 | 100% |
| - Tonga, Masibekela* | 612 | 0.423 | 13.35 | 0.423 | 13.3 | 100% |
| - Komatipoort | 615 | 0.015 | 0.48 | 0.015 | 0.5 | 99% |
| - Driekoppies* | 613 | 0.209 | 6.60 | 0.209 | 6.6 | 100% |
| - Lomati* | 614 | 0.095 | 3.00 | 0.095 | 3.0 | 100% |
| **Irrigation (SA)** | **-** | **12.06** | **380.49** | **10.328** | **325.93** | **86%** |
| **Irrigation (uncontrolled)** | **-** | **0.550** | **17.37** | **0.519** | **16.36** | **94%** |
| - X11A1 DD Irr | 211 | 0.016 | 0.49 | 0.016 | 0.50 | 101% |
| - X11A1 RoR Irr | 217 | 0.014 | 0.44 | 0.011 | 0.34 | 76% |
| - X11B1 DD Irr | 221 | 0.009 | 0.28 | 0.009 | 0.28 | 101% |
| - X11B1 RoR Irr | 225 | 0.015 | 0.48 | 0.015 | 0.46 | 97% |
| - X11B2 DD Irr | 229 | 0.008 | 0.27 | 0.009 | 0.27 | 101% |
| - X11C1 DD Irr | 233 | 0.019 | 0.60 | 0.019 | 0.60 | 101% |
| - X11D1 DD Irr | 237 | 0.017 | 0.54 | 0.017 | 0.54 | 101% |
| - X11D1 RoR Irr | 241 | 0.011 | 0.34 | 0.011 | 0.34 | 100% |
| - X11D2 RoR Irr | 247 | 0.004 | 0.12 | 0.004 | 0.12 | 103% |
| - X11D3 RoR Irr | 251 | 0.003 | 0.10 | 0.003 | 0.10 | 100% |
| - X11E1 RoR Irr | 255 | 0.002 | 0.06 | 0.002 | 0.06 | 100% |
| - X11G1 RoR Irr | 259 | 0.003 | 0.09 | 0.003 | 0.09 | 102% |
| - X11H1 DD Irr | 265 | 0.023 | 0.72 | 0.023 | 0.72 | 100% |
| - X11H1 RoR Irr | 269 | 0.024 | 0.75 | 0.024 | 0.75 | 101% |
| - X11J1 RoR Irr | 273 | 0.011 | 0.36 | 0.011 | 0.35 | 98% |
| - X11K1 DD Irr | 277 | 0.026 | 0.81 | 0.026 | 0.82 | 101% |
| - X11K2 DD Irr | 281 | 0.014 | 0.44 | 0.014 | 0.44 | 101% |
| - X11K2 RoR Irr | 285 | 0.118 | 3.71 | 0.101 | 3.18 | 86% |
| - X11K3 RoR Irr | 289 | 0.041 | 1.28 | 0.038 | 1.19 | 93% |
| - X11K4 RoR Irr | 293 | 0.062 | 1.96 | 0.058 | 1.82 | 93% |
| - X12A1 RoR Irr | 297 | 0.003 | 0.09 | 0.003 | 0.09 | 93% |
| - X12B1 DD Irr | 303 | 0.003 | 0.09 | 0.003 | 0.09 | 100% |
| - X12C2 RoR Irr | 307 | 0.001 | 0.03 | 0.001 | 0.03 | 100% |
| - X12D1 RoR Irr | 311 | 0.006 | 0.18 | 0.005 | 0.16 | 93% |
| - X12D2 DD Irr | 315 | 0.004 | 0.13 | 0.004 | 0.13 | 100% |
| - X12D2 RoR Irr | 319 | 0.018 | 0.57 | 0.017 | 0.54 | 94% |
| - X12F3 RoR Irr | 323 | 0.018 | 0.56 | 0.017 | 0.53 | 95% |
| - X12G3 DD Irr | 327 | 0.011 | 0.36 | 0.011 | 0.36 | 101% |
| - X12G3 RoR Irr | 331 | 0.048 | 1.52 | 0.045 | 1.43 | 94% |
| **Komati River Catchment** | **Scenario 2 - Allocated water use** | | | | | |
| **Water Use Categories** | **Channels** | **Demand** | | **Supply** | | **Assurance** |

| | | m3/s | MCM/a | m3/s | MCM/a | |
|---|---|---|---|---|---|---|
| **Irrigation Swaziland** | **Swaz** | **8.278** | **261.24** | **8.118** | **256.19** | **98%** |
| - X13E1 RoR Irr | 335 | 0.247 | 7.80 | 0.226 | 7.14 | 92% |
| - X13G1 RoR Irr | 341 | 0.224 | 7.08 | 0.206 | 6.51 | 92% |
| - X13G2 RoR Irr | 345 | 0.048 | 1.51 | 0.044 | 1.37 | 91% |
| - X13G3 RoR Irr | 437 | 0.244 | 7.69 | 0.229 | 7.23 | 94% |
| - X14D2 RoR Irr | 379 | 0.029 | 0.92 | 0.029 | 0.92 | 100% |
| - X14E1 RoR Irr | 385 | 0.120 | 3.79 | 0.120 | 3.78 | 100% |
| - X14G2 RoR Irr | 389 | 0.056 | 1.76 | 0.056 | 1.75 | 100% |
| - X13G1 Mbuluzi tra for Irr (min-max) | 617 | 3.861 | 121.83 | 3.792 | 119.67 | 98% |
| - X13H2 Mhlume Irr (min-max)* | 642 | 3.450 | 108.87 | 3.417 | 107.83 | 99% |
| **Irrigation SA (controlled)** | **SA** | **11.507** | **363.12** | **9.810** | **309.56** | 85% |
| - X13J1 controlled (X13J1.ird) | 620 | 0.015 | 0.48 | 0.014 | 0.43 | 90% |
| - X13J2 controlled (X13J2.ird) | 621 | 0.184 | 5.80 | 0.053 | 1.66 | 29% |
| - X13J3 controlled (min-max) | 622 | 1.836 | 57.94 | 1.767 | 55.77 | 96% |
| - X13J4 controlled (min-max) | 623 | 0.190 | 5.99 | 0.183 | 5.79 | 97% |
| - X13K1 controlled (X13K1.ird) | 624 | 0.722 | 22.77 | 0.117 | 3.70 | 16% |
| - X13K2 controlled (min-max)^ | 640 | 3.725 | 117.56 | 3.653 | 115.27 | 98% |
| - X13L1 controlled (X13L1.ird) | 626 | 0.781 | 24.65 | 0.050 | 1.58 | 6% |
| - X13L2 controlled (min-max) | 641 | 1.127 | 35.56 | 1.103 | 34.81 | 98% |
| - X14F1 controlled (X14F1.ird) | 628 | 0.005 | 0.17 | 0.005 | 0.17 | 100% |
| - X14G1 controlled (min-max) | 629 | 0.395 | 12.45 | 0.388 | 12.25 | 98% |
| - X14G3 controlled (min-max) | 631 | 0.106 | 3.34 | 0.104 | 3.28 | 98% |
| - X14H1 controlled (min-max) | 632 | 2.422 | 76.42 | 2.372 | 74.85 | 98% |
| **Transfers** | **-** | **0.269** | **8.48** | **0.250** | **7.89** | 93% |
| - X14B1 (Louws Creek IB) (Shiyaf.tra) | 389 | 0.146 | 4.61 | 0.136 | 4.28 | 93% |
| - Barberton [Lomati Dam to SuidK] | 618 | 0.123 | 3.87 | 0.115 | 3.62 | 93% |
| **Total Water Req. (MCM/a)** | **-** | **-** | **869.52** | **-** | **803.89** | **92%** |

*** Allocation used**

**^ Irrigation requirement reduced to meet terms of IIMA**

## Table A.3 Results of the water availability assessment for Scenario 3

| Komati River Catchment | Scenario 3 - Allocated water use and reserve | | | | | |
|---|---|---|---|---|---|---|
| Water Use Categories | Channels | Demand | | Supply | | Assurance |
| | | m3/s | MCM/a | m3/s | MCM/a | |
| **Crocc border flows** | **617** | **1.950** | **61.54** | **1.950** | **61.54** | **100%** |
| **Strategic** | **509** | **3.3** | **105.09** | **3.005** | **94.83** | **100%** |
| **Industrial** | **-** | **0.077** | **2.42** | **0.067** | **2.10** | **87%** |
| - Nkomati Mine* | 643 | 0.063 | 1.99 | 0.053 | 1.66 | 84% |
| - Komati Sugar Mill | 616 | 0.014 | 0.43 | 0.014 | 0.44 | 103% |
| **Domestic** | **-** | **1.593** | **50.27** | **1.504** | **47.45** | **94%** |
| - Carolina | 600 | 0.019 | 0.60 | 0.016 | 0.50 | 84% |
| - Badplaas [Buffelspruit] | 605 | 0.010 | 0.31 | 0.009 | 0.27 | 89% |
| - Elukwatini [Teespruit] | 606 | 0.051 | 1.60 | 0.044 | 1.39 | 87% |
| - Elukwatini [Komati R] | 607 | 0.051 | 1.60 | 0.044 | 1.40 | 87% |
| - Ekulindeni | 608 | 0.023 | 0.72 | 0.020 | 0.64 | 89% |
| - Swaziland Dom 1* | 644 | 0.637 | 20.10 | 0.567 | 17.91 | 89% |
| - Swaziland Dom 2 [Mhlume] | 610 | 0.061 | 1.92 | 0.061 | 1.92 | 100% |
| - Tonga, Masibekela* | 612 | 0.423 | 13.35 | 0.423 | 13.35 | 100.0% |
| - Komatipoort | 615 | 0.015 | 0.48 | 0.015 | 0.47 | 99% |
| - Driekoppies* | 613 | 0.209 | 6.60 | 0.209 | 6.60 | 100.0% |
| - Lomati* | 614 | 0.095 | 3.00 | 0.095 | 3.00 | 100.0% |
| **Irrigation (SA)** | **SA** | **12.06** | **380.49** | **10.159** | **320.60** | **84%** |
| **Irrigation (uncontrolled)** | **SA** | **0.55** | **17.37** | **0.406** | **12.81** | **74%** |
| - X11A1 DD Irr | 211 | 0.016 | 0.49 | 0.016 | 0.50 | 101% |
| - X11A1 RoR Irr | 217 | 0.014 | 0.44 | 0.005 | 0.15 | 33% |
| - X11B1 DD Irr | 221 | 0.009 | 0.28 | 0.009 | 0.28 | 101% |
| - X11B1 RoR Irr | 225 | 0.015 | 0.48 | 0.010 | 0.30 | 63% |
| - X11B2 DD Irr | 229 | 0.008 | 0.27 | 0.009 | 0.27 | 101% |
| - X11C1 DD Irr | 233 | 0.019 | 0.60 | 0.019 | 0.60 | 101% |
| - X11D1 DD Irr | 237 | 0.017 | 0.54 | 0.017 | 0.54 | 101% |
| - X11D1 RoR Irr | 241 | 0.011 | 0.34 | 0.008 | 0.24 | 71% |
| - X11D2 RoR Irr | 247 | 0.004 | 0.12 | 0.003 | 0.10 | 87% |
| - X11D3 RoR Irr | 251 | 0.003 | 0.10 | 0.003 | 0.09 | 85% |
| - X11E1 RoR Irr | 255 | 0.002 | 0.06 | 0.002 | 0.05 | 83% |
| - X11G1 RoR Irr | 259 | 0.003 | 0.09 | 0.003 | 0.08 | 95% |
| - X11H1 DD Irr | 265 | 0.023 | 0.72 | 0.023 | 0.72 | 100% |
| - X11H1 RoR Irr | 269 | 0.024 | 0.75 | 0.021 | 0.66 | 88% |
| - X11J1 RoR Irr | 273 | 0.011 | 0.36 | 0.009 | 0.29 | 81% |
| - X11K1 DD Irr | 277 | 0.026 | 0.81 | 0.024 | 0.75 | 93% |
| - X11K2 DD Irr | 281 | 0.014 | 0.44 | 0.013 | 0.42 | 96% |
| - X11K2 RoR Irr | 285 | 0.118 | 3.71 | 0.040 | 1.26 | 34% |
| - X11K3 RoR Irr | 289 | 0.041 | 1.28 | 0.038 | 1.19 | 93% |
| - X11K4 RoR Irr | 293 | 0.062 | 1.96 | 0.038 | 1.18 | 60% |
| - X12A1 RoR Irr | 297 | 0.003 | 0.09 | 0.003 | 0.08 | 83% |
| - X12B1 DD Irr | 303 | 0.003 | 0.09 | 0.003 | 0.09 | 100% |
| - X12C2 RoR Irr | 307 | 0.001 | 0.03 | 0.001 | 0.03 | 91% |
| - X12D1 RoR Irr | 311 | 0.006 | 0.18 | 0.004 | 0.14 | 79% |
| - X12D2 DD Irr | 315 | 0.004 | 0.13 | 0.004 | 0.13 | 100% |
| - X12D2 RoR Irr | 319 | 0.018 | 0.57 | 0.015 | 0.49 | 85% |
| - X12F3 RoR Irr | 323 | 0.018 | 0.56 | 0.016 | 0.50 | 89% |
| - X12G3 DD Irr | 327 | 0.011 | 0.36 | 0.011 | 0.36 | 101% |
| - X12G3 RoR Irr | 331 | 0.048 | 1.52 | 0.041 | 1.31 | 86% |
| **Komati River Catchment** | **Scenario 3 - Allocated water use and reserve** | | | | | |
| **Water Use Categories** | **Channels** | **Demand** | | **Supply** | | **Assurance** |

| | | m3/s | MCM/a | m3/s | MCM/a | |
|---|---|---|---|---|---|---|
| **Irrigation Swaziland** | Swaz | **8.278** | **261.24** | **7.968** | **251.44** | **96%** |
| - X13E1 RoR Irr | 335 | 0.247 | 7.80 | 0.212 | 6.69 | 86% |
| - X13G1 RoR Irr | 341 | 0.224 | 7.08 | 0.194 | 6.11 | 86% |
| - X13G2 RoR Irr | 345 | 0.048 | 1.51 | 0.030 | 0.93 | 62% |
| - X13G3 RoR Irr | 437 | 0.244 | 7.69 | 0.218 | 6.87 | 89% |
| - X14D2 RoR Irr | 379 | 0.029 | 0.92 | 0.003 | 0.09 | 10% |
| - X14E1 RoR Irr | 385 | 0.120 | 3.79 | 0.120 | 3.79 | 100% |
| - X14G2 RoR Irr | 389 | 0.056 | 1.76 | 0.056 | 1.76 | 100% |
| - X13G1 Mbuluzi tra for Irr (min-max) | 617 | 3.861 | 121.83 | 3.775 | 119.12 | 98% |
| - X13H2 Mhlume Irr (min-max)* | 642 | 3.450 | 108.87 | 3.361 | 106.07 | 97% |
| **Irrigation SA (controlled)** | SA | **11.507** | **363.12** | **9.753** | **307.79** | **85%** |
| - X13J1 controlled (X13J1.ird) | 620 | 0.015 | 0.48 | 0.012 | 0.39 | 82% |
| - X13J2 controlled (X13J2.ird) | 621 | 0.184 | 5.80 | 0.038 | 1.20 | 21% |
| - X13J3 controlled (min-max) | 622 | 1.836 | 57.94 | 1.734 | 54.71 | 94% |
| - X13J4 controlled (min-max) | 623 | 0.190 | 5.99 | 0.183 | 5.78 | 96% |
| - X13K1 controlled (X13K1.ird) | 624 | 0.722 | 22.77 | 0.081 | 2.55 | 11% |
| - X13K2 controlled (min-max)^ | 640 | 3.725 | 117.56 | 3.678 | 116.08 | 99% |
| - X13L1 controlled (X13L1.ird) | 626 | 0.781 | 24.65 | 0.038 | 1.19 | 5% |
| - X13L2 controlled (min-max) | 641 | 1.127 | 35.56 | 1.124 | 35.48 | 100% |
| - X14F1 controlled (X14F1.ird) | 628 | 0.005 | 0.17 | 0.005 | 0.16 | 96% |
| - X14G1 controlled (min-max) | 629 | 0.395 | 12.45 | 0.386 | 12.17 | 98% |
| - X14G3 controlled (min-max) | 631 | 0.106 | 3.34 | 0.104 | 3.27 | 98% |
| - X14H1 controlled (min-max) | 632 | 2.422 | 76.42 | 2.371 | 74.81 | 98% |
| **Transfers** | | **0.269** | **8.48** | **0.218** | **6.87** | 81% |
| - Barberton [Lomati Dam to SuidK] | 618 | 0.123 | 3.87 | 0.109 | 3.43 | 89% |
| - X14B1 (Louws Creek IB) (Shiyaf.tra) | 389 | 0.146 | 4.61 | 0.109 | 3.43 | 75% |
| **Ecological Water Requirements** | - | **7.216** | **227.71** | **7.216** | **227.71** | **100%** |
| - EWR 5 (Nooitgedacht Dam) | 704 | 1.104 | 34.8 | 0.414 | 13.06 | 37% |
| - EWR X11F (Gemsbokhoek) | 710 | 1.214 | 38.3 | 1.214 | 38.30 | 100% |
| - EWR X11H-1(Vygeboom Dam) | 712 | 1.722 | 54.3 | 1.721 | 54.32 | 100% |
| - EWR X11J-1 (Gladdespruit) | 713 | 0.285 | 9.0 | 0.279 | 8.80 | 98% |
| - EWR X11K-4 (Upper Komati) | 717 | 5.129 | 161.9 | 3.995 | 126.07 | 78% |
| - EWR X12H-3 (Hoegenoeg) | 733 | 3.253 | 102.7 | 3.252 | 102.63 | 100% |
| - EWR X13B-1 (Maguga Dam) | 740 | 7.386 | 233.1 | 7.385 | 233.05 | 100% |
| - EWR X14E-1 (Driekoppies Dam) | 761 | 1.748 | 55.2 | 1.748 | 55.15 | 100% |
| - EWR X14H-1 (Lomati) | 766 | 1.480 | 46.7 | 1.480 | 46.72 | 100% |
| - EWR X13K-2 | 768 | 7.216 | 227.7 | 7.216 | 227.71 | 100% |
| **Total Water Use Demand (MCM/a)** | - | - | **869.52** | - | **784.83** | **90%** |
| **Total Demand and reserve (MCM/a)** | - | - | **1097.23** | - | **1012.54** | **92%** |

*** Allocation used**

**^ Irrigation requirement reduced to meet terms of IIMA**

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# YIELD RESULTS FOR THE CROCODILE (EAST) CATCHMENT

## Table A.4 Results of the water availability assessment for Scenario 1

| Crocodile River Catchment | Scenario 1 - Best est of current day use with Croc Main IB alloc | | | | | |
|---|---|---|---|---|---|---|
| Water Use Categories | Channels | Demand | | Supply | | Assurance |
| | | m3/s | MCM/a | m3/s | MCM/a | |
| **Cross border flows** | **617** | **0.900** | **28.40** | **0.900** | **28.40** | **100%** |
| **Strategic** | **-** | **-** | **-** | **-** | **-** | **-** |
| **Industrial** | **-** | **0.708** | **22.35** | **0.709** | **22.36** | **100%** |
| - Sappi Ngodwana | 600 | 0.424 | 13.37 | 0.424 | 13.38 | 100% |
| - Malelane Sugar Mill | 603 | 0.285 | 8.98 | 0.285 | 8.98 | 100% |
| **Domestic** | **-** | **1.538** | **48.53** | **1.537** | **48.52** | **100%** |
| - Dullstroom | 604 | 0.015 | 0.48 | 0.015 | 0.48 | 100% |
| - Machadorp | 605 | 0.015 | 0.48 | 0.015 | 0.48 | 100% |
| - Watervalboven | 606 | 0.023 | 0.72 | 0.023 | 0.72 | 100% |
| - Nelspruit, Emoyeni | 601 | 0.369 | 11.63 | 0.368 | 11.62 | 100% |
| - White River 1 (Longmere) | 607 | 0.036 | 1.13 | 0.036 | 1.13 | 100% |
| - White River 2 (Sand) | 612 | 0.024 | 0.75 | 0.024 | 0.75 | 100% |
| - Nsikazi South | 602 | 0.810 | 25.56 | 0.810 | 25.56 | 100% |
| - Matsulu | 608 | 0.167 | 5.26 | 0.167 | 5.26 | 100% |
| - Malelane | 609 | 0.068 | 2.16 | 0.068 | 2.16 | 100% |
| - Hectorspruit | 610 | 0.011 | 0.36 | 0.011 | 0.36 | 100% |
| **Irrigation (All)** | **-** | **16.296** | **514.26** | **14.253** | **449.79** | **87%** |
| **Irrigation (Outside Croc Main IB)** | **-** | **2.980** | **94.03** | **1.767** | **55.75** | **59%** |
| - X21B2 RoR Irr | 201 | 0.025 | 0.78 | 0.025 | 0.79 | 101% |
| - X21B3 DD Irr | 207 | 0.039 | 1.24 | 0.035 | 1.11 | 90% |
| - X21C1 RoR Irr | 211 | 0.036 | 1.12 | 0.036 | 1.13 | 101% |
| - X21C2 DD Irr | 215 | 0.031 | 0.97 | 0.028 | 0.89 | 92% |
| - X21C3 RoR Irr | 219 | 0.005 | 0.15 | 0.005 | 0.16 | 102% |
| - X21H2 Ngo Irr | 235 | 0.001 | 0.04 | 0.001 | 0.04 | 92% |
| - X21K2 RoR Irr | 249 | 0.002 | 0.06 | 0.002 | 0.06 | 100% |
| - X21K3 RoR Irr | 253 | 0.002 | 0.05 | 0.002 | 0.05 | 100% |
| - X22A2 RoR Irr | 257 | 0.002 | 0.06 | 0.002 | 0.06 | 100% |
| - X22C1 DD Irr | 271 | 0.039 | 1.22 | 0.036 | 1.13 | 93% |
| - X22C2 RoR Irr | 275 | 0.255 | 8.05 | 0.079 | 2.50 | 31% |
| - X22C3 RoR Irr (F17 adj)* | 279 | 0.671 | 21.17 | 0.178 | 5.62 | 27% |
| - X22F1 IB Irr | 283 | 0.327 | 10.31 | 0.288 | 9.09 | 88% |
| - X22F2 IB Irr | 287 | 0.486 | 15.32 | 0.474 | 14.97 | 98% |
| - X22H1 IB Irr | 291 | 0.065 | 2.06 | 0.060 | 1.91 | 92% |
| - X22H2 IB Irr | 297 | 0.317 | 9.99 | 0.022 | 0.68 | 7% |
| - X23D1 RoR Irr (F17 adj)* | 343 | 0.089 | 2.82 | 0.089 | 2.81 | 100% |
| - X23D2 RoR (F17 adj) | 347 | 0.121 | 3.82 | 0.033 | 1.04 | 27% |
| - X23E2 DD Irr | 351 | 0.024 | 0.76 | 0.020 | 0.62 | 81% |
| - X23F1 RoR Irr | 355 | 0.227 | 7.15 | 0.217 | 6.85 | 96% |
| - X23G2 RoR (F17 adj)* | 363 | 0.128 | 4.05 | 0.046 | 1.45 | 36% |
| - X23H1 RoR Irr | 369 | 0.073 | 2.31 | 0.073 | 2.31 | 100% |
| - X24B1 DD Irr | 389 | 0.015 | 0.47 | 0.014 | 0.43 | 92% |
| - X24B2 DD Irr | 395 | 0.001 | 0.04 | 0.001 | 0.04 | 100% |
| **Irrigation (Crocodile Main IB)*** | | **13.316** | **420.23** | **12.486** | **394.04** | **94%** |
| Crocodile River Catchment | Scenario 1 - Best est of current day use with Croc Main IB alloc | | | | | |
| Water Use Categories | Channels | Demand | | Supply | | Assurance |
| | | m3/s | MCM/a | m3/s | MCM/a | |
| - X21D1 controlled (X21D1.ird) | 620 | 0.120 | 3.80 | 0.105 | 3.31 | 87% |
| - X21E1 controlled (X21E2.ird) | 621 | 0.255 | 8.05 | 0.241 | 7.62 | 95% |
| - X21J2 controlled (X21J2.ird) | 622 | 0.211 | 6.66 | 0.200 | 6.32 | 95% |

| | | | | | | |
|---|---|---|---|---|---|---|
| - X22B1 controlled (X22B1.ird) | 623 | 0.156 | 4.93 | 0.146 | 4.61 | 93% |
| - X22B2 controlled (X22B2.ird) | 624 | 0.168 | 5.29 | 0.160 | 5.03 | 95% |
| - X22C3 controlled (X22C3.ird) | 625 | 0.970 | 30.60 | 0.919 | 29.00 | 95% |
| - X22H3 controlled (Primkop.ird) | 626 | 0.394 | 12.44 | 0.328 | 10.34 | 83% |
| - X22J2 controlled (X22J2.ird) | 627 | 0.754 | 23.81 | 0.718 | 22.66 | 95% |
| - X22K3 controlled (X22K3.ird) | 628 | 1.173 | 37.02 | 1.106 | 34.90 | 94% |
| - X23A2 controlled (X23A2.ird) | 629 | 0.042 | 1.32 | 0.042 | 1.32 | 100% |
| - X23B3 controlled (X23B3.ird) | 630 | 0.536 | 16.90 | 0.421 | 13.30 | 79% |
| - X23D2 controlled (X23D2.ird) | 631 | 0.247 | 7.80 | 0.181 | 5.72 | 73% |
| - X23F2 controlled (X23F2.ird) | 632 | 0.519 | 16.39 | 0.476 | 15.01 | 92% |
| - X23G2 controlled (X23G2.ird) | 633 | 0.204 | 6.44 | 0.191 | 6.01 | 93% |
| - X23H4 controlled (X23H4.ird) | 634 | 0.431 | 13.60 | 0.406 | 12.83 | 94% |
| - X23H5 controlled (X23H3.ird) | 635 | 0.229 | 7.22 | 0.217 | 6.86 | 95% |
| - X24C2 controlled (X24C2.ird) | 636 | 0.290 | 9.16 | 0.276 | 8.70 | 95% |
| - X24D2 controlled (X24D2.ird) | 637 | 1.792 | 56.56 | 1.688 | 53.27 | 94% |
| - X24E2 controlled (X24E2.ird) | 638 | 1.101 | 34.73 | 1.038 | 32.76 | 94% |
| - X24F1 controlled (X24F1.ird) | 639 | 1.094 | 34.52 | 1.037 | 32.74 | 95% |
| - X24H1 controlled (X24H1.ird) | 640 | 2.630 | 83.00 | 2.590 | 81.74 | 98% |
| **Inflows and urban returns** | | | | **0.494** | **15.59** | |
| - Shiyalongubu Dam transfers to Kaap (Louws Cr) | 644 | | | 0.139 | 4.37 | |
| - Nelspruit, Emoyeni | 614 | | | 0.192 | 6.06 | |
| - Nsikazi South | 615 | | | 0.164 | 5.16 | |
| **Other** | - | - | - | - | **5.41** | - |
| - Blinkwater transfer (Sand R to White R) | 611 | 0.500 | 15.78 | 0.172 | 5.41 | 34% |
| **Total Water Req. (MCM/a)** | **-** | | **613.54** | | **549.07** | **89%** |

* Crocodile Main IB - SA allocations (not Treaty)

## Table A.5 Results of the water availability assessment for Scenario 2

| Crocodile River Catchment | Scenario 2 - Allocated water use | | | | | |
|---|---|---|---|---|---|---|
| Water Use Categories | Channels | Demand | | Supply | | Assurance |
| | | m3/s | MCM/a | m3/s | MCM/a | |
| **Cross border flows** | **617** | **1.600** | **50.49** | **1.600** | **50.49** | **100%** |
| **Strategic** | **-** | **-** | **-** | **-** | **-** | **-** |
| **Industrial** | **-** | **0.843** | **26.61** | **0.843** | **26.61** | **100%** |
| - Sappi Ngodwana* | 600 | 0.463 | 14.60 | 0.463 | 14.60 | 100% |
| - Malelane Sugar Mill | 603 | 0.381 | 12.01 | 0.381 | 12.01 | 100% |
| **Domestic** | **-** | **1.468** | **46.34** | **1.469** | **46.34** | **100%** |
| - Dullstroom | 604 | 0.015 | 0.480 | 0.015 | 0.48 | 100% |
| - Machadorp* | 605 | 0.023 | 0.72 | 0.023 | 0.72 | 100% |
| - Watervalboven* | 606 | 0.030 | 0.96 | 0.030 | 0.96 | 100% |
| - Nelspruit, Emoyeni* | 601 | 0.472 | 14.90 | 0.472 | 14.90 | 100% |
| - White River 1 (Longmere)* | 607 | 0.040 | 1.25 | 0.040 | 1.25 | 100% |
| - White River 2 (Sand) | 612 | 0.024 | 0.75 | 0.024 | 0.75 | 100% |
| - White River 3 (Croc)* | 642 | 0.063 | 1.99 | 0.063 | 1.99 | 100% |
| - Nsikazi South* | 641 | 0.555 | 17.51 | 0.555 | 17.51 | 100% |
| - Matsulu | 608 | 0.167 | 5.26 | 0.167 | 5.26 | 100% |
| - Malelane | 609 | 0.068 | 2.16 | 0.068 | 2.16 | 100% |
| - Hectorspruit | 610 | 0.011 | 0.36 | 0.011 | 0.36 | 100% |
| **Irrigation (All)** | **-** | **15.281** | **482.23** | **13.687** | **431.92** | **90%** |
| **Irrigation (Outside Croc Main IB)** | **-** | **2.060** | **65.00** | **1.495** | **47.18** | **73%** |
| - X21B2 RoR Irr | 201 | 0.025 | 0.78 | 0.022 | 0.69 | 88% |
| - X21B3 DD Irr | 207 | 0.039 | 1.24 | 0.035 | 1.11 | 90% |
| - X21C1 RoR Irr | 211 | 0.036 | 1.12 | 0.032 | 0.99 | 89% |
| - X21C2 DD Irr | 215 | 0.031 | 0.97 | 0.028 | 0.89 | 92% |
| - X21C3 RoR Irr | 219 | 0.005 | 0.15 | 0.004 | 0.14 | 90% |
| - X21H2 Ngo Irr | 235 | 0.001 | 0.04 | 0.001 | 0.03 | 77% |
| - X21K2 RoR Irr | 249 | 0.002 | 0.06 | 0.002 | 0.06 | 90% |
| - X21K3 RoR Irr | 253 | 0.002 | 0.05 | 0.001 | 0.04 | 88% |
| - X22A2 RoR Irr | 257 | 0.002 | 0.06 | 0.002 | 0.05 | 89% |
| - X22C1 DD Irr | 271 | 0.039 | 1.22 | 0.036 | 1.13 | 93% |
| - X22C2 RoR Irr | 275 | 0.255 | 8.05 | 0.076 | 2.40 | 30% |
| - X22F1 IB Irr | 283 | 0.327 | 10.31 | 0.287 | 9.05 | 88% |
| - X22F2 IB Irr | 287 | 0.486 | 15.32 | 0.474 | 14.96 | 98% |
| - X22H1 IB Irr | 291 | 0.065 | 2.06 | 0.060 | 1.90 | 92% |
| - X22H2 IB Irr (F17 adj)* | 297 | 0.317 | 9.99 | 0.020 | 0.64 | 6% |
| - X23D1 RoR Irr | 343 | 0.089 | 2.82 | 0.090 | 2.83 | 100% |
| - X23E2 DD Irr | 351 | 0.024 | 0.76 | 0.020 | 0.62 | 81% |
| - X23F1 RoR Irr | 355 | 0.227 | 7.15 | 0.217 | 6.85 | 96% |
| - X23H1 RoR Irr | 369 | 0.073 | 2.31 | 0.073 | 2.31 | 100% |
| - X24B1 DD Irr | 389 | 0.015 | 0.47 | 0.014 | 0.43 | 92% |
| - X24B2 DD Irr | 395 | 0.001 | 0.04 | 0.001 | 0.04 | 100% |
| **Irrigation (Crocodile Main IB)** | **-** | **13.221** | **417.23** | **12.192** | **384.74** | **92%** |
| - X21D1 controlled (X21D1.ird) | 620 | 0.120 | 3.80 | 0.105 | 3.33 | 88% |
| - X21E1 controlled (X21E2.ird) | 621 | 0.255 | 8.05 | 0.240 | 7.57 | 94% |
| - X21J2 controlled (X21J2.ird) | 622 | 0.211 | 6.66 | 0.198 | 6.25 | 94% |
| - X22B1 controlled (X22B1.ird) | 623 | 0.156 | 4.93 | 0.145 | 4.56 | 92% |
| - X22B2 controlled (X22B2.ird) | 624 | 0.168 | 5.29 | 0.158 | 4.98 | 94% |
| - X22C3 controlled (X22C3.ird) | 625 | 0.970 | 30.60 | 0.910 | 28.73 | 94% |
| **Crocodile River Catchment** | **Scenario 2 - Allocated water use** | | | | | |
| **Water Use Categories** | **Channels** | **Demand** | | **Supply** | | **Assurance** |
| | | **m3/s** | **MCM/a** | **m3/s** | **MCM/a** | |

| | | | | | | |
|---|---|---|---|---|---|---|
| - X22H3 controlled (Primkop.ird) | 626 | 0.394 | 12.44 | 0.324 | 10.22 | 82% |
| - X22J2 controlled (X22J2.ird) | 627 | 0.754 | 23.81 | 0.710 | 22.41 | 94% |
| - X22K3 controlled (X22K3.ird) | 628 | 1.173 | 37.02 | 1.097 | 34.62 | 94% |
| - X23A2 controlled (X23A2.ird) | 629 | 0.042 | 1.32 | 0.042 | 1.32 | 100% |
| - X23B3 controlled (X23B3.ird) | 630 | 0.536 | 16.90 | 0.422 | 13.32 | 79% |
| - X23D2 controlled (X23D2.ird) | 631 | 0.247 | 7.80 | 0.183 | 5.76 | 74% |
| - X23F2 controlled (X23F2.ird) | 632 | 0.519 | 16.39 | 0.474 | 14.94 | 91% |
| - X23G2 controlled (X23G2.ird) | 633 | 0.204 | 6.44 | 0.190 | 5.98 | 93% |
| - X23H4 controlled (X23H4.ird) | 634 | 0.431 | 13.60 | 0.404 | 12.74 | 94% |
| - X23H5 controlled (X23H3.ird) | 635 | 0.229 | 7.22 | 0.216 | 6.81 | 94% |
| - X24C2 controlled (X24C2.ird) | 636 | 0.290 | 9.16 | 0.274 | 8.64 | 94% |
| - X24D2 controlled (X24D2.ird) | 637 | 1.792 | 56.56 | 1.689 | 53.31 | 94% |
| - X24E2 controlled (X24E2.ird) | 638 | 1.101 | 34.73 | 1.058 | 33.39 | 96% |
| - X24F1 controlled (X24F1.ird) | 639 | 1.094 | 34.52 | 1.078 | 34.03 | 99% |
| - X24H1 controlled (X24H1.ird)^ | 645(mi-m) | 2.535 | 80.00 | 2.276 | 71.82 | 90% |
| **Inflows and urban returns** | **-** | **-** | **-** | **0.496** | **15.64** | |
| - Shiyalongubu Dam transfers to Kaap (Louws Cr) | 644 | | 215.48 | 0.139 | 4.37 | |
| - Nelspruit, Emoyeni* | 614 | | 136.62 | 0.246 | 7.76 | |
| - Nsikazi South* | 643 | | 82.72 | 0.111 | 3.50 | |
| **Other** | - | - | - | **0.176** | **5.54** | - |
| - Blinkwater transfer | 611 | 0.500 | 15.78 | 0.176 | 5.54 | 35% |
| **Total Water Req. (MCM/a)** | **-** | - | **605.67** | - | **555.36** | **92%** |

*** Crocodile Main IB - SA allocations (not Treaty)**
**^ Irrigation requirement reduced to meet SA allocation for irrigation**

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## Table A.6 Results of the water availability assessment for Scenario 3

| Crocodile River Catchment | Scenario 3 - Allocated water use and reserve | | | | | |
|---|---|---|---|---|---|---|
| Water Use Categories | Channels | Demand | | Supply | | Assurance |
| | | m3/s | MCM/a | m3/s | MCM/a | |
| **Cross border flows** | **617** | **1.600** | **50.49** | **1.600** | **50.5** | **100%** |
| **Strategic** | **-** | **-** | **-** | **-** | **-** | **-** |
| **Industrial** | **-** | **0.843** | **26.60** | **0.843** | **26.6** | **100%** |
| - Sappi Ngodwana* | 600 | 0.463 | 14.60 | 0.463 | 14.60 | 100% |
| - Malelane Sugar Mill | 603 | 0.380 | 12.00 | 0.381 | 12.01 | 100% |
| **Domestic** | **-** | **1.468** | **46.34** | **1.389** | **43.8** | **95%** |
| - Dullstroom | 604 | 0.015 | 0.48 | 0.015 | 0.48 | 100% |
| - Machadorp* | 605 | 0.023 | 0.72 | 0.023 | 0.71 | 99% |
| - Watervalboven* | 606 | 0.030 | 0.96 | 0.030 | 0.95 | 99% |
| - Nelspruit, Emoyeni* | 601 | 0.472 | 14.90 | 0.452 | 14.25 | 96% |
| - White River 1 (Longmere)* | 607 | 0.040 | 1.25 | 0.040 | 1.25 | 100% |
| - White River 2 (Sand) | 612 | 0.024 | 0.75 | 0.024 | 0.75 | 100% |
| - White River 3 (Croc)* | 642 | 0.063 | 1.99 | 0.059 | 1.86 | 93% |
| - Nsikazi South* | 641 | 0.555 | 17.51 | 0.507 | 16.00 | 91% |
| - Matsulu | 608 | 0.167 | 5.26 | 0.162 | 5.12 | 97% |
| - Malelane | 609 | 0.068 | 2.16 | 0.067 | 2.11 | 98% |
| - Hectorspruit | 610 | 0.011 | 0.36 | 0.011 | 0.36 | 100% |
| **Irrigation (All)** | | **15.281** | **482.23** | **11.273** | **355.75** | **74%** |
| **Irrigation (Outside Croc Main IB)** | **-** | **2.060** | **65.00** | **1.425** | **44.97** | **69%** |
| - X21B2 RoR Irr | 201 | 0.025 | 0.78 | 0.015 | 0.47 | 60% |
| - X21B3 DD Irr | 207 | 0.039 | 1.24 | 0.035 | 1.11 | 90% |
| - X21C1 RoR Irr | 211 | 0.036 | 1.12 | 0.021 | 0.65 | 58% |
| - X21C2 DD Irr | 215 | 0.031 | 0.97 | 0.028 | 0.89 | 92% |
| - X21C3 RoR Irr | 219 | 0.005 | 0.15 | 0.003 | 0.09 | 61% |
| - X21H2 Ngo Irr | 235 | 0.001 | 0.04 | 0.001 | 0.04 | 100% |
| - X21K2 RoR Irr | 249 | 0.002 | 0.06 | 0.001 | 0.03 | 55% |
| - X21K3 RoR Irr | 253 | 0.002 | 0.05 | 0.001 | 0.03 | 56% |
| - X22A2 RoR Irr | 257 | 0.002 | 0.06 | 0.001 | 0.03 | 53% |
| - X22C1 DD Irr | 271 | 0.039 | 1.22 | 0.036 | 1.13 | 93% |
| - X22C2 RoR Irr | 275 | 0.255 | 8.05 | 0.059 | 1.87 | 23% |
| - X22F1 IB Irr | 283 | 0.327 | 10.31 | 0.306 | 9.65 | 94% |
| - X22F2 IB Irr | 287 | 0.486 | 15.32 | 0.481 | 15.17 | 99% |
| - X22H1 IB Irr | 291 | 0.065 | 2.06 | 0.064 | 2.01 | 98% |
| - X22H2 IB Irr (F17 adj)* | 297 | 0.317 | 9.99 | 0.026 | 0.80 | 8% |
| - X23D1 RoR Irr | 343 | 0.089 | 2.82 | 0.074 | 2.34 | 83% |
| - X23E2 DD Irr | 351 | 0.024 | 0.76 | 0.018 | 0.56 | 73% |
| - X23F1 RoR Irr | 355 | 0.227 | 7.15 | 0.182 | 5.74 | 80% |
| - X23H1 RoR Irr | 369 | 0.073 | 2.31 | 0.060 | 1.89 | 82% |
| - X24B1 DD Irr | 389 | 0.015 | 0.47 | 0.014 | 0.43 | 92% |
| - X24B2 DD Irr | 395 | 0.001 | 0.04 | 0.001 | 0.04 | 100% |
| **Irrigation (Crocodile Main IB)** | | **13.221** | **417.23** | **9.848** | **310.78** | **74%** |
| - X21D1 controlled (X21D1.ird) | X21d1.ird | 0.120 | 3.80 | 0.093 | 2.92 | 77% |
| - X21E1 controlled (X21E2.ird) | X21e2.ird | 0.255 | 8.05 | 0.172 | 5.41 | 67% |
| - X21J2 controlled (X21J2.ird) | X21j2.ird | 0.211 | 6.66 | 0.143 | 4.51 | 68% |
| - X22B1 controlled (X22B1.ird) | X22b1.ird | 0.156 | 4.93 | 0.102 | 3.23 | 66% |
| - X22B2 controlled (X22B2.ird) | X22b2.ird | 0.168 | 5.29 | 0.115 | 3.63 | 69% |
| - X22C3 controlled (X22C3.ird) | X22c3.ird | 0.970 | 30.60 | 0.697 | 22.01 | 72% |
| Crocodile River Catchment | Scenario 3 - Allocated water use and reserve | | | | | |
| Water Use Categories | Channels | Demand | | Supply | | Assurance |
| | | m3/s | MCM/a | m3/s | MCM/a | |

| | | | | | | |
|---|---|---|---|---|---|---|
| - X22H3 controlled (Primkop.ird) | Primkop.ird | 0.394 | 12.44 | 0.382 | 12.07 | 97% |
| - X22J2 controlled (X22J2.ird) | X22j2.ird | 0.754 | 23.81 | 0.535 | 16.87 | 71% |
| - X22K3 controlled (X22K3.ird) | X22k3.ird | 1.173 | 37.02 | 0.868 | 27.40 | 74% |
| - X23A2 controlled (X23A2.ird) | X23a2.ird | 0.042 | 1.32 | 0.042 | 1.32 | 100% |
| - X23B3 controlled (X23B3.ird) | X23b3.ird | 0.536 | 16.90 | 0.303 | 9.57 | 57% |
| - X23D2 controlled (X23D2.ird) | X23d2.ird | 0.247 | 7.80 | 0.141 | 4.46 | 57% |
| - X23F2 controlled (X23F2.ird) | X23f2.ird | 0.519 | 16.39 | 0.381 | 12.01 | 73% |
| - X23G2 controlled (X23G2.ird) | X23g2.ird | 0.204 | 6.44 | 0.154 | 4.86 | 76% |
| - X23H4 controlled (X23H4.ird) | X23h4.ird | 0.431 | 13.60 | 0.328 | 10.35 | 76% |
| - X23H5 controlled (X23H3.ird) | X23h5.ird | 0.229 | 7.22 | 0.176 | 5.54 | 77% |
| - X24C2 controlled (X24C2.ird) | X24c2.ird | 0.290 | 9.16 | 0.229 | 7.23 | 79% |
| - X24D2 controlled (X24D2.ird) | X24d2.ird | 1.792 | 56.56 | 1.381 | 43.57 | 77% |
| - X24E2 controlled (X24E2.ird) | X24e2.ird | 1.101 | 34.73 | 0.931 | 29.37 | 85% |
| - X24F1 controlled (X24F1.ird) | X24f1.ird | 1.094 | 34.52 | 0.999 | 31.53 | 91% |
| - X24H1 controlled (X24H1.ird)^ | 645(mi-m) | 2.535 | 80.00 | 1.677 | 52.92 | 66% |
| **Inflows and urban returns** | | | | | | |
| - Shiyalongubu Dam transfers to Louws Cr | 644 | | | 0.139 | 4.37 | |
| - Nelspruit, Emoyeni* | 614 | | | 0.246 | 7.76 | |
| - Nsikazi South* | 643 | | | 0.111 | 3.50 | |
| **Other** | **-** | **0.500** | **15.78** | **0.084** | **2.64** | |
| - Blinkwater transfer | 600 | 0.500 | 15.78 | 0.084 | 2.64 | |
| **EWR** | **-** | **6.482** | **204.56** | **6.482** | **204.6** | **100%** |
| - EWR 1 (X21A1) | 641 | 0.153 | 4.83 | 0.142 | 4.49 | 93% |
| - EWR 2 (X21B3) | 642 | 0.736 | 23.23 | 0.736 | 23.22 | 100% |
| - EWR 3 (X21E2) | 643 | 2.723 | 85.94 | 2.264 | 71.46 | 83% |
| - EWR 4 (X22K2) | 644 | 4.092 | 129.13 | 4.092 | 129.13 | 100% |
| - EWR 5 (X24D2) | 645 | 8.140 | 256.87 | 8.140 | 256.87 | 100% |
| - EWR 6 (X24H2) | 646 | 6.482 | 204.56 | 6.482 | 204.57 | 100% |
| - EWR 7 (X23H-1) | 647 | 0.979 | 30.89 | 0.979 | 30.90 | 100% |
| **Total Water Use Demand (MCM/a)** | **-** | **12.453** | **810.22** | | **681.25** | 84% |

*** Crocodile Main IB - SA allocations (not Treaty)**
**^ Irrigation requirement reduced to meet SA allocation for irrigation**

–

## YIELD RESULTS FOR THE SABIE CATCHMENT

### Table A.7 Results of the water availability assessment for Scenario 1

| Sabie River Catchment | Scenario 1 - Best est of current day use | | | | | |
|---|---|---|---|---|---|---|
| Water Use Categories | Channels | Demand | | Supply | | Ass |
| | | m3/s | MCM/a | m3/s | MCM/a | |
| **Cross border flows** | - | - | - | - | - | - |
| **Strategic** | - | - | - | - | - | - |
| **Industrial** | - | - | - | - | - | - |
| **Domestic** | - | **0.639** | **20.17** | **0.639** | **20.17** | **100%** |
| - Sabie | 600 | 0.049 | 1.56 | 0.049 | 1.56 | 100% |
| - Graskop | 620 | 0.011 | 0.36 | 0.011 | 0.36 | 100% |
| - Inyaka WTW | 604 | 0.507 | 15.99 | 0.507 | 15.99 | 100% |
| - Dom 1 | 605 | 0.057 | 1.79 | 0.057 | 1.79 | 100% |
| - Dom 2 | 606 | 0.004 | 0.12 | 0.004 | 0.12 | 100% |
| - Dom 4 | 608 | 0.011 | 0.36 | 0.011 | 0.36 | 100% |
| **Transfers out** | **-** | **0.205** | **6.48** | **0.205** | **6.48** | **100%** |
| - Nsikazi North (Hazy View) | 619 | 0.205 | 6.48 | 0.205 | 6.48 | 100% |
| **Irrigation Sabie (all)** | **-** | **3.172** | **100.10** | **2.636** | **83.20** | **83%** |
| **Irrigation Upper Sabie** | **-** | **2.624** | **82.81** | **2.221** | **70.09** | **85%** |
| - Irr1 X31D2 MD | 117 | 0.362 | 11.44 | 0.242 | 7.64 | 67% |
| - Irr2 X31D2 RoR | 121 | 0.119 | 3.76 | 0.120 | 3.78 | 101% |
| - Irr3 X31D3 MD | 125 | 0.443 | 13.98 | 0.168 | 5.30 | 38% |
| - Irr4 X31D3 RoR | 129 | 0.453 | 14.30 | 0.454 | 14.31 | 100% |
| - Irr5 X31E2 RoR | 133 | 0.037 | 1.15 | 0.036 | 1.15 | 100% |
| - Irr21 X31E3 RoR | 611 | 0.046 | 1.45 | 0.046 | 1.45 | 100% |
| - Irr22 X31G1 RoR | 613 | 0.050 | 1.59 | 0.048 | 1.51 | 95% |
| - Irr6 X31G3 RoR | 137 | 0.073 | 2.30 | 0.073 | 2.30 | 100% |
| - Irr23 X31H2 RoR | 615 | 0.004 | 0.14 | 0.004 | 0.14 | 100% |
| - Irr7 X31J1 MD | 141 | 0.220 | 6.93 | 0.220 | 6.94 | 100% |
| - Irr8 X31J1 RoR | 147 | 0.291 | 9.17 | 0.291 | 9.18 | 100% |
| - Irr9 X31K1 RoR | 151 | 0.093 | 2.92 | 0.093 | 2.93 | 100% |
| - Irr24 X31L3 RoR | 617 | 0.023 | 0.72 | 0.023 | 0.72 | 99% |
| - Irr10 X31M1 RoR | 155 | 0.411 | 12.97 | 0.404 | 12.74 | 98% |
| **Irrigation Sand** | - | **0.548** | **17.290** | **0.415** | **13.103** | **76%** |
| - Irr15 X32C6 Dam | 177 | 0.010 | 0.33 | 0.010 | 0.33 | 101% |
| - Irr17 X32F3 RoR | 185 | 0.135 | 4.26 | 0.017 | 0.54 | 13% |
| - Irr11 X32C2 MD | 159 | 0.025 | 0.79 | 0.021 | 0.66 | 84% |
| - Irr12 X32C2 RoR | 165 | 0.035 | 1.11 | 0.031 | 0.96 | 87% |
| - Irr13 X32C4 RoR | 169 | 0.030 | 0.96 | 0.028 | 0.89 | 93% |
| - Irr14 X32C5 RoR | 173 | 0.181 | 5.71 | 0.177 | 5.57 | 98% |
| - Irr16 X32F1 RoR | 181 | 0.047 | 1.48 | 0.047 | 1.47 | 99% |
| - Irr18 X32F4 RoR | 189 | 0.011 | 0.35 | 0.011 | 0.35 | 100% |
| - Irr19 X32G1 RoR | 193 | 0.061 | 1.93 | 0.061 | 1.93 | 100% |
| - Irr20 X32D2 RoR | 609 | 0.012 | 0.39 | 0.012 | 0.39 | 101% |
| **Total Water Req. (MCM/a)** | - | - | **126.75** | - | **109.85** | **87%** |

## Table A.8 Results of the water availability assessment for Scenario 2

| Sabie River Catchment | Scenario 2 - Allocated water use | | | | | |
|---|---|---|---|---|---|---|
| Water Use Categories | Channels | Demand | | Supply | | Ass |
| | | m3/s | MCM/a | m3/s | MCM/a | |
| **Cross border flows** | - | - | - | - | - | |
| **Strategic** | - | - | - | - | - | |
| **Industrial** | - | - | - | - | - | |
| **Domestic** | **-** | **0.859** | **27.11** | **0.859** | **27.11** | **100%** |
| - Sabie | 621 | 0.063 | 1.99 | 0.063 | 1.99 | 100% |
| - Graskop* | 625 | 0.011 | 0.36 | 0.011 | 0.36 | 100% |
| - Hazy View* | 626 | 0.016 | 0.50 | 0.016 | 0.50 | 100% |
| - Inyaka WTW | 619 | 0.697 | 21.99 | 0.697 | 21.99 | 100% |
| - Dom 1 | 605 | 0.057 | 1.79 | 0.057 | 1.79 | 100% |
| - Dom 2 | 606 | 0.004 | 0.12 | 0.004 | 0.12 | 100% |
| - Dom 4 | 608 | 0.011 | 0.36 | 0.011 | 0.36 | 100% |
| **Transfers out** | **-** | **0.254** | **8.02** | **0.254** | **8.02** | **100%** |
| - Nsikazi North* | 620 | 0.254 | 8.02 | 0.254 | 8.02 | 100% |
| **Irrigation Sabie (all)** | **-** | **3.091** | **97.53** | **2.586** | **81.61** | **84%** |
| **Irrigation Upper Sabie** | **-** | **2.543** | **80.24** | **2.171** | **68.51** | **85%** |
| - Irr8 X31J1 RoR (controlled)* | 623 | 0.461 | 14.55 | 0.461 | 14.54 | 100% |
| - Irr9 X31K1 RoR (controlled)* | 622 | 0.062 | 1.95 | 0.062 | 1.95 | 100% |
| - Sabie IB (controlled) (min-Max)* | 624 | 0.214 | 6.75 | 0.214 | 6.75 | 100% |
| - Irr1 X31D2 MD | 117 | 0.362 | 11.42 | 0.242 | 7.64 | 67% |
| - Irr2 X31D2 RoR (adj for alloc) | 121 | 0.094 | 2.98 | 0.095 | 2.98 | 100% |
| - Irr3 X31D3 MD (adj for alloc) | 125 | 0.419 | 13.22 | 0.174 | 5.49 | 42% |
| - Irr4 X31D3 RoR (adj for alloc) | 129 | 0.287 | 9.06 | 0.288 | 9.09 | 100% |
| - Irr5 X31E2 RoR | 133 | 0.037 | 1.15 | 0.036 | 1.15 | 100% |
| - Irr21 X31E3 RoR | 611 | 0.046 | 1.45 | 0.046 | 1.45 | 100% |
| - Irr22 X31G1 RoR | 613 | 0.050 | 1.58 | 0.048 | 1.51 | 96% |
| - Irr6 X31G3 RoR | 137 | 0.073 | 2.30 | 0.073 | 2.30 | 100% |
| - Irr23 X31H2 RoR | 615 | 0.004 | 0.14 | 0.004 | 0.14 | 100% |
| - Irr24 X31L3 RoR | 617 | 0.023 | 0.72 | 0.023 | 0.72 | 100% |
| - Irr10 X31M1 RoR | 155 | 0.411 | 12.97 | 0.406 | 12.81 | 99% |
| **Irrigation Sand** | **-** | **0.548** | **17.290** | **0.415** | **13.100** | 76% |
| - Irr15 X32C6 Dam | 177 | 0.010 | 0.33 | 0.010 | 0.33 | 101% |
| - Irr17 X32F3 RoR | 185 | 0.135 | 4.26 | 0.017 | 0.54 | 13% |
| - Irr11 X32C2 MD | 159 | 0.025 | 0.79 | 0.021 | 0.66 | 84% |
| - Irr12 X32C2 RoR | 165 | 0.035 | 1.11 | 0.031 | 0.96 | 87% |
| - Irr13 X32C4 RoR | 169 | 0.030 | 0.96 | 0.028 | 0.88 | 92% |
| - Irr14 X32C5 RoR | 173 | 0.181 | 5.71 | 0.177 | 5.57 | 98% |
| - Irr16 X32F1 RoR | 181 | 0.047 | 1.48 | 0.047 | 1.47 | 99% |
| - Irr18 X32F4 RoR | 189 | 0.011 | 0.35 | 0.011 | 0.35 | 100% |
| - Irr19 X32G1 RoR | 193 | 0.061 | 1.93 | 0.061 | 1.93 | 100% |
| - Irr20 X32D2 RoR | 609 | 0.012 | 0.39 | 0.012 | 0.39 | 101% |
| **Total Water Req. (MCM/a)** | **-** | **-** | **132.65** | **-** | **116.74** | **88%** |

* SA allocations

# Table A.9 Results of the water availability assessment for Scenario 3

| Sabie River Catchment | Scenario 3 - Allocated water use with reserve | | | | | |
|---|---|---|---|---|---|---|
| Water Use Categories | Channels | Demand | | Supply | | Ass |
| | | m3/s | MCM/a | m3/s | MCM/a | |
| **Cross border flows** | - | - | - | - | - | |
| **Strategic** | - | - | - | - | - | |
| **Industrial** | - | - | - | - | - | |
| **Domestic** | **-** | **0.859** | **27.11** | **0.837** | **26.42** | **97%** |
| - Sabie | 621 | 0.063 | 1.99 | 0.053 | 1.68 | 84% |
| - Graskop* | 646 | 0.011 | 0.36 | 0.007 | 0.21 | 59% |
| - Hazy View* | 647 | 0.016 | 0.50 | 0.016 | 0.49 | 98% |
| - Inyaka WTW | 619 | 0.697 | 21.99 | 0.694 | 21.91 | 100% |
| - Dom 1 | 605 | 0.057 | 1.79 | 0.054 | 1.69 | 95% |
| - Dom 2 | 606 | 0.004 | 0.12 | 0.004 | 0.12 | 97% |
| - Dom 4 | 608 | 0.011 | 0.36 | 0.010 | 0.32 | 88% |
| **Transfers out** | **-** | **0.254** | **8.02** | **0.242** | **7.63** | **95%** |
| - Nsikazi North* | 620 | 0.254 | 8.02 | 0.242 | 7.63 | 95% |
| **Irrigation Sabie (all)** | **-** | **3.091** | **97.53** | **2.202** | **69.49** | **71%** |
| **Irrigation Upper Sabie** | **-** | **2.543** | **80.24** | **1.869** | **58.97** | **73%** |
| - Irr8 X31J1 RoR (controlled)* | 623 | 0.461 | 14.55 | 0.461 | 14.54 | 100% |
| - Irr9 X31K1 RoR (controlled)* | 622 | 0.062 | 1.95 | 0.036 | 1.13 | 58% |
| - Sabie IB (controlled) (min-Max)* | 624 | 0.214 | 6.75 | 0.136 | 4.30 | 64% |
| - Irr1 X31D2 MD | 117 | 0.362 | 11.42 | 0.242 | 7.64 | 67% |
| - Irr2 X31D2 RoR (adj for alloc) | 121 | 0.094 | 2.98 | 0.053 | 1.66 | 56% |
| - Irr3 X31D3 MD (adj for alloc) | 125 | 0.419 | 13.22 | 0.174 | 5.49 | 42% |
| - Irr4 X31D3 RoR (adj for alloc) | 129 | 0.287 | 9.06 | 0.181 | 5.71 | 63% |
| - Irr5 X31E2 RoR | 133 | 0.037 | 1.15 | 0.036 | 1.15 | 100% |
| - Irr21 X31E3 RoR | 611 | 0.046 | 1.45 | 0.046 | 1.45 | 100% |
| - Irr22 X31G1 RoR | 613 | 0.050 | 1.58 | 0.003 | 0.09 | 5% |
| - Irr6 X31G3 RoR | 137 | 0.073 | 2.30 | 0.062 | 1.97 | 86% |
| - Irr23 X31H2 RoR | 615 | 0.004 | 0.14 | 0.004 | 0.14 | 100% |
| - Irr24 X31L3 RoR | 617 | 0.023 | 0.72 | 0.023 | 0.72 | 100% |
| - Irr10 X31M1 RoR | 155 | 0.411 | 12.97 | 0.411 | 12.98 | 100% |
| **Irrigation Sand** | **-** | **0.548** | **17.290** | **0.334** | **10.524** | **61%** |
| - Irr15 X32C6 Dam | 177 | 0.010 | 0.33 | 0.010 | 0.33 | 101% |
| - Irr17 X32F3 RoR | 185 | 0.135 | 4.26 | 0.017 | 0.54 | 13% |
| - Irr11 X32C2 MD | 159 | 0.025 | 0.79 | 0.012 | 0.38 | 48% |
| - Irr12 X32C2 RoR | 165 | 0.035 | 1.11 | 0.018 | 0.58 | 52% |
| - Irr13 X32C4 RoR | 169 | 0.030 | 0.96 | 0.018 | 0.58 | 60% |
| - Irr14 X32C5 RoR | 173 | 0.181 | 5.71 | 0.135 | 4.24 | 74% |
| - Irr16 X32F1 RoR | 181 | 0.047 | 1.48 | 0.043 | 1.34 | 91% |
| - Irr18 X32F4 RoR | 189 | 0.011 | 0.35 | 0.011 | 0.35 | 99% |
| - Irr19 X32G1 RoR | 193 | 0.061 | 1.93 | 0.058 | 1.81 | 94% |
| - Irr20 X32D2 RoR | 609 | 0.012 | 0.39 | 0.012 | 0.37 | 95% |
| Sabie River Catchment | Scenario 3 - Allocated water use with reserve | | | | | |
| Water Use Categories | Channels | Demand | | Supply | | Ass |
| | | m3/s | MCM/a | m3/s | MCM/a | |
| **EWR** | **-** | **12.232** | **209.3** | **12.027** | **206.4** | **99%** |
| - EWR 1 | 638 | 1.656 | 52.3 | 1.639 | 51.72 | 99% |
| - EWR 2 | 628 | 0.733 | 23.1 | 0.733 | 23.13 | 100% |
| **- EWR 3 [Sabie]** | **639** | **5.281** | **166.7** | **5.281** | **166.66** | **100%** |
| - EWR 4 | 629 | 1.183 | 37.3 | 1.089 | 34.37 | 92% |
| - EWR 5 | 632 | 1.176 | 37.1 | 1.176 | 37.11 | 100% |
| - EWR 6 | 643 | 0.499 | 15.7 | 0.498 | 15.72 | 100% |

| | | | | | | |
|---|---|---|---|---|---|---|
| - EWR 7 | 641 | 0.353 | 11.1 | 0.353 | 11.14 | 100% |
| **- EWR 8 [Sand]** | **645** | **1.351** | **42.6** | **1.258** | **39.70** | **93%** |
| **Total Water Req. (MCM/a)** | **-** | **-** | **341.9** | **-** | **309.9** | **91%** |

* SA allocations

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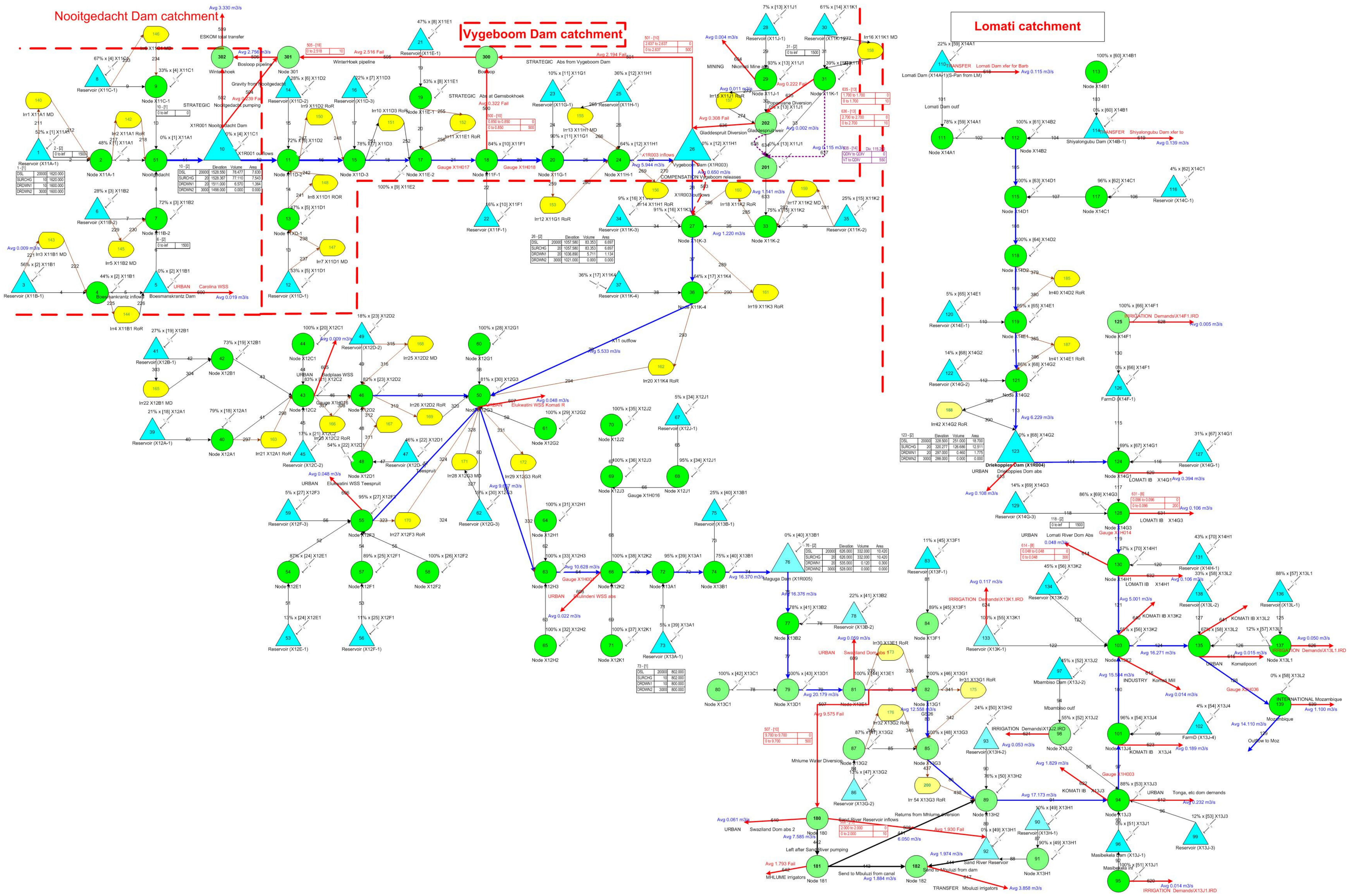
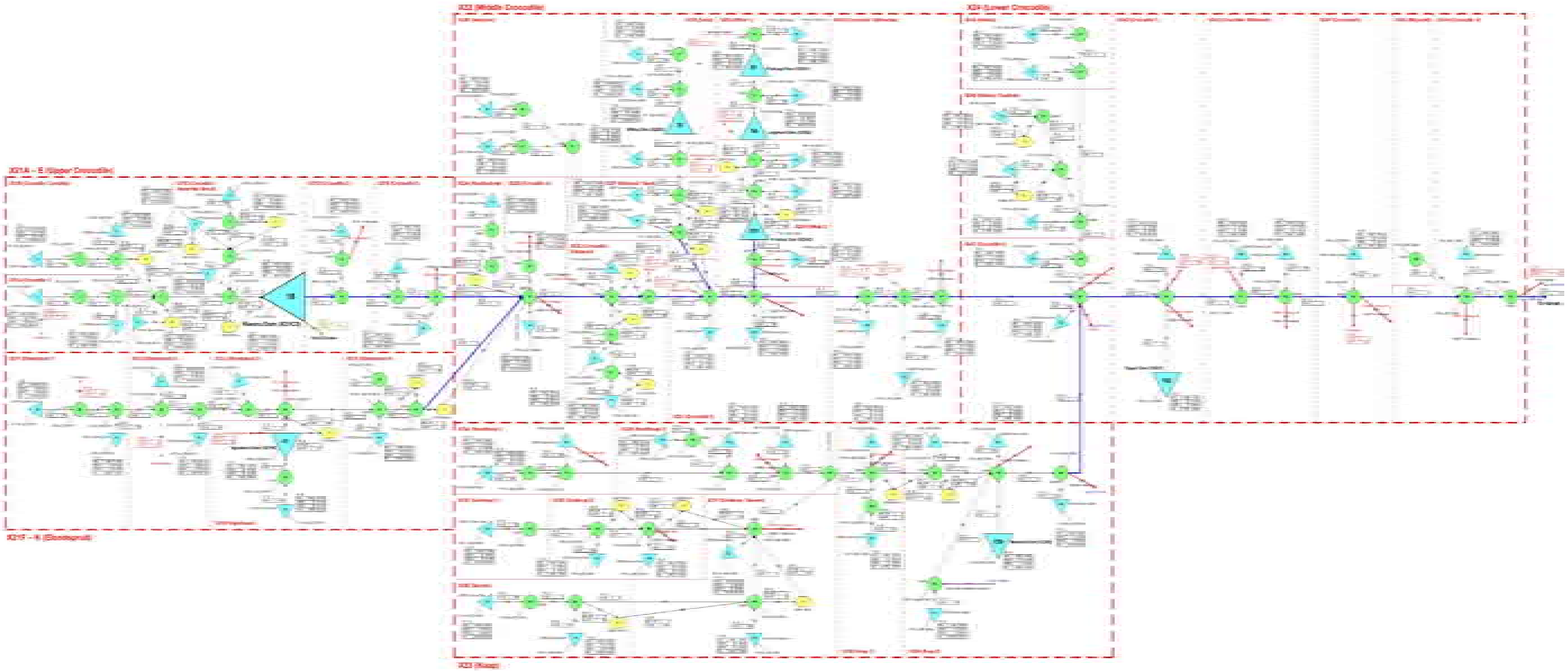
# APPENDIX B WRYM SYSTEM DIAGRAMS

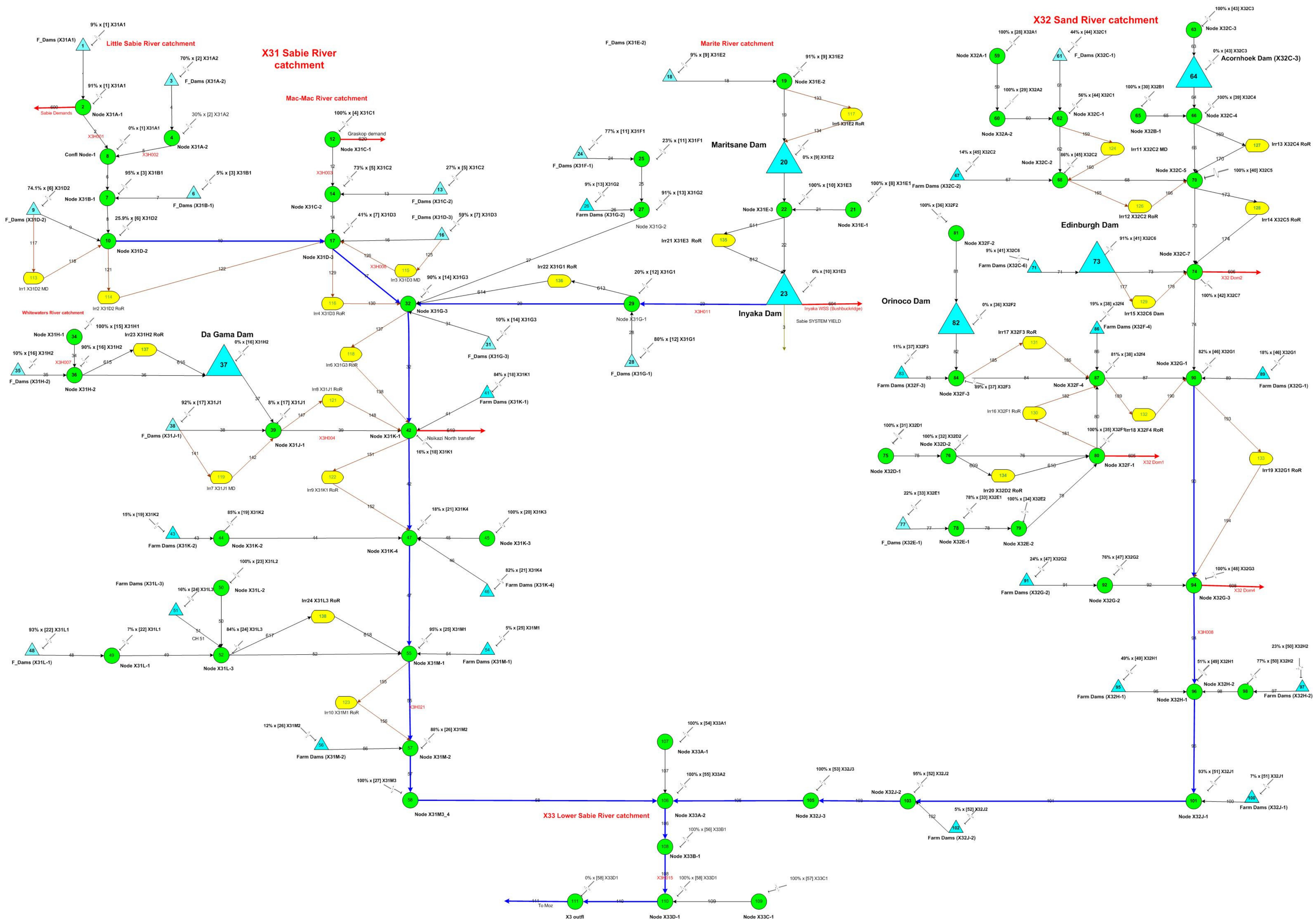
# Network 1: WQRYM system diagram for the Komati River system



## Network 2: WRYM system dagram for the Crocodile system

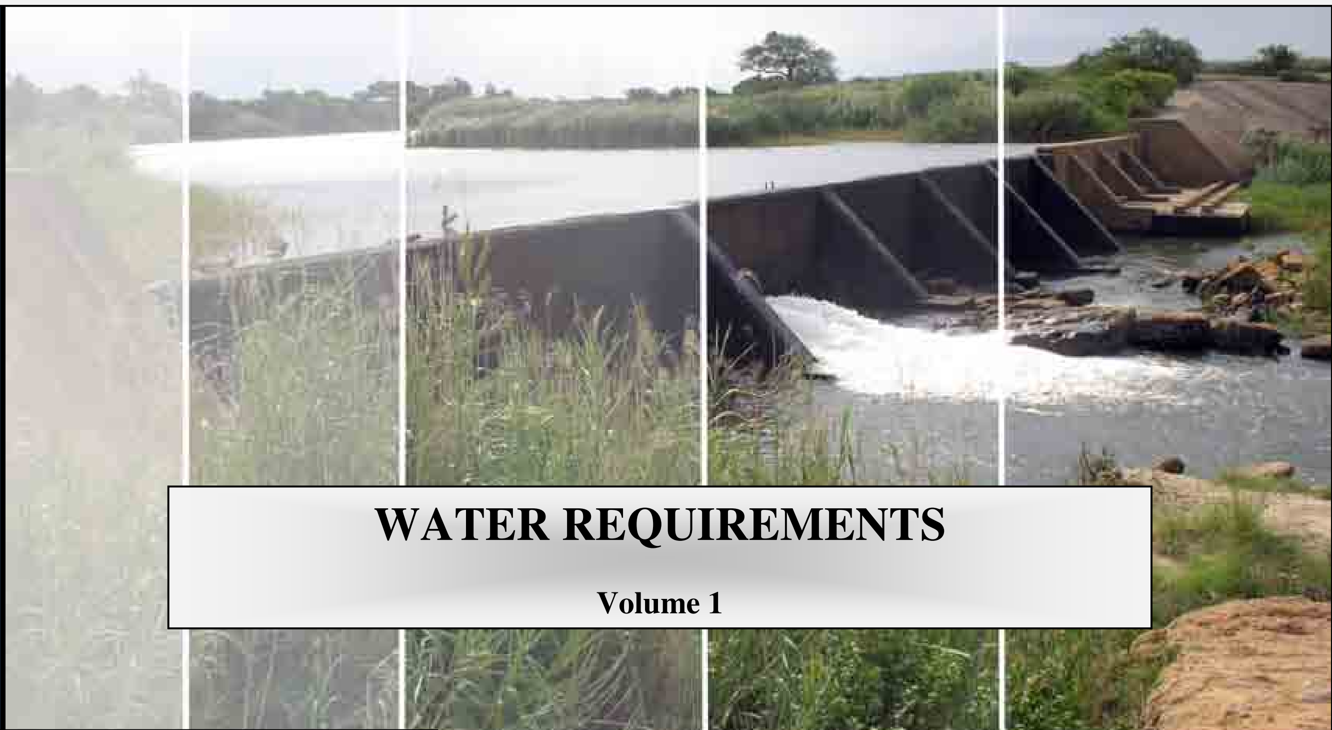


# Network 3: WRYM system diagram for the Sabie system



DEPARTMENT OF WATER AFFAIRS & FORESTRY

# INKOMATI WATER AVAILABILITY ASSESSMENT



## WATER REQUIREMENTS

Volume 1

Report No. PWMA 05/X22/00/0908

June 2009

Water for Africa
Environmental, Engineering & Management Consultants (Pty) Ltd

CPH2O

SRK Consulting
Engineers and Scientists

| | |
|---|---|
| **PROJECT NAME:** | INKOMATI WATER AVAILABILITY ASSESSMENT |
| **REPORT TITLE:** | Water Requirements: Volume 1 |
| **AUTHORS:** | S Mallory |
| | A Beater |
| **REPORT STATUS:** | FINAL |
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30/9/2009

**SJL Mallory** (Date)

Project Leader

**DEPARTMENT OF WATER AFFAIRS AND FORESTRY**

Directorate of Water resource Planning Systems

Approved for Department of Water Affairs and Forestry by:

27/10/2009 29/10/2009

N J van Wyk (Date) J A van Rooyen (Date)

Chief Engineer: Water Resource Planning (East) Director: Water Resource Planning

# SCHEDULE OF REPORTS

| | | |
|---|---|---|
| | PWMA 05/X22/00/0808 | Main Report |
| This Report ☞ | PWMA 05/X22/00/0908 | Water Requirements Volume 1<br>Water Requirements<br>Volume 2: Assessment of Alien Vegetation |
| | PWMA 05/X22/00/1008 | Ecological Water Requirements |
| | PWMA 05/X22/00/1108 | Water Quality |
| | PWMA 05/X22/00/1208 | Infrastructure and Operating Rules Volume 1<br>Infrastructure and Operating Rules<br>Volume 2: Appendices |
| | PWMA 05/X22/00/1308 | Rainfall Volume !: Report<br>Rainfall Volume 2: Appendices |
| | PWMA 05/X22/00/1408 | Hydrology of Komati River Volume 1<br>Hydrology of Komati River<br>Volume 2: Appendices |
| | PWMA 05/X22/00/1508 | Hydrology of Crocodile River Volume 1<br>Hydrology of Crocodile River<br>Volume 2 Appendices |
| | PWMA 05/X22/00/1608 | Hydrology of Sabie River Volume 1<br>Hydrology of Sabie River<br>Volume 2 Appendices |
| | PWMA 05/X22/00/1708 | Yield Modelling Volume 1<br>Yield Modelling Volume 2: Appendices |

# WATER REQUIREMENTS REPORT

# EXECUTIVE SUMMARY

### Introduction and purpose of the study and this report

*The Inkomati Water Management Area (WMA) shown in **Figure 1.1** is located in the north-eastern corner of South Africa and incorporates the catchments of the Komati, Crocodile and Sabie Rivers. The Komati River rises in the south west corner of the WMA, flows through Swaziland then re-enters South Africa before flowing on into Mozambique. The Crocodile River, located in the centre of the WMA, joins the Komati River just before flowing into Mozambique, while the Sabie River forms a separate catchment in the North of the WMA, also flowing into Mozambique after flowing through the Kruger National Park. Once in Mozambique, the Sabie River joins the Komati River which at this point is referred to as the Incomati River. The Incomati River Basin is therefore an international river basin, shared by South Africa, Swaziland and Mozambique.*

*Previous studies reported that the Inkomati WMA is water stressed, with water requirements in excess of the available water resources, especially if the water requirements of Mozambique and the ecological Reserve are taken into account. This Water Availability Assessment consists of three main components, the first of which was to update the hydrology of the catchment, the second to determine the water requirements and where possible the actual water use within the WMA, and the third to set up a water resources model that accurately reflects the current situation of the catchment.*

*The purpose of this report is to document all the current water requirements within the Inkomati Water Management Area (WMA). Current within the context of this report is the year 2004. This report does not address future water requirements. The report also provides background as to how the information on water requirements was obtained.*

### Domestic Water Requirements

*Domestic water use within the Inkomati WMA is limited compared to other more developed catchments in South Africa. This is due to limited urban development. **Table I** lists the domestic water requirements in each major catchment within the study area and the significant towns and rural settlements in those catchments.*

**Table I: Current (2004) Domestic Water Requirements**

| Catchment | Requirement (million m$^3$/annum) | Domestic user / WSS |
|---|---|---|
| **Komati River catchment** | | |
| Upper Komati (X11 / X12) | 4.8 | Carolina, Badplaas, Elukwatwini, Ekulandini |
| Komati Swaziland (X13) | 3.8 | Piggs Peaks, small towns and villages |
| Lower Komati (X13) | 7.8 | Tonga, Masibekela, Magudu, Komatipoort |
| Lomati (X14) | 4.9 | Driekoppies, Nyathi, Langeloop |
| **Sub-Total** | **21.3** | |
| **Crocodile River catchment** | | |
| Upper Crocodile (X21) | 1.7 | Machadorp, Waterval Boven, Dullstroom |
| Middle Crocodile (X22) | 13.5 | Nelspruit, White River |
| Kaap River (X23) | 3.9 | Umjindi LM (Barbeton)* |
| Lower Crocodile (X24) | 39.4 | Nsikasi (North* and South), Matsula, Malalane, Hectorspruit, Marloth Park, Kaapmuiden |
| **Sub-total** | **58.5** | |
| **Sabie River catchment** | | |
| Sabie (X31) | 7.4 | Sabie, Graskop, Hazyview*, Hoxani |
| Sand (X32) | 13.3 | Bushbuckridge and numerous villages/settlements |
| **Sub-total** | **20.7** | |
| **TOTAL** | **100.4** | |

* Supplied from Sabie canal / Lomati Dam

## Industrial and Mining Water Requirements

*There are a number of large industrial water users in the Inkomati WMA while water use by the mining sector is insignificant. They are located in the Komati and Crocodile catchments. There are no significant mining or industrial water users in the Sabie catchments, in the Swaziland portion of the Komati River catchment or in the Lomati (X14) catchments. There are however several saw mills in the upper Sabie River catchments that negatively impact on water quality. The 2004 industrial and mining water requirements are summarized in **Table II**.*

**Table II: Current (2004) Industrial and mining water Requirements**

| Catchment | Water requirement (million m$^3$/annum) | Description |
|---|---|---|
| Komati | 0.1<br>0.5 | Inkomati Nickel mine in the upper Komati<br>Komati Sugar mill (TSB) in the lower Komati |
| Crocodile | 13.4<br>9.0 | Sappi Ngdwana in the Elands catchment<br>Malelane Sugar mill in the lower Crocodile |
| Sabie | 0 | |
| **TOTAL** | **23.0** | |

**Irrigation Water Requirements**

*By far the largest water user in the Inkomati WMA is the irrigation sector. It is important therefore to obtain good estimates of the water allocations to this sector as well as the actual water use. The difference between the allocation and actual use is important to understand and quantify as it has large implications, from the calibration of hydrological models through to the allocation of the limited water resources within the Inkomati WMA.*

*Within the context of this report, the irrigation water requirement is based on a theoretical calculation of how much water is required based on the crop area, the crop type, application efficiency of the irrigation system and climatic conditions. The model used to estimate the crop water requirements is the so-called WQT model, details of which can be found in the WRYM User Manual (DWAF, 2008). For a number of reasons, the actual water use does not always correspond to the theoretical water requirements or the allocated amount. Some of the reasons applicable in the Inkomati WMA are as follows:*

- *There is insufficient water available to supply all irrigators with their theoretical requirement.*
- *The theoretical water requirement assumes a so-called optimum crop water requirement which requires a high level of management to monitor. If water is cheap, as it is in much of the WMA, irrigators could over-irrigate if the water is available.*
- *In cases where water usage is controlled by an irrigation board, irrigators are more likely to be irrigating according to their quota or allocation and not according to a theoretical requirement.*

*For the purposes of this study, two estimates of irrigation demand have been made. These are as follows:*

- ***A theoretical calculation using the WQT model** (DWAF, 2008) and irrigated areas (and crop types) obtained from the validation study (DWAF, 2006).*
- ***Allocated water use** based on various sources of information. Where a discrepancy between estimates was found, the highest estimate was used. The various sources of allocated water use included:*
  - *Scheduled water use of irrigation boards. Since much of the irrigation within the WMA falls within irrigation boards, this accounts for most of the irrigation within the WMA.*
  - *Irrigation allocated in terms of the Komati Basin Treaty (JWC, 1984).*
  - *Irrigation allocated in terms of the Interim Inkomaputo Water Use Agreement (TPTC, 2004).*

*Irrigation water requirements and allocations are given in **Table III** and **IV** respectively.*

## Table III: Irrigated crop areas and irrigation water requirements (WQT model) in the Inkomati River catchments

| Catchment | Irrigated area ($km^2$) | Dominant crops type | Crop water requirements (million $m^3$ / annum) |
|---|---|---|---|
| **Komati** | | | |
| X11 | 29 | Maize | 14 |
| X12 | 8 | Maize | 4 |
| X13 | 359 | Sugarcane | 444 |
| X14 | 116 | Sugarcane | 126 |
| **Sub-total** | **512** | **Sugarcane** | **588** |
| **Crocodile** | | | |
| X21 | 39 | Maize | 21 |
| X22 | 213 | Vegetables (Cash crops) | 149 |
| X23 | 98 | Sugarcane | 92 |
| X24 | 163 | Sugarcane | 192 |
| **Sub-total** | **513** | **Sugarcane** | **454** |
| **Sabie** | | | |
| X31 | 103 | Citrus | 82 |
| X32 | 25 | Vegetables | 17 |
| **Sub-total** | **128** | **Citrus** | **99** |
| **TOTAL** | **1153** | | **1141** |

## Table IV: Allocations to irrigators in the Inkomati River catchments

| Catchment | Irrigation allocation (million $m^3$/annum) | Comment |
|---|---|---|
| Komati | 642 | Interim Inkomati Water Use Agreement (IIMA). Essentially the same as other allocations |
| Crocodile | 482<br>(307) | South Africa's allocation in terms of scheduled area and application rates plus existing lawful use.<br>IIMA allocation is less and not realistic. |
| Sabie | 98 | Interim Inkomati Water Use Agreement (IIMA). |
| **TOTAL** | **1222** | |

### Streamflow reduction due to afforestation

*Forestry in the escarpment areas of the Inkomati WMA provides an important economic input to WMA. The area of forestry appears to have increased significantly in some areas in recent years. Very few if any new licences for afforestation have been issued for many years by DWAF and hence it is uncertain whether the increased area is due to unlawful development or simply improved techniques in measuring the afforested areas. The afforested areas at tertiary catchment scale and the estimated streamflow reductions are summarised in* ***Table V****.*

**Table V: Inkomati catchment: Afforestation and estimated streamflow reduction**

| Catchment | Afforestation area ($km^2$) | Streamflow reduction (million $m^3$/annum) |
|---|---|---|
| X11: Upper Komati | 256 | 31 |
| X12: Middle Komati | 461 | 39 |
| X13: Lower Komati | 189 | 18 |
| X14: Lomati | 297 | 29 |
| **Komati sub-total** | **1203** | **117** |
| X21: Upper Crocodile | 587 | 52 |
| X22: Middle Crocodile | 901 | 66 |
| X23: Kaap | 443 | 40 |
| X24: Lower Crocodile | 12 | 0.4 |
| **Crocodile sub-total** | **1944** | **158** |
| X31: Sabie | 797 | 86 |
| X32: Sand | 56 | 4 |
| X33: Lower Sabie | 0 | 0 |
| **Sabie sub-total** | **853** | **90** |
| **TOTAL** | **4000** | **365** |

## Transfers out of catchments

*When dealing with the transfer of water from one catchment to another it is important to distinguish between the types of transfer. In this study transfers have been divided into transfers 'out' of the Inkomati WMA to adjacent WMAs, transfers into the WMA from adjacent WMAs, transfers out of the tertiary catchments but within the WMA and transfers between quinary catchments within each of the Komati, Crocodile and Sabie catchments. From a water requirement point view, only transfers out the WMA constitute an additional requirement that has not already been assigned to one of the user sectors described above. These additional requirements are given for current (2004) transfers in* ***Table VI****.*

**Table VI: Transfers to adjacent WMA's from the Inkomati WMA**

| Transfer scheme | Location | 2004 transfer (million $m^3$ /annum) | Description |
|---|---|---|---|
| Nooitgedacht/Vygeboom System to Eskom (1962 – 2004) | Upper Komati | 115 | Transfers from Nooitgedacht and Vygeboom Dams to Eskom p/s in Olifants WMA |
| Komati Mbuluzi transfer (1980 – 2004) | Mhlume weir d/s of Maguga Dam | 122 | From Komati River at CDC weir in Swaziland for irrigation in the Mbuluzi [W60] |
| **TOTAL** | | **237** | |

## Cross border flows

*The Pigg's Peak Agreement, signed in 1991, was an interim trilateral agreement stipulating that a minimum flow of 2 $m^3$/s (averaged over a three day period) should be recorded at Ressano Garcia. The more recent Interim IncoMaputo Water Use Agreement (TPTC 2002), states that a minimum flow of 2.6 $m^3$/s is required at Ressano Garcia for environmental purposes. This is assumed to be split 55 % and 45 % between the Komati and Crocodile Rivers respectively*

*(DWAF 2003). In addition to this, the IIMA also lists the existing water use by the three basin states. In the case of Mozambique, it lists requirements of 29 million $m^3$/annum and 1 million $m^3$/annum respectively for irrigation and domestic use in the Incomati River upstream of the confluence of the Sabie River. These users have no other source of water other than the flow that crosses the South African border and Ressano Garcia and hence it is realistic expectation that in addition to the stated minimum ecological flow requirements that these users must be supplied from South Africa. Assuming the 55 % / 45 % split between the Komati and Crocodile catchments, the following minimum flows are required from each sub-basin:*

*Komati: 61 million $m^3$/a or 1.95 $m^3$/s*
*Crocodile: 51 million $m^3$/a or 1.60 $m^3$/s*

## Conclusions

*Tables VI and VII summarise the water requirements, streamflow reduction and transfers out of the catchments for the two scenarios considered in this study, namely, the current (2004) best estimate of water requirements within the catchments and the allocated water requirements.*

**Table VI: Summary of current (2004) water requirements in the Inkomati WMA (Scenario 1: Theoretical and best estimates)**

| User group | Komati (incl. Swaziland) (million $m^3$ /annum) | Crocodile | Sabie |
|---|---|---|---|
| **Cross border flows** | 35 | 28 | 0 |
| **Transfers out of WMA** | 227(1) | 0 | 0 |
| **Industrial** | 1 | 22 | 0 |
| **Domestic** | 21 | 58 | 21 |
| **Irrigation(1)** | 492 | 454 | 99 |
| **Total** | **826** | **562** | **120** |
| **Afforestation (SFRA)** | 117 | 158 | 90 |

**Notes:** (1) Transfers for Eskom (105) and for irrigation in the Mbuluzi catchment (122).

**Table VII: Summary of allocated water requirements in the Inkomati WMA (Scenario 2: Water allocations)**

| User group | Komati (incl. Swaziland) (million $m^3$ /annum) | Crocodile | Sabie |
|---|---|---|---|
| **Cross border flows** | 61 | 51 | 0 |
| **Transfer out** | 132(1) | 0 | 0 |
| **Industrial** | 2 | 27 | 0 |
| **Domestic** | 50 | 58 | 27 |
| **Irrigation** | 642(2) | 482 | 98 |
| **Total** | **887** | **618** | **125** |
| **Afforestation (SFRA)** | 117 | 158 | 90 |

**Notes:** (1) Allocation to Eskom, which is not achievable with the current infrastructure
(2) The transfer to Mbuluzi of 122 million $m^3$/annum is included in the allocation.

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# List of Tables

# Appendices



# List of Figures in Appendix A

# Abbreviations and Acronyms

| | |
|---|---|
| DFID | Department for International Development |
| DWAF | National Department of Water Affairs and Forestry. |
| GIS | Geographic Information System |
| IB | Irrigation Board |
| ISP | Internal Strategic Perspective |
| KOBWA | Komati Basin Water Authority |
| LM | Local municipality |
| MAR | Natural Mean Annual Runoff |
| NWA | National Water Act (Act 36 of 1998) |
| NWRS | National Water Resource Strategy |
| SAPPI | South Africa Pulp and Paper Industry |
| WAAS | Water Availability Assessment Study |
| WARMS | Water Use Authorization and Registration Management System |
| WMA | Water Management Area |
| WMS | Water Management Systems Database |
| WQT | Water Quality Model |
| WR90 | The Water Resources (Hydrology) of South Africa completed |
| WRC | Water Research Commission |
| WRSM | Water Resource Simulation Model |
| WRYM | Water Resource Yield Model |
| WSS | Water supply scheme |

# 1. Introduction

The Inkomati Water Management Area (WMA), located in the north-eastern corner of South Africa, incorporates the catchments of the Komati, Crocodile and Sabie Rivers. The Komati River rises in the south west corner of the WMA, flows through Swaziland then re-enters South Africa before flowing on into Mozambique where it is known as the Incomati River. The Crocodile River is located in the centre of the WMA, completely within South Africa, joins the Komati River just before flowing into Mozambique. The Sabie River in the northern part of the WMA is joined by the Sand River in the Kruger National Park (KNP) before flowing into Mozambique. The northern most part of the WMA (catchment X4) is undeveloped and comprises two rivers. The Massintoto and Uanetze Rivers both originate and flow through the KNP before entering Mozambique. All the rivers join the Incomati River in Mozambique. The Incomati River Basin is therefore an international river basin, shared by South Africa, Swaziland and Mozambique.

The Inkomati WMA is considered to be stressed, with water requirements in excess of the available water resources, especially if the water requirements of Mozambique and the ecological Reserve are taken into account. The result of this is that the ecological Reserve is not met and the cross-border flows into Mozambique have on occasions been less than stipulated in various international agreements. The assurance of water supply to the irrigation sector is also very low in some areas, especially the lower reaches of the Crocodile river.

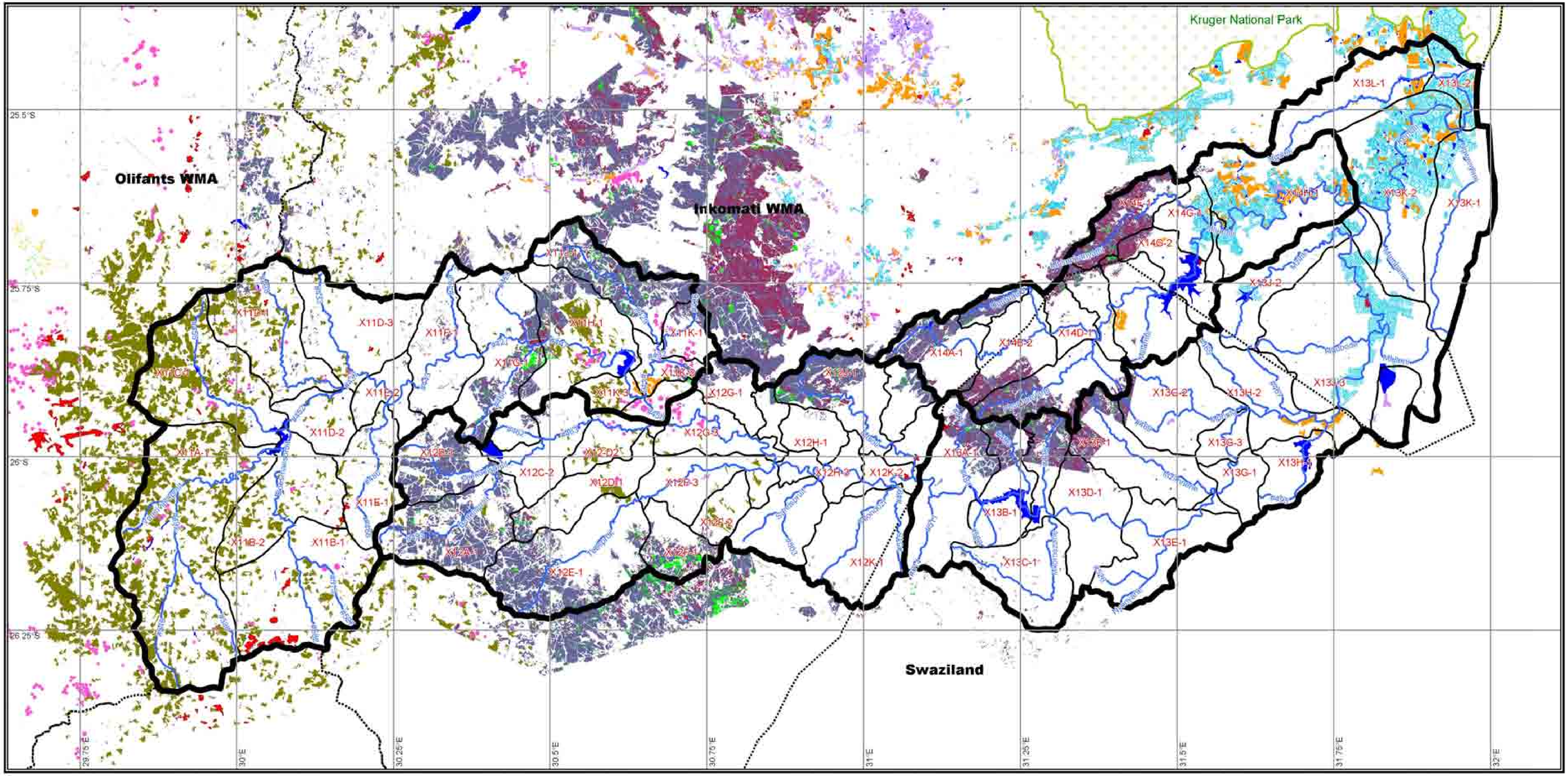
The National Water Act (Act 36 of 1998) provides the legal tool in the form of compulsory licensing, which allows the state to reallocate the water resource in accordance with the water supply objectives and priorities given in the National Water Act (NWA) and the National Water Resources Strategy (NWRS). In order to embark on such a reallocation process, a thorough understanding of current water use and the currently available water resource is required. The purpose of this study is to provide this understanding and set up a water resources model with the latest water use and system configuration which will facilitate water reallocation.

The study consists of three main components, the first of which is to determine the water requirements and where possible the actual water use within the WMA. The requirements must be determined for present day use to form a basis for re-allocation, while current and past water requirements are required for the calibration of the hydrological model, the second component of the study. The final component is to set up a water resources model which accurately reflects the current situation of the catchment in term of water requirements and water availability.

This report documents the water requirements in the Inkomati WMA. The information presented in this report was obtained primarily from the Validation and Verification study (DWAF, 2006), while additional information on urban water use was obtained from the Water Service Development Plans and personal contact with numerous individuals within the WMA. Historical water use was sourced from previous reports.

The purpose of this report is to document all the current water requirements within the Inkomati Water Management Area (WMA). Current within the context of this report is the year 2004. This report does not address future water requirements. The report also provides background as to how the information on water requirements was obtained. In some cases, there are significant discrepancies between the concepts of 'requirement' and 'water use' and where this is a problem, the methods used to distinguish between the two are described.

All maps and figures in this report are provided in **Appendix A**. Landuse maps for the Inkomati WMA are provided for the Komati (X1), Crocodile (X2) and Sabie (X3) drainage catchments in **Figures 1.1**, **1.2** and **1.3**. **Sections 2, 3, 4, 5, 6** and **7** summarise the different water uses that impact on runoff in the Inkomati WMA. **Section 8** refers to cross border flow requirements and **section 9** summarises current water requirements.




**Legend**

- Dryland Farming
- Clearfelled
- Eucalyptus Plantation
- Pine Plantation
- Wattle Plantation
- Maize Irrigation
- Vegetable Irrigation
- Citrus Irrigation
- Sugar Cane Irrigation
- Mining Activity
- Water Managemaent Areas
- Secondary Drainage Boundaries


N

**Figure 1.1a**

**Land use *in* the Komati River Catchment**

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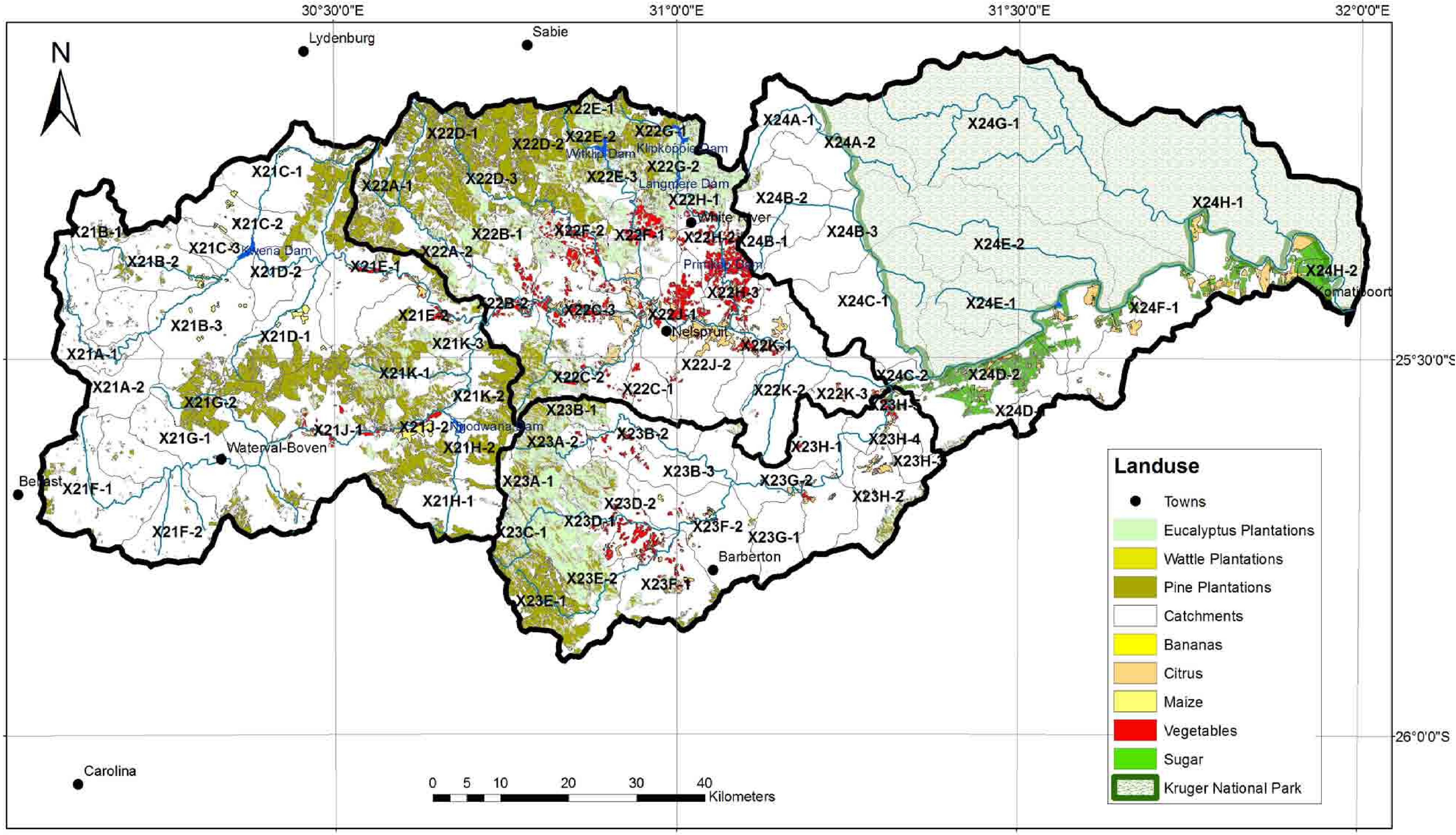
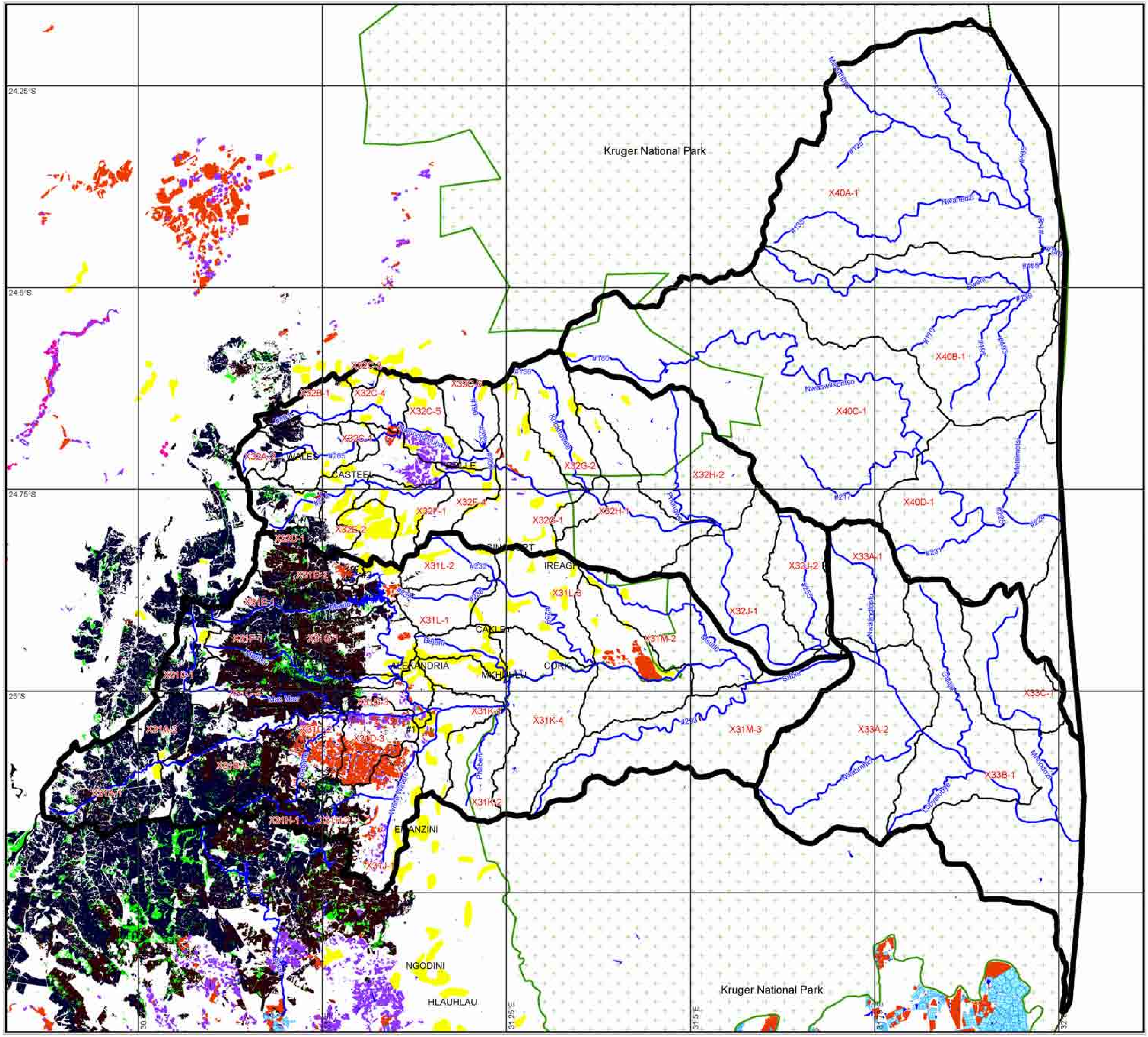



Figure 1.1b : Crocodile (East) Catchment - Landuse




# Figure 1.1c

## Land use in the Sabie River Catchment

**Legend**

- Dryland Farming
- Clearfelled
- Eucalyptus Plantation
- Pine Plantation
- Wattle Plantation
- Maize Irrigation
- Vegetable Irrigation
- Citrus Irrigation
- Sugar Cane Irrigation
- Mining Activity
- Water Management Areas
- Settlements

N

Prepared by:
RL Mallory
04/12/2008
Landuse.map

Scale 1:505870

0 2.5 5 10 15 20 25 km

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Reg. No. 2005/001583/07

# 2. Domestic water requirements

## 2.1 Introduction

It has been common practice in previous water resources studies to separate urban and rural water requirements. The reason for this is that rural water requirements were often not catered for in terms of water supply i.e. water was fetched in buckets from a nearby stream or from boreholes, and thus had very little influence on the available water resource. Since the last hydrological study of the Inkomati, several large-scale water supply schemes (WSS's) have been implemented. These supply water to numerous villages throughout the study area, blurring the distinction between rural and urban water use. **Figure 2.1** shows the main WSS's within the Inkomati WMA and within the local municipalities. **Figure 2.2** shows current domestic water demands at quinary catchment level.

While it is recognised that the per capita water use may vary from small villages (whose residents are probably relying on free basic water of 6 000 l/household/month) and established urban areas such as Nelspruit (where water use is nearer 350 l/person/day), the important point is to obtain accurate present day and historical water use estimates for towns and villages in the study area and to identify the source of this water as well as the point of abstraction in the case of rivers. Present day water use or current water requirements are provided for 2004 hydrological year, which relates to water requirements up to September 2005.

## 2.2 Komati River Catchment

Urban development within the Komati River catchment is limited, and the associated domestic water requirements are relatively small and often include rural water requirements. The main water supply schemes, current water requirements, and sources of water are summarized in **Table 2.1**. The Komati catchment has been divided into the Komati upstream of Swaziland, the Komati in Swaziland, the Komati downstream of Swaziland to the Mozambique border and the Lomati catchment.

Current (2004) water use information was obtained mostly from the Water Services Development Plans (WSDP) for the Albert Luthuli and Nkomazi Local Municipalities. Historical water use information was obtained mostly from the **JIBS study** (TPTC, 2001), and the **Maguga Basin Review** (Kobwa, 1998).

None of these supply schemes had detailed (monthly) water use information. The annual records were disaggregated to create monthly time series of water use. The time series developed for the various water supply schemes for the hydrological (WRSM2000) model are provided in **Appendix B**.

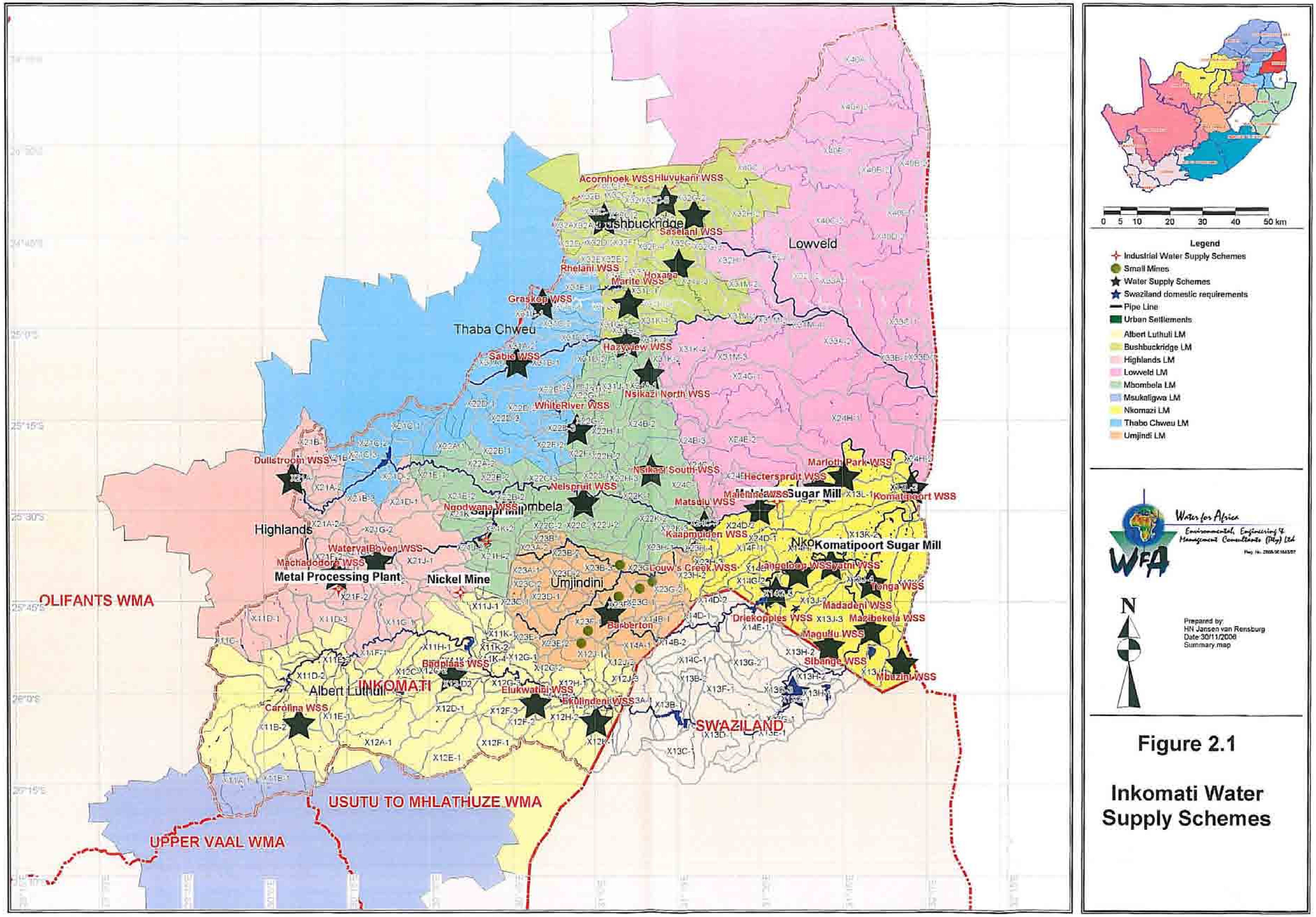
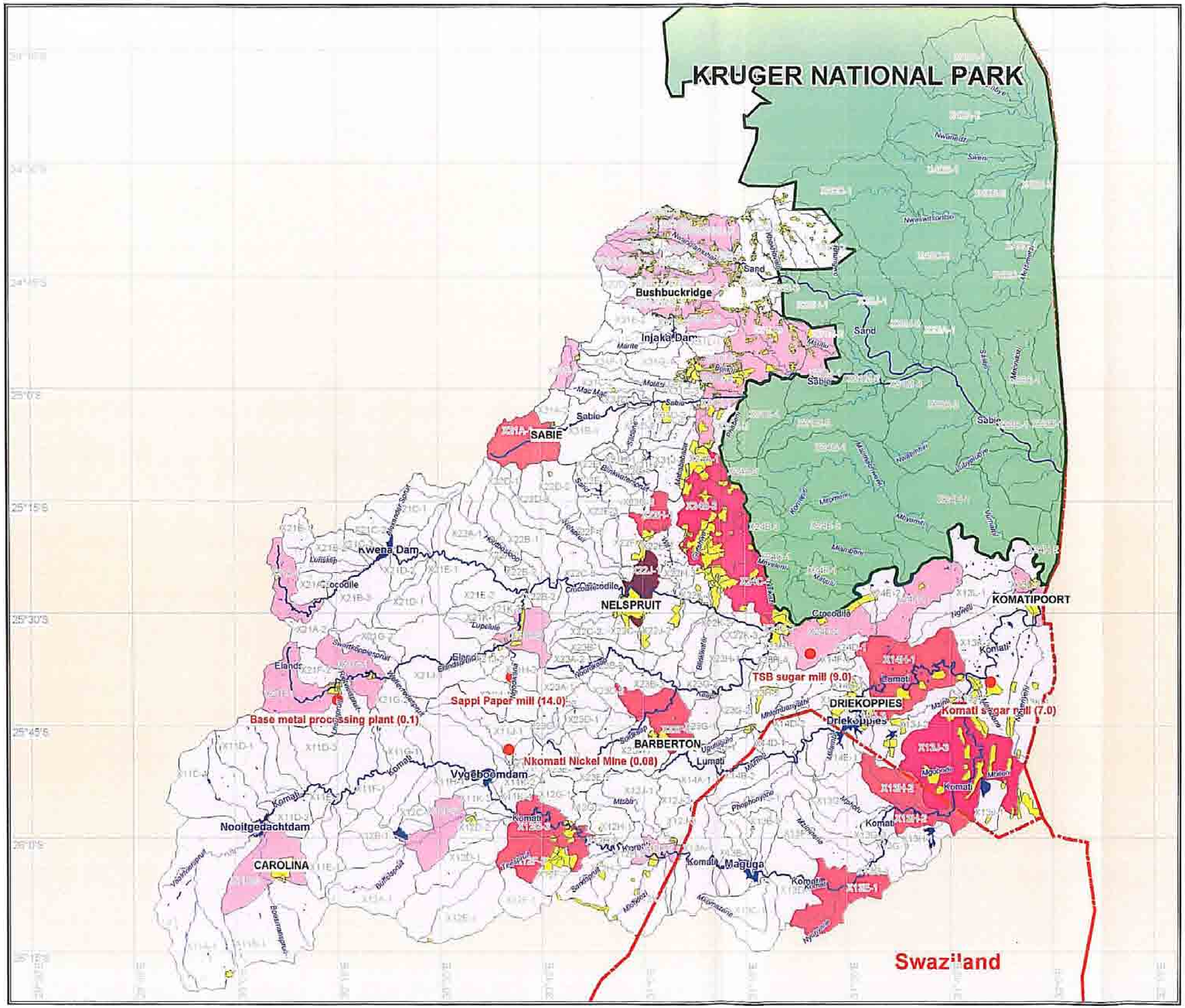



Figure 2.1

Inkomati Water Supply Schemes



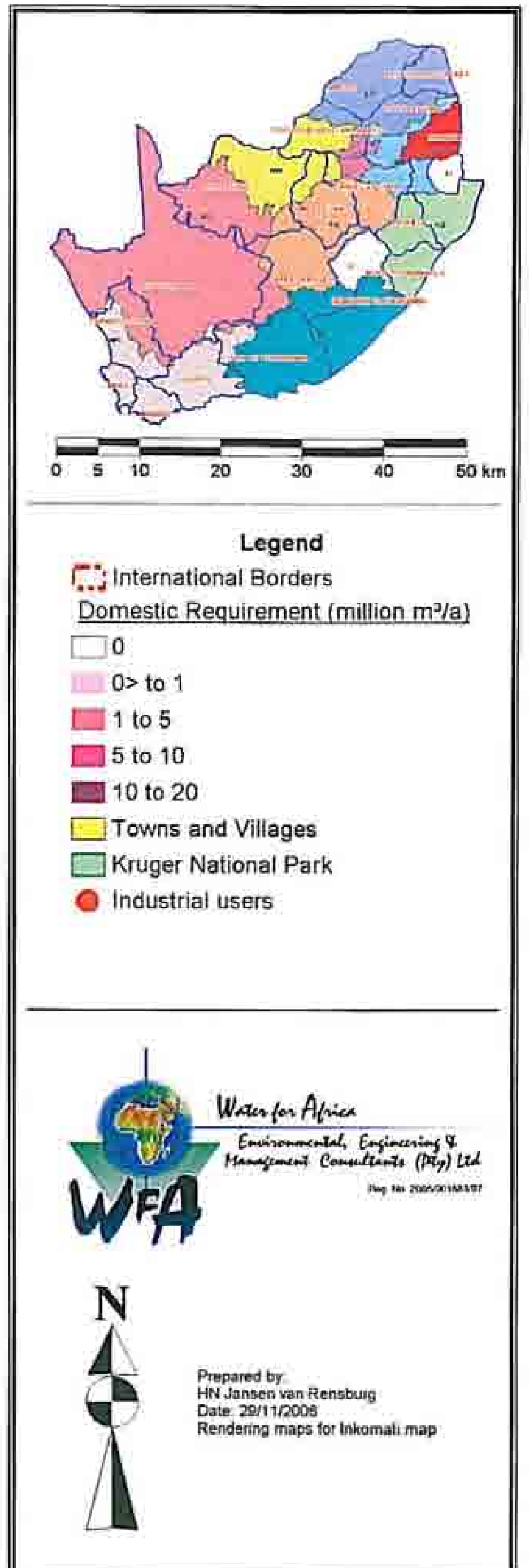




**Figure 2.2**

**Current Domestic and Industrial Water Requirements in the Inkomati WMA**

**Table 2.1 Domestic water supply schemes in the Komati River catchment**

| Water supply scheme | Location (quinary) | Current req. (Million $m^3$ /annum) | Source of water |
|---|---|---|---|
| **Komati up stream of Swaziland (Albert Luthuli Local Municipality)** | | | |
| Carolina | X11B-1 | 0.6 | Boesmanskrantz Dam |
| Badplaas | X12C-2 | 0.3 | Buffelspruit River |
| Elukwatwini | X12F-3/G-3 | 3.2 | Theespruit (1982) & Komati River (2000) |
| Ekulendini | X12K-2 | 0.7 | Komati River |
| **Total (2004)** | | **4.8** | |
| **Komati in Swaziland** | | | |
| Maguga to CDC weir | X13E-1 | 1.9 | Komati River |
| CDC weir to Managa | X13H-2 | 1.9 | Komati River |
| **Total (2004)** | | **3.8** | |
| **Komati down stream of Swaziland (Nkomazi Local Municipality)** | | | |
| Tonga; Masibekela; Sibange; Madadeni; Magudu | X13J-3 | 7.3 | Komati River |
| Komatipoort | X13L-2 | 0.5 | Komati and Crocodile Rivers |
| **Total (2004)** | | **7.8** | |
| **Lomati catchment (Nkomazi Local Municipality)** | | | |
| Driekoppies | X14G-3;H-1 | 3.4 | Driekoppies Dam (X13G-2) |
| Nyathi; Langeloop | X14H-1 | 1.5 | Lomati River |
| **Total (2004)** | | **4.9** | |
| **Total (2004)** | | **21.3** | **Komati River Catchment** |

### 2.2.1 Upper Komati catchment upstream of Swaziland

There are four domestic water supply schemes in the Komati catchment upstream of Swaziland. All the schemes are located within the Albert Luthuli Local Municipality. Detailed diagrams of these Schemes and the communities supplied are available in the **Inkomati WAAS Infrastructure report** (PWMA 05/X22/00/1208). The Carolina WSS and Badplaas WSS are operated by the Local Municipality while Elukwatini and Elukindeni WSS's are operated for the LM by the DWAF in Mpumalanga.

The current Carolina WSS became operational around 1977 after construction of the Boesmanskrantz dam was completed. There is no record of when the Badplaas WSS became operational, but has been set at 1960. The Elukwatini WSS became operational in 1982, with water being abstracted from the Theespruit. This was augmented with abstractions from the Komati River from about 2000. This scheme is restricted by its distribution capacity of 8.64 Ml/day and the maximum that is delivered is less than the annual requirement of 4.1 million $m^3$

/annum (**Albert Luthuli WSDP,** 2003). The Elukindeni WSS became operational in the mid 1990's and is currently abstracting all its water from the Komati River. Alternative sources, such as tributary rivers and groundwater, are no longer used. The domestic water use time series for the four towns are provided in **Appendix B** in **Tables B-1, B-2, B-3** and **B-4**.

### 2.2.2 Komati catchment in Swaziland

According to information obtained from KOBWA, there are abstractions for domestic water use from the Komati River, below Maguga Dam to Managa at the South African border. These abstractions have been divided into abstractions downstream of Maguga Dam to CDC weir, and abstractions downstream of CDC weir to Managa. The current (2004) abstractions of 3.8 million $m^3$/annum are similar to domestic abstractions determined by **JIBS (2001)** for 1991 and are likely to be underestimated. According to the **IncoMaputu Water Use Agreement** (TPTC, 2002) Swaziland has a high assurance allocation for domestic requirements of 22 million $m^3$/annum. The domestic water use time series for Swaziland is provided in **Appendix B** in **Table B-5**.

### 2.2.3 Komati catchment downstream of Swaziland

There are six water supply schemes in the Lower Komati catchments within South Africa, namely the Tonga, Masibekela, Sibanga, Madadeni, Magudu and Komatipoort Schemes. All the schemes abstract water from the Komati River and are located within and operated by the Nkomazi Local Municipality. Detailed diagrams of these Schemes and the communities that they supply can be found in the **Inkomati WAAS Infrastructure report** (PWMA 05/X22/00/1208). There is no record of when these schemes became operational and with the exception of Komatipoort there is no historical use data. However it is assumed that most of these schemes only became operational in the mid to late 1990's and the time series provided represent an estimate of water requirements based on current water use. The domestic water use time series for these WSSs is provided in **Appendix B** in **Tables B-6** and **B-7**.

### 2.2.4 Lomati river catchment

There are three water supply schemes in the lower Lomati catchments within South Africa. All the schemes are located within the Nkomazi LM. Detailed diagrams of the schemes and the communities that they supply are provided in the **Inkomati WAAS Infrastructure report** (PWMA 05/X22/00/1208). The schemes, namely the Driekoppies and Langeloop / Nyathi Schemes are operated by the LM. There is no record of when these schemes became operational and there is no historical data. However it was assumed that most of these schemes only became operational in the mid to late 1990's. The schemes abstract water from the Driekoppies Dam or the Lomati River. The domestic water time series for the WSS's are provided in **Appendix B** in **Tables B-8** and **B-9**.

## 2.3 Crocodile River Catchment

The urban developments in the Crocodile River catchments are much greater than in the Komati catchments, due to the rapid increase in domestic water supply with increasing levels of service. The urban and rural water requirements in the Crocodile River catchment now make up a significant portion of the total water requirements in the catchments. The area surrounding Nelspruit, which includes White River and Kanyamazane, form part of the Maputo corridor and has expanded rapidly over the last 10 to 15 years, resulting in increased urban and rural water requirements. The water supply to the various towns in the Crocodile catchment is discussed from the upstream to the downstream end of the catchment.

The main water supply schemes, current water requirements and sources of water are summarized in **Table 2.2**. Most of the information was obtained from the Water Services Development Plans.

The time series developed for the various water supply schemes for the hydrological (WRSM2000) model are provided in **Appendix B**.

### 2.3.1 Domestic water use in the Upper Crocodile (X21) catchment

There are several small towns in upper Crocodile catchment located within the Emakhazeni LM that abstract water for domestic use. They include:

- Dullstroom / Sakhelwe are supplied from the Dullstroom Dam that is located in the headwaters of the Crocodile River. The abstractions are from 1966 and are presented in **Table B-10** in **Appendix B**, with current (2004) abstractions estimated at 0.48 million $m^3$/annum.
- Machadadorp / Emthonjeni are supplied from a small dam located in the upper reaches of the Elands River. Abstractions are from 1950 and are presented in **Table B-11** in **Appendix B**. The current (2004) abstractions are estimated at 0.48 million $m^3$/annum. The town has a draft allocation of 2074 $m^3$/day or 0.76 million $m^3$/annum.
- Waterval Boven / Emgwenya are supplied by run of river abstractions from the Elands River. Abstractions are from 1947 and are presented in **Table B-12** in Appendix **B**, with current (2004) abstractions estimated at 0.72 million $m^3$/annum. The town has a run-of-river draft allocation of 2472 $m^3$/day or 0.9 million $m^3$/annum.

**Table 2.2 Domestic water supply schemes in the Crocodile River catchment**

| Water supply scheme | Location (quinary) | Current req. (Million $m^3$/annum) | Source of water |
|---|---|---|---|
| **Upper Crocodile (X21)** | | | |
| Machadadorp/Emthonjeni | X21F-1 | 0.5 | Elands River |
| Dullstroom/Sakhelwe | X21A-1 | 0.5 | Crocodile River |
| Waterval Boven/Emgwenya | X21G-1 | 0.7 | Elands River |
| Kaapsehoop | X21K-2 | Unknown | Boreholes |
| **Total (2004)** | | **1.7** | |
| **Middle Crocodile (X22)** | | | |
| Nelspruit | X22J-1 | 11.6 | Crocodile River |
| White River and Rocky Drift | X22H-1 | 1.9 | Longmere / Witklip Dams |
| **Total (2004)** | | **13.5** | |
| **Kaap (X23)** | | | |
| Barberton | X23F-2 | 3.9* | Lomati Dam (X14A-1) |
| **Total (2004)** | | **3.9** | |
| **Lower Crocodile (X24)** | | | |
| Nsikazi South WSS: Kanyamazane, Daantjie, Luphisi, Tekwane, Lehawu, Zwelitsha, Hlau-Hlau, Gutshwa | X24A-C | 25.6 | Crocodile River (X22K-1) (Ka-Nyamazane WTW) |
| Nsikazi North WSS: Phola, Salubindza, Manzini, Lundi, Phameni, Makoka, Chweni, Malukutu | X24A-B | 6.0* | Sabie River (X31K-1) |
| Matsulu | X24C-2 | 5.2 | Crocodile River |
| Malelane | X24D-2 | 2.2 | Crocodile River |
| Hectorspruit, Marloth Park | X24F-1 | 0.4 | Crocodile River |
| **Total (2004)** | | **39.4** | |
| **Total (2004)** | | **58.5** | |

* Water transferred from adjacent catchments

## 2.3.2 Umjindi Local Municipality

The Umjindi LM abstracts water from two sources. The main source of supply is the Lomati Dam situated in the upper reaches of the Lomati River (X14). The 2004 transfer to Barberton from this source was 3.9 million $m^3$/annum. Barberton also has a run-of-river allocation of 0.5 million $m^3$/annum from the Suidkaap River. Currently there are no abstractions from the Suidkaap River due to the unreliable nature of flow in the river (Pers comm, Mr F de Wet, 2006). Abstractions from Lomati Dam started around 1990 and are presented in **Table B-13** in **Appendix B**.

### 2.3.3 Mbombela Local Municipality

The town of Nelspruit and the Emonyeni Township are supplied out of the Crocodile River. The Mbombela Local Municipality currently holds a number of water use licences for these domestic and other users. The abstractions are supported by releases from the Kwena Dam.

The town of Nelspruit itself, i.e. the former Nelspruit Town Council, uses on average 10 million $m^3$/annum while the capacity of the treatment plants is approximately 16 million $m^3$/annum. The Mbombela LM has also taken over the water supply to the Rocky Drift Industrial area. The abstractions for Rocky Drift are from the Crocodile River and only started operating recently (2006). Prior to 2006 Rocky Drift was supplied by the White River Regional Water Supply Scheme.

The Mbombela LM has an annual allocation of 10.2 million $m^3$/annum for Nelspruit / Emonyeni and 5 million $m^3$/annum for Rocky Drift. The current (2004) abstractions for Nelspruit are 11.6 million $m^3$/annum. Abstractions started around 1900 and are presented in **Table B-14** in **Appendix B**.

### 2.3.4 White River / Rocky Drift

The town of White River and the Rocky Drift industrial area are supplied via the White River Regional Water Supply Scheme, which sources water from the Witklip and Longmere Dams with allocations of 0.75 million $m^3$/annum and 1.25 million $m^3$/annum from these two dams respectively. This combined allocation of 2 million $m^3$/annum has been exceeded since 1997. Current water supply to White River and Rocky Drift is 1.9 million $m^3$/annum, while measured abstractions from the dams are 2.4 million $m^3$/annum. The difference between abstractions and metered supplies are due to system losses. Abstractions started around 1900 and metered supplied are presented in **Table B-15** in **Appendix B**. From 2006 this scheme will only supply White River.

### 2.3.4 Nsikasi Water Supply Schemes

There are numerous towns and rural settlements in the Nsikazi catchments (X24A, X14B) to the east of Nelspruit as shown in **Figure 2.1**. The Nsikazi WSS abstracts water from two sources for domestic users. The Nsikazi South Water Supply Scheme abstracts water from the Crocodile River and is supported by releases from Kwena Dam. The allocation for this water supply scheme is 17.5 million $m^3$/annum, while the current (2004) abstraction was estimated at approximately 25.6 million $m^3$/annum. The capacity of the water treatment works of this scheme is 60 000$m^3$/day which is less then the estimate of current demands. The scheme is known to have high unaccounted for water and it is likely the requirements are over estimated. Abstractions started around 1966 and are presented in **Table B-16** in **Appendix B**.

The Nsikazi North Water Supply Scheme transfers water from the Sabie canal in the Sabie River catchment. The annual allocation for this supply scheme is 8 million $m^3$/annum, while the current (2004) abstraction was estimated at approximately 6 million $m^3$/annum. Abstractions started around 1994 and are presented in **Table B-17** in **Appendix B.**

### 2.3.5 Matsulu WSS

Matsulu is a rapidly expanding largely rural settlement on the northern bank of the Crocodile River, downstream of Krokodilpoort and close to Kaapmuiden. The Mbombela LM is the water service provider for Matsulu settlement. The current (2004) water requirements of 5.25 million $m^3$/annum are supplied from the Crocodile River and supported by releases from Kwena Dam. The annual allocation from the Crocodile River for this water supply scheme is 4.4 million $m^3$/annum. Abstractions started around 1966 and are presented in **Table B-18** in **Appendix B**.

### 2.3.6 Water supply schemes downstream of Krokodilpoort

There are a number of small towns and settlements downstream of Krokodilpoort, namely Kaapmuiden, Malelane, Hectorspruit and Marloth Park, that all abstract water directly from the Crocodile River. The current (2004) water requirements of these towns are estimated at about 2.5 million $m^3$/annum. Abstractions for Malelane and Hectorspruit started around 1966 and are presented in **Tables B-19** and **B-20** in **Appendix B**.

## 2.4 Sabie catchments

The urban and rural water requirements in the Sabie catchments have increased rapidly in recent years, in particular in the Sand River catchment. This is due to increasing service delivery to the numerous rural settlements in this area and the total water supply to the urban and rural users are becoming significant relative to the total water requirements in the catchment.

The main water supply schemes, current water requirements and sources of water are summarized in **Table 2.3**. This information was obtained from the Water Services Development Plans, etc.

In terms of the IIMA (TPTC, 2004) the allocation to first priority users in the Sabie catchments is 80 million $m^3$/annum.

**Table 2.3 Domestic water supply schemes in the Sabie River catchment**

| Water supply scheme | Location (quinary) | Current req. (million $m^3$/annum) | Source of water |
|---|---|---|---|
| Sabie | X31A-1 | 1.6 | Disused Mine Shaft |
| Graskop | X31C-1 | 0.4 | Fountain |
| Hazyview | X31K-1 | 0.5 | Sabie River Canal |
| Inyaka – Lower Sabie | X31K-1 to L-3 | 5.0** | Inyaka Dam (X31E-3) supplies water to settlements in the lower Sabie |
| Inyaka – Sand River | X32A-1 to X32F-4 | 12.0** | Inyaka Dam (X31E-3) supplies water to Bushbuckridge and Sand River settlements in X32. |
| Sand River – Local sources | X32A-1 to X32F-4 | 2.3** | Edinburgh Dam, rivers, etc |
| **Total [2004]** | | **20.8** | |

** Estimate, actual requirements need to be confirmed

### 2.4.1 Thaba Chweu Local Municipality Water Supply Schemes

The towns of Sabie and Graskop are located in the upper Sabie River catchment within the Thaba Chweu LM. Sabie Town abstracts its water from a disused mine shaft. Graskop abstracts water from a spring to supply the town and surrounding areas. The towns have a combined annual allocation of 2.32 million $m^3$/annum, while current (2004) abstractions are about 2 million $m^3$/annum. Abstractions started in the 1970's and are presented in **Table B-21** and **B22** in **Appendix B**.

### 2.4.2 Bushbuckridge Local Municipality and Inyaka Dam WSS

There are a large number of villages and settlements in the Lower Sabie catchments (X31K, L) and the Sand catchments (X32A to F). Most of these settlements, including Bushbuckridge receive water from the recently constructed Inyaka Dam in the upper Marite catchment. Abstractions by the Inyaka WSS started within the last 10 years and are presented from 2002 in **Table B-23**. In 2004 about 16 million $m^3$/annum was transferred to domestic users of which 5 million $m^3$/annum goes to settlements in the Lower Sabie catchments and 11 million $m^3$/annum was transferred to Bushbuckridge and to settlements in the Sand River catchments. Inyaka Dam currently has an annual allocation of 22 million $m^3$/annum. In 2004 abstractions from local resources within the Sand River catchment were estimated at about 2.3 million $m^3$/annum. The abstractions have been combined and are presented in **Table B-24** in **Appendix B**.

### 2.4.3 Hazyview

Hazyview and surrounding settlements receive water pumped from the Sabie River Canal. The current (2004) abstraction was estimated at 0.48 million $m^3$ and are included with transfers made from the Sabie canal to the Nsikazi North Water Supply Scheme (**section 2.3.4**).

# 3. Strategic water requirements

## 3.1 Introduction

There are no strategic water requirements (water demands for power generation) within the Inkomati WMA. However there are large transfers of water from the Upper Komati catchments to the Olifants WMA for power generation. **Section 7** details these inter-basin transfers.

# 4. Industrial and mining water requirements

## 4.1 Introduction

There are a number of large industrial water users in the Inkomati WMA and these are described in the following section and listed in **Table 4.1**. Water use by mining is insignificant and the main concerns are regarding water quality impacts from mining. These impacts have been reported on in the **Inkomati WAAS water quality report** (P WMA05/X22/00/1108). **Figure 2.2** shows the main industrial users and their current (2004) water requirements. There are no significant mining or industrial water users in the Sabie catchments or in the Swaziland portion of the Komati River catchments or in the Lomati (X14) catchments. There are, however, several saw mills in the upper Sabie River which negatively impact on water quality.

## 4.2 Industrial water requirements

The main industrial water users in the Inkomati WMA are the Sappi paper mill at Ngwodwana in the Elands catchment and the TSB sugar mills near Malalane and Komatipoort. **Table 4.1** lists the industrial users and there current water requirements. Current (2204) demands are estimated at 23 million $m^3$/annum however this could be higher as there is some doubt regarding the actual water requirements of the TSB sugar mills.

**Table 4.1 Current water requirements by industry and mines in the Inkomati WMA**

| Industry / mine | Location (quinary) | Current req. (million $m^3$/annum) | Source of water |
|---|---|---|---|
| **Industrial Users:** | | | |
| Komati sugar Mill (TSB) | X13K-2 | 0.4 | Lower Komati River |
| Malelane sugar mill (TSB) | X24D-2 | 9.0 | Crocodile River, operational since 1967 |
| Sappi paper mill | X21H-2 | 13.4 | Ngodwana Dam |
| Base metal processing plant | X21F-1 | 0.1 | Leeuspruit, a tributary of the Elands River |
| **Mining Users:** | | | |
| Nkomati Nickel Mine | X11J-1 | 0.1 | Gladdespruit and springs |
| **Total (2004)** | | **23.0** | |

### 4.2.1 Sappi paper mill

The Sappi paper mill at Ngodwana has been operational since 1966 and has an annual allocation of 14.6 million $m^3$/annum. The water use time series is presented in **Table C-1** in **Appendix C** and the current (2004) water use is 13.4 million $m^3$/annum. The water is supplied from the Ngwodwana Dam which is owned and operated by Sappi. Return flows from the paper mill are substantial and are used to irrigate the grounds and crops in the area of the Mill. The water quality aspects of the irrigation return flows are addressed in the **Inkomati WAAS Water**

**Quality report** (PWMA 05/X22/00/1108).

While the purpose of this report is not to address future water requirements, it should be noted that Sappi intend expanding the capacity of their Paper Mill and will require additional raw water. It is understood that Sappi has already obtained additional water allocations through trading with irrigators upstream of the plant but are also considering recycling as an option to increase their water supply.

### 4.2.2 TSB Malelane sugar mill

The TSB sugar mill located near Malelane in the lower Crocodile River catchment obtains its water from run-of-river abstractions out of the Crocodile River with support from the Kwena Dam. TSB have a licence to utilise 12 million $m^3$/annum while their abstraction records indicate actual use of approximately 9 million $m^3$/annum on average. Abstractions began in 1967 and the historical water use is presented in **Table C-2** in **Appendix C**. Return flows from the sugar mill are substantial and are used to irrigate crops in the area of the Mill.

### 4.2.3 TSB Komati sugar mill

The TSB sugar mill located near Komatipoort in the lower Komati catchment obtains its water from run-of-river abstractions out of the Komati River and is supported by upstream releases from the Driekoppies Dam and Maguga Dam system. Abstractions began about 1994 and the ‘estimated’ consumptive water use time series is presented in **Table C-3** in **Appendix C**. Actual water abstracted by the sugar mill is much higher but much of the water abstracted is returned to the Komati River or used to irrigate crops in the area of the mill. The consumptive use of the Komati Mill is estimated at 0.42 million $m^3$/annum in 2004.

### 4.2.4 Base metal processing plant

A base metal processing plant is located in the upper reaches of the Elands River catchment in the X21F quaternary catchment near Machadadorp. The water requirements of this plant are estimated to be approximately 0.1 million $m^3$/annum. The plant has two water use licenses, 0.06 million $m^3$/annum from the Leeuspruit, a tributary of the Elands River, a second license to abstract 0.07 million $m^3$/annum from groundwater.

## 4.3 Mining water requirements

The Angovaal Nkomati Nickel mine in the Gladdespruit (X11J-1) catchment currently abstracts 216 $m^3$/day. The mine will be expanding operations in 2007 and water requirements will increase significantly to 5475 $m^3$/day. The water use license for the mine is currently 0.42 million $m^3$/annum but is being revised. Abstractions began about 1994 and the ‘estimated’ water use time series is presented in **Table C-4** in **Appendix C**.

There are a number of coal mines in the upper reaches of the Komati River, upstream of

Nooitgedacht Dam, but the water requirements are insignificant. The Crocodile catchment also has a few mines but their water requirements are insignificant.

# 5. Irrigation water requirements

## 5.1 Introduction

The largest water user in the Inkomati WMA is the irrigation sector. It is important therefore to obtain good estimates of the water allocations to this sector as well as the actual water use. The difference between the allocation and actual use is important to understand and quantify as it has large implications, from the calibration of hydrological models through to the allocation of the limited water resources within the Inkomati WMA.

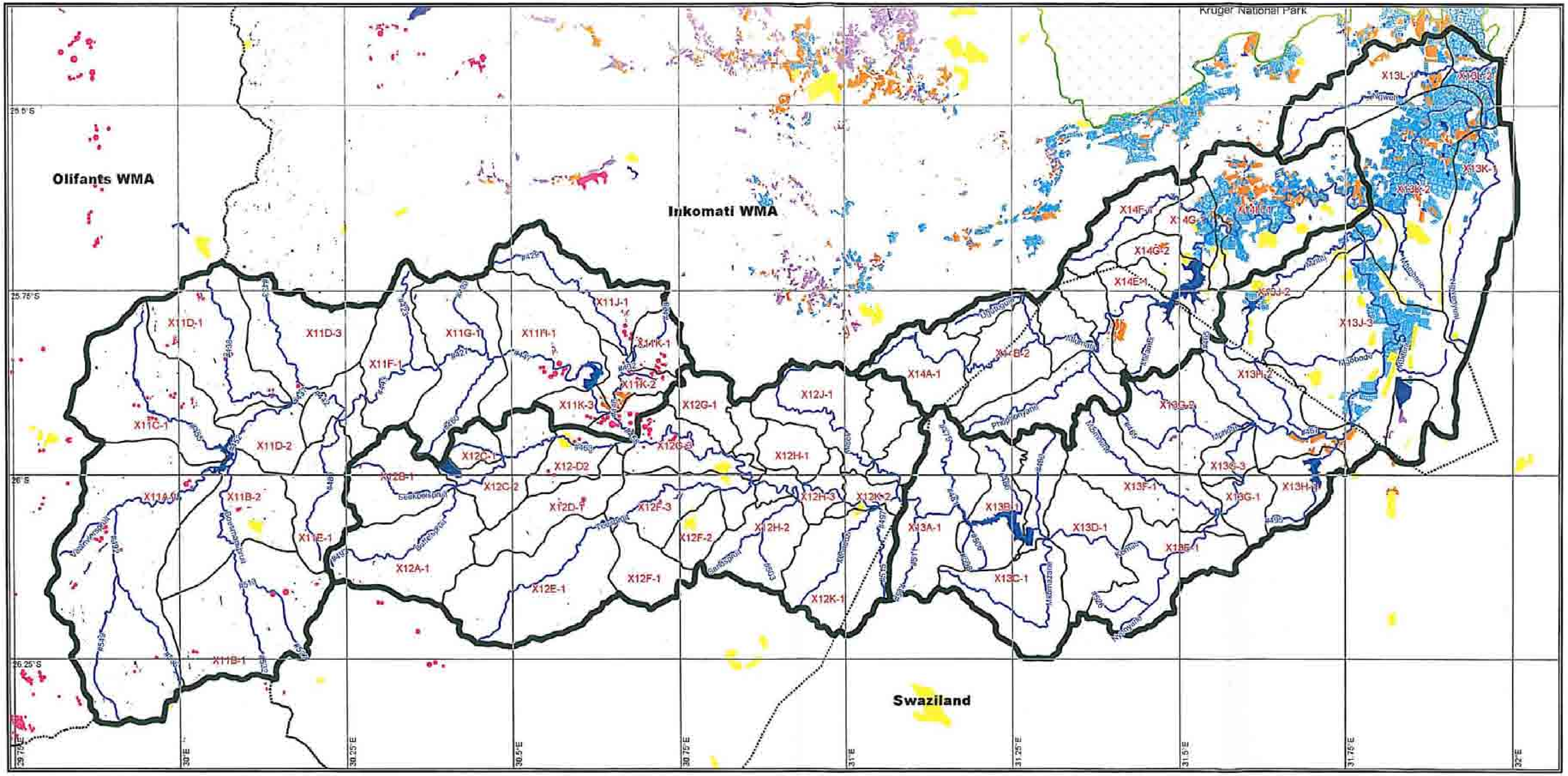
Within the context of this study, the irrigation water requirements were determined using a theoretical calculation of how much water is required, based on crop areas, crop types, application efficiencies of irrigation systems and climatic conditions. The model used to estimate the crop water requirements is the Irrigation Block sub-model that was developed for the WQT water quality model. Details of the can be found in the **WRYM User Manual** (DWAF, 2008) and **WRSM theory manual** (SSI, 2006). The JIBS report (TPTC, 2001) and the Validation study (DWAF, 2006) estimates of water requirements are all based on theoretical estimates using the principles described in **Appendix E**.

For a number of reasons, the actual water use does not always correspond to the theoretical water requirements or the allocated amount. Some of the reasons applicable in the Inkomati WMA are as follows:

- There is insufficient water available to supply all irrigators with their theoretical requirement.
- The theoretical water requirement assumes a so-called optimum crop water requirement, which requires a high level of management to monitor. If water is cheap, as it is in much of the WMA, irrigators could over-irrigate if the water is available.
- In cases where water usage is controlled by an irrigation board, irrigators are more likely to be irrigating according to their quota or allocation and not according to a theoretical requirement.

For the purposes of this study, two estimates of irrigation demand have been made. These are as follows:

- **A theoretical calculation using the WQT model** (DWAF, 2008) that requires irrigated areas (and crop types) obtained from the validation study (DWAF, 2006). In the case of the Lower Komati catchment, a more up to date GIS coverage of the irrigated area was obtained from the DWAF Mpumalanga Regional office. Crop factors for sugar cane, the dominant crop in this area, were calculated using recorded abstractions in the Lomati catchment and the Lecler model (Lecler, 2006). When calculating these crop factors, the following was taken into account:
    - o That sugar cane is a ratoon crop and is replanted about every 7 years.
    - o That the Komati mill shuts down from early December to the end of February.




**Legend**

- Maize Irrigation
- Vegetable Irrigation
- Citrus Irrigation
- Sugar Cane Irrigation
- Water Management Areas
- Secondary Drainage Boundaries
- Towns and Villages


N

**Figure 5.1**

**Irrigation in the Komati River Catchment**

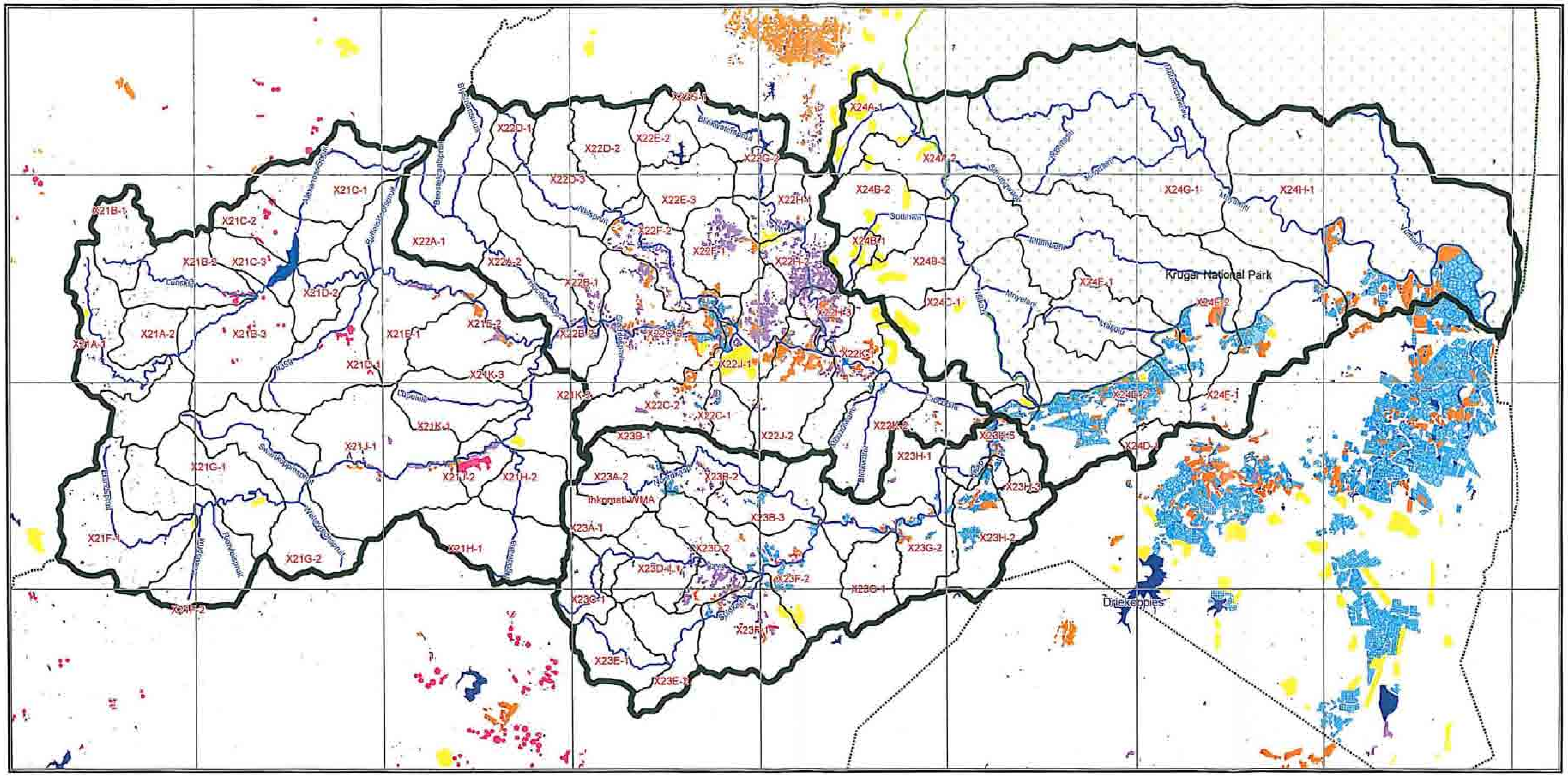
Water for Africa

Environmental, Engineering & Management Consultants (Pty) Ltd

Reg. No. 2005/001583/07

Prepared By:
RL Mallory
27/01/2009

Landuse.map




**Legend**

- Maize Irrigation
- Vegetable Irrigation
- Citrus Irrigation
- Sugar Cane Irrigation
- Water Management Areas
- Towns and Villages


N

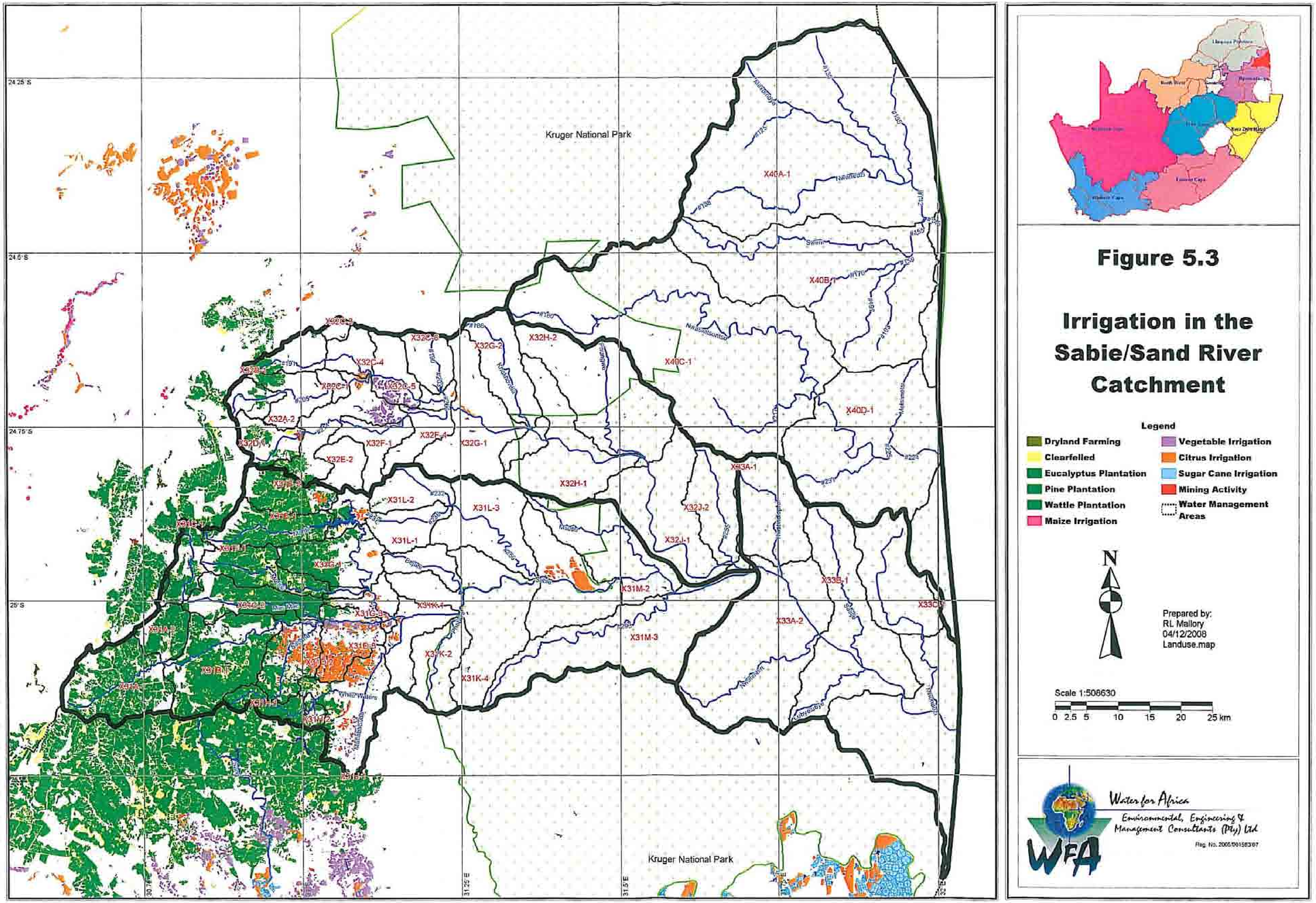
# Figure 5.2

## Irrigation in the Crocodile River Catchment

Water for Africa
Environmental, Engineering & Management Consultants (Pty) Ltd
Reg. No. 2005/001563/07

Prepared By:
RL Mallory
27/1/2009

Landuse.map


Kruger National Park
Figure 5.3
Irrigation in the Sabie/Sand River Catchment
Legend
Dryland Farming
Clearfelled
Eucalyptus Plantation
Pine Plantation
Wattle Plantation
Maize Irrigation
Vegetable Irrigation
Citrus Irrigation
Sugar Cane Irrigation
Mining Activity
Water Management Areas
N
Prepared by:
RL Mallory
04/12/2008
Landuse.map
Scale 1:508630
0 2.5 5 10 15 20 25 km
Water for Africa
Environmental, Engineering & Management Consultants (Pty) Ltd
WfA

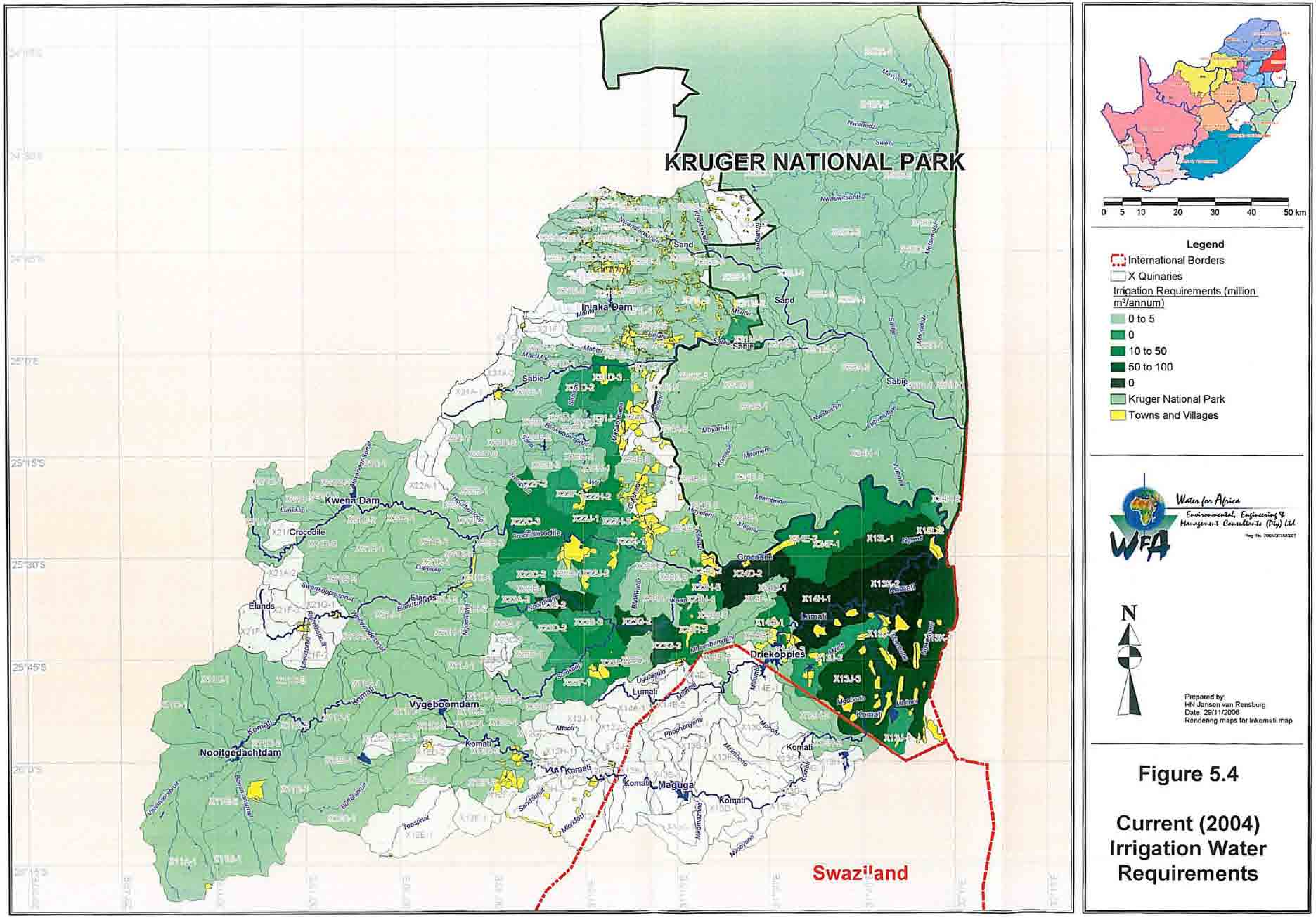



**Figure 5.4**

**Current (2004) Irrigation Water Requirements**

- That sugar cane is not irrigated in the month prior to harvesting.

The crop factors determined for sugarcane as well as for the other crops identified in this project are presented in **Table 5.1**.

**Table 5.1 Crop factors for irrigated crops (applicable to Class A evaporation)**

| Crop Type | Crop factors | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Ave | Min | Max |
| Sugar cane[WfA] | 0.67 | 0.81 | 0.86 | 0.9 | 0.8 | 0.74 | 0.71 | 0.69 | 0.66 | 0.63 | 0.62 | 0.64 | 0.73 | 0.62 | 0.90 |
| Citrus[(3)] | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 |
| Bananas[(3)] | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 |
| Maize[2] | 0.50 | 0.90 | 1.10 | 0.97 | 0.33 | | | | | | | | 0.76 | 0.33 | 1.10 |
| Vegetable[1] | | | | | | 0.42 | 0.70 | 0.99 | 0.97 | 0.78 | 0.57 | | 0.74 | 0.42 | 0.99 |

Notes: 1) In the Verification study (DWAF, 2006) vegetable crops were captured from satellite imagery, with no distinction between vegetable type, therefore crop factors are a composite for late season vegetables.
2) Early season maize
3) WQT Crop factors for citrus, bananas and maize same as WR90

- **Allocated water use** based on various sources of information. Where a discrepancy between estimates was found, the highest estimate was used. The various sources of allocated water use include:
  - Scheduled water use by irrigation boards. Since much of the irrigation within the WMA falls within irrigation boards, this accounts for most of the irrigation within the WMA.
  - Irrigation allocated in terms of the **Komati Basin Treaty** (JWC, 1984).
  - Irrigation allocated in terms of the **Interim Inkomati Water Use Agreement** (TPTC, 2004).

The following sections report on the estimated irrigation requirements based on the above two approaches.

## 5.2 Komati

### 5.2.1 Theoretical irrigation water requirements

The largest water user in the Komati River catchments is the irrigation sector. According to the **Verification study** (DWAF, 2006) the total irrigation water requirements in the Komati River catchments is 716 million $m^3$/annum. This was based on a theoretical calculation using the SAPWAT model. This estimate is in stark contrast to the JIBS (**DWAF, 1995**) report that gives the water requirement of the irrigation sector as only 407 million $m^3$/annum based on a survey carried out in the early 1990's. The table below gives an indication of how the irrigation requirements have grown since the early 1990's, based on the **Verification Study** (DWAF, 2006).

**Table 5.1 Historical irrigation requirements in the Komati River catchment**

| Year | Irrigation water requirement ( million $m^3$/annum) | Source of information |
|---|---|---|
| ~1991 | 407 | TPTC, 2001 (JIBS study) |
| 1996 | 434 | DWAF, 2006 (Validation study) |
| 1998 | 563 | DWAF, 2006 (Validation study) |
| 2004 | 716 | DWAF, 2006 (Validation study) |

This large increase in irrigation water requirements is attributed firstly to the construction of the Driekoppies and Maguga Dams, which has allowed the expansion of the area irrigated downstream of the dams. Secondly to the use of the SAPWAT irrigation model to estimate the crop water requirements by the Verification study (2006). The SAPWAT model was applied using a uniform crop factor of 0.8 throughout the year for sugar cane. This approach fails to take into account the fact that sugarcane is a ratoon crop or that the cane is not watered in the month prior to cutting.

A more accurate estimate using the Irrigation block model using the 'WfA' determined crop factors determined for sugarcane resulted in a current day estimate (2004) of 588 million $m^3$/annum as summarised in **Table 5.2**. Quinary catchment crop information and crop water requirements versus water supplied is provided in **Appendix D** in **Table D1**.

**Table 5.2 Crop areas and estimated water requirements in the Komati River**

| Drainage Catchment | Irrigated area ($km^2$) | Dominant crops type | Crop water requirements (million $m^3$/annum) |
|---|---|---|---|
| X11 in South Africa | 29 | Maize | 13.9 |
| X12 in South Africa | 8 | Maize | 3.6 |
| X13 in South Africa | 302 | Sugarcane | 381.3 |
| X14 in South Africa | 108 | Sugar cane | 119.6 |
| **Sub-total** | **447** | **Sugar cane** | **518.4** |
| X13 in Swaziland | 57 | Sugarcane | 63.1 |
| X14 in Swaziland | 8 | Citrus | 6.5 |
| **Sub-total** | **65** | **Sugarcane** | **69.6** |
| **Total** | **512** | | **588.0** |

## 5.2.2 Allocated irrigation water requirements

*Komati Basin Treaty*

The Komati Treaty (JWC, 1984) with Swaziland allocates South Africa 538.8 million $m^3$/annum from the Komati River catchment which is distributed as follows:

**Upstream of Swaziland:**

134.5 million $m^3$/annum to high assurance use (mostly for Eskom)

23.8 million $m^3$/annum to low assurance use (irrigation)

**Downstream of Swaziland:**

23.2 million $m^3$/annum to high assurance use (domestic and industrial)

357.2 million $m^3$/annum to low assurance use (irrigation)

**Swaziland:**

15.1 million $m^3$/annum to high assurance use (domestic and industrial)

260.2 million $m^3$/annum to low assurance use (irrigation)

*Interim IncoMaputo Water Use Agreement*

The IIMA (TPTC, 2004) allocates the same amounts to Swaziland and South Africa as those given above.

*Scheduled irrigation*

Almost all of the irrigation in the lower Komati and Lomati River catchments falls within the Komati River Irrigation Board (IB) or the Lomati River IB. The scheduled areas of these irrigation boards are summarised in **Table 5.3**.

**Table 5.3 Summary of irrigation allocations within Komati and Lomati River IBs**

| Irrigation board | Source of water | Scheduled area (ha) | Scheduled appl. rate (mm/annum) | Water requirement ( million $m^3$/annum) |
|---|---|---|---|---|
| Komati River IB | Komati River/Maguga Dam | 22 758 | 995 | 226 |
| Lomati River IB | Lomati River/Driekoppies Dam | 7 536 | 850 | 64 |
| **Total** | | **30 294** | | **290** |

The scheduled irrigation requirements within the irrigation boards are less than the allocation of the Komati Basin Treaty and the IIMA, therefore an allocated irrigation water use of 381 million $m^3$/annum for South Africa and 261 million $m^3$/annum for Swaziland has been used in the water resources yield model.

## 5.3 Crocodile

### 5.3.1 Theoretical irrigation water requirements

As for the WMA as a whole, the largest water user in the Crocodile River catchment is the irrigation sector. The JIBS (DWAF, 1995) report gives the total water use by the irrigation sector as 281 million $m^3$/annum based on a survey carried out in the early 1990's while the validation study (DWAF, 2006) gives the total irrigation water requirement in the Crocodile River catchment as 400 million $m^3$/annum in 2004. **Table 5.4** gives an indication of how the irrigation requirements have grown since the early 1990's.

**Table 5.4 Historical irrigation requirements in the Crocodile River catchment**

| Year | Irrigation water requirements ( million $m^3$/annum) | Source of information |
|---|---|---|
| ~1991 | 281 | TPTC, 2001 (JIBS study) |
| 1996 | 255 | DWAF, 2006 (Validation study) |
| 1998 | 330 | DWAF, 2006 (Validation study) |
| 2004 | 400 | DWAF, 2006 (Validation study) |

As with the Komati catchment, **Table 5.4** provides an estimate of the irrigation water requirement based on the theoretical SAPWAT calculation. Where the irrigated area lies within an irrigation board, the actual water use can probably be more accurately determined from the scheduled application rate relevant to the particular irrigation board. It must be noted, however, that this scheduled amount, as given in **Table 5.4**, again represents a requirement rather than a water use since restrictions are often imposed by the irrigation boards themselves and the irrigators are almost certainly not receiving all the water calculated from the scheduled application rate.

A more accurate estimate using the WQT model resulted in a current day requirement (2004) of 454 million $m^3$ / annum as summarised in **Table 5.5**. Detailed quinary catchment crop information and crop water requirements versus water supplied is provided in **Appendix D** in **Table D2**.

**Table 5.5 Crop areas and estimated water requirements in the Crocodile River**

| Catchment | Irrigated area ($km^2$) | Dominant crop | Crop water requirements (million $m^3$/annum) |
|---|---|---|---|
| X21: Upper Crocodile | 38.7 | Maize | 21.3 |
| X22: Middle Crocodile | 212.5 | Cash crops; Vegetables | 149.0 |
| X23: Kaap | 98.0 | Sugarcane | 91.7 |
| X24: Lower Crocodile | 162.8 | Sugarcane | 192.4 |
| **Total** | **512.0** | | **454.4** |

## 5.3.2 Allocated irrigation water requirements

*Interim IncoMaputo Water Use Agreement*

The IIMA (TPTC, 2004) allocated 307 million $m^3$ / annum to irrigation in the Crocodile River catchment. This is much less then the actual irrigation in the catchment.

*Scheduled irrigation*

Most of the irrigation within the Crocodile River catchments falls within one of the many irrigation boards. The schedule of these boards is given below in **Table 5.6**.

**Table 5.6 Summary of irrigation allocations within the Crocodile River IBs**

| Irrigation board | Source of water | Scheduled area (ha) | Scheduled appl. rate (mm/annum) | Requirement ( million $m^3$/annum) |
|---|---|---|---|---|
| Elands River | Elands River | 2 704 | 770 | 20.8 |
| Kaap (upper) | Kaap River | 4 431 | 660 | 29.2 |
| Kaap (lower) | Kaap River | 990 | 700 | 6.9 |
| Crocodile Major (upstream of Krokodilpoort) | Crocodile River / Kwena Dam | 10 952 | 800 | 87.6 |
| Crocodile Major (downstream of Krokodilpoort) | Crocodile River / Kwena Dam | 17 334 | 1 300 | 225.3 |
| White River Valley | Witklip, Klipkopjes, Longmere, Primkop Dams | 8 892 | 275 to 600 | 30.4 |
| **Total** | | **45 303** | | **400.2** |

*Other lawful irrigation*

In addition to formally allocated water use, there are a number of irrigators who fall outside of irrigation boards but, under the old Water Act (Act 56 of 1954), had riparian rights. Under the new Water Act (Act 36 of 1998) these users would be recognised as existing lawful users. The quantity of this unscheduled irrigation has not been finalized but is currently being assessed by Mpumalanga Regional Office of the DWAF. In the interim, the WQT irrigation model was used to estimate these irrigation requirements, which are accepted as allocated water use. The estimated water requirements or allocations, for the purposes of this study, are given in **Table 5.7**.

**Table 5.7 Estimated probable lawful water use not already listed in irrigation boards within the Crocodile River catchment**

| Catchment | Crop area ($km^2$) | Dominant crops | Estimated crop water requirement (million $m^3$/annum) |
|---|---|---|---|
| X21 | 15.3 | Maize | 4.5 |
| X22 | 75.0 | Vegetables | 53.4 |
| X23 | 13.2 | Sugar | 12.2 |
| X24 | 10.3 | Sugar | 11.6 |
| **Total** | **113.8** | | **81.7** |

## 5.4 Sabie

### 5.4.1 Theoretical irrigation water requirements

The irrigation sector is the largest water user in the Sabie and Sand River catchments. The **Sabie River Catchment Study** (1990) report gave the total water use by the irrigation sector as 60 million $m^3$/annum based on a survey carried out in the mid eighties. The report notes that this figure may be an over estimate since the area upon which the calculation is based included areas of seasonal crops which may not have been irrigated at the time. The validation study (DWAF, 2006), gave the 2004 irrigation water requirement in the Sabie River catchment as 59 million $m^3$ / annum. **Table 5.8** gives an indication of irrigation trends in the Sabie catchment.

**Table 5.8 Summary of irrigation requirements in the Sabie River catchments**

| Year | Water requirements ( million $m^3$/annum) | Source of information |
|---|---|---|
| ~1985 | 60.0 | DWAF, 1990 (Sabie Catchment Study) |
| 1996 | 52.3 | DWAF, 2006 (Validation study) |
| 1998 | 58.4 | DWAF, 2006 (Validation study) |
| 2004 | 59.0 | DWAF, 2006 (Validation study) |

As discussed in previous sections, the WQT irrigation model was used to estimate the crop water requirements of the Sabie catchments. The 2004 crops areas and crop water requirements are summarized for the Sabie and Sand catchments in **Table 5.9**. These requirements are significantly higher than previous estimates. Detailed quinary catchment crop information and crop water requirements versus water supplied is provided in **Appendix D** in **Table D3**.

**Table 5.9 Crop areas and estimated water requirements based on the WQT model**

| Catchment | Irrigated area ($km^2$) | Dominant crop type | Crop water requirements (million $m^3$/annum) |
|---|---|---|---|
| X31 | 103 | Citrus | 82 |
| X32 | 25 | Vegetables | 17 |
| **Total** | **128** | | **99** |

### 5.4.2 Allocated irrigation water requirements

*Interim IncoMaputo Water Use Agreement*

The IIMA (TPTC, 2004) allocated 98 million $m^3$/annum to irrigation in the Sabie River catchments. This is greater than the allocation made in terms of South African law and hence when evaluating this scenario which has a greater demand on the Sabie system, an assumption needs to be made as to where this additional irrigation will be located in future. Its seems most likely that this additional irrigation will be located in the lower Sabie River upstream of the confluence with the Sand River and that the water requirements of these irrigators will be supplemented from the Inyaka Dam.

*Scheduled irrigation*

Unlike the Komati and Crocodile catchments, a relatively small portion of the irrigation within the Sabie and Sand catchments fall within irrigation boards. The schedules for these boards are given in **Table 5.10**.

**Table 5.10 Summary of irrigation allocations for IBs in the Sabie River catchments**

| Irrigation board | Source of water | Scheduled area (ha) | Scheduled appl. rate (mm/annum) | Requirement ( million $m^3$/annum) |
|---|---|---|---|---|
| Sabie River | Sabie River / Sabie Canal | 2 063 | 530 | 10.9 |
| Burgershall | Da Gama Dam | 1160 | 600 | 6.9 |
| De Rust | Da Gama Dam | 424 | 530 | 2.3 |
| White Waters | Da Gama Dam / White Waters River | 1200 | 530 | 6.4 |
| **Total** | | **4847** | | **26.5** |

*Other lawful irrigation*

As with the other catchments the irrigation located outside of the irrigation boards was assumed to be lawful for the purposes of this study.

## 5.5 Summary of irrigation scenarios

Irrigation water requirements were estimated for two scenarios. These are:

- Best estimate using a theoretical models
- Lawful allocation (maximum)

These two scenarios are summarized in **Table 5.11** for the whole Inkomati WMA.

**Table 5.11 Irrigation water requirement scenarios in the Inkomati WMA**

| Catchment | Best estimate (theoretical) (million $m^3$/annum) | IIMA allocation (million $m^3$/annum) |
|---|---|---|
| Komati | 588 | 642 |
| Crocodile | 454 | (307) 484* |
| Sabie | 99 | 98 |
| **Total** | **1141** | **1124** |

Note: * South African allocation

# 6. Afforestation

## 6.1 Introduction

Forestry in the escarpment areas of the Inkomati WMA provides an important economic input to WMA. The area of forestry appears to have increased significantly in some areas in recent years. Very few if any new licences for afforstation have been issued for many years by the DWAF and hence it is uncertain whether the increased area is due to unlawful development or improved techniques in measuring the afforested areas.

## 6.2 Komati catchments

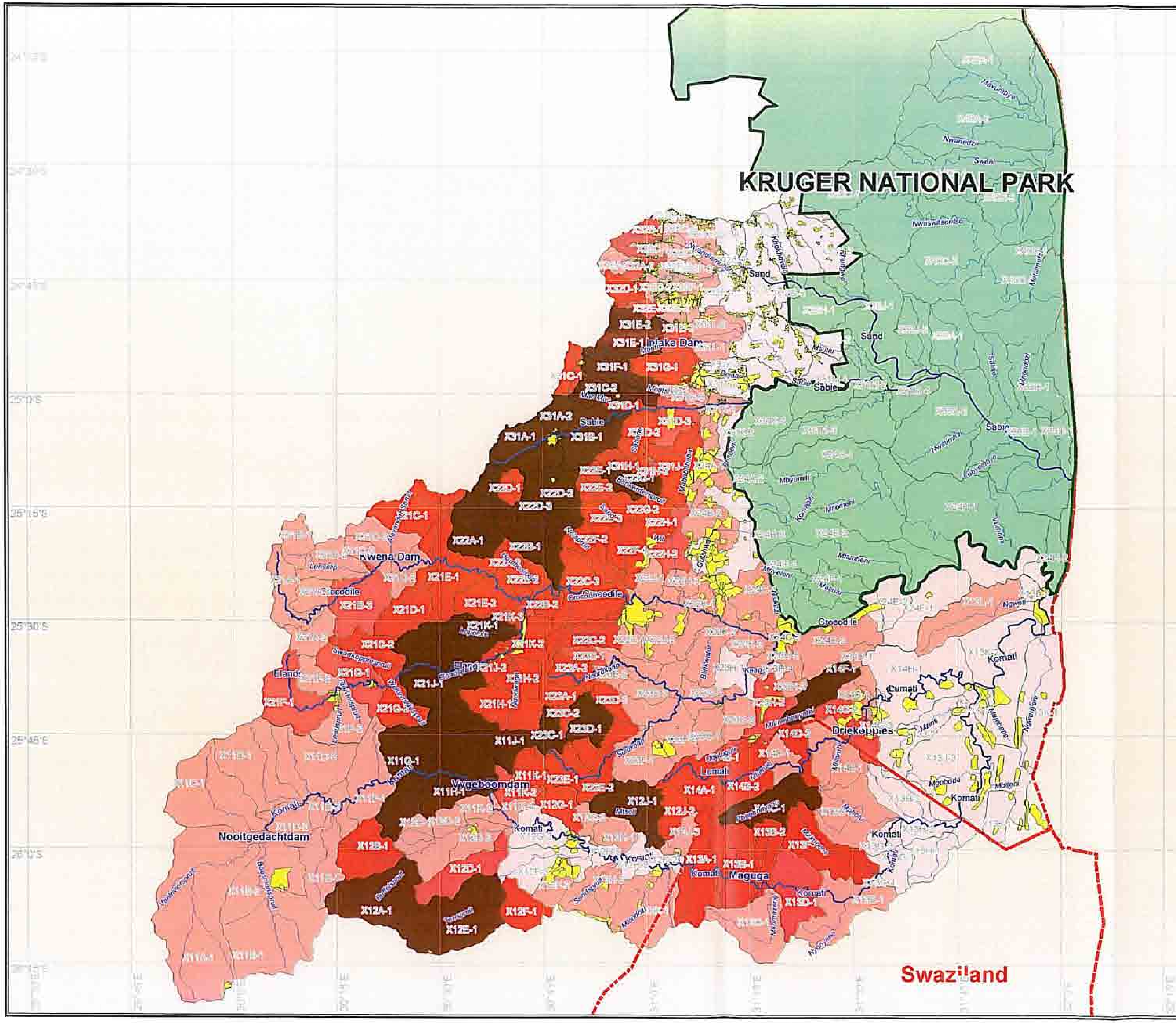
Afforestation at current (2004) levels covers about 11% of the Komati River catchments. **Table 6.1** provides a summary of the current situation for defined sub-areas. Afforestation is significant (>15 %) in two areas, namely in the Hoogenoeg catchments downstream of Vygeboom Dam but upstream of Swaziland and in the Driekoppies Dam catchments in Swaziland. In the remaining sub-areas forestry is locally significant in terms of stream flow reduction and impact on yield. Pine plantations are the dominant forest species at 79 % and the SFR impact of forestry is estimated to be 117 million $m^3$ / annum at current development levels.

The Komati landuse map, **Figure 1.1a** shows the forestry in the Komati and **Figure 6.1** the reduction in runoff caused by forestry. **Table F-1** in **Appendix F** provides quinary catchments details for forestry and the historical growth in forestry. Information about current (2004) forestry was obtained from the **Verification study** (DWAF, 2006) while the growth in forestry area was derived from this study and previous studies, (JIBS study reports, WR90, etc.).

**Table 6.1 Current day (2004) forestry in the Komati River catchments**

| Sub-area | Quinary catchments | Quinary area ($km^2$) | Forested area ($km^2$) | Species Distribution | | | SFR |
|---|---|---|---|---|---|---|---|
| | | | | Pine | Euca-lypt | Wattle | MCM/a |
| Komati u/s of Nooitgedacht Dam | X11A-1 to X11C-1 | 1588 | 6.8 | 55% | 24% | 21% | 0.1 |
| Komati - Nooitgedacht to Vygeboom | X11E-1 to X11H-1 | 1544 | 132.3 | 84% | 14% | 2% | 14.5 |
| Komati – Hoogenoeg catchments | X11J-1 to X12K-2 | 2958 | 578.4 | 92% | 8% | 0% | 55.9 |
| Komati in Swaziland | X13A-1 to X13H-2 | 1928 | 189.2 | 71% | 29% | 0% | 18.4 |
| Komati d/s of Swaziland to Mozambique | X13J-1 to X13L-2 | 1696 | 0.0 | 0% | 0% | 0% | 0.0 |
| Lomati u/s of Driekoppies Dam | X14A-1 to X14G-2 | 908 | 213.1 | 67% | 33% | 0% | 20.2 |
| Lomati d/s of Driekoppies Dam | X14F-1 to X14H-1 | 571 | 83.6 | 39% | 61% | 0% | 8.2 |
| **Total X catchments** | | **11193** | **1203.4** | **79%** | **20%** | **1%** | **117.3** |
| **RSA catchments** | | **8357** | **801.1** | **85%** | **14%** | **1%** | **78.6** |
| **Swaziland catchments** | | **2836** | **402.3** | **69%** | **31%** | **0%** | **38.7** |

Notes: MCM/a – million $m^3$ / annum




Water for Africa Environmental, Engineering & Management Consultants (Pty) Ltd

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HN Jansen van Rensburg
Date: 20/11/2006
Rendering maps for Inkomati.map

# Figure 6.1

## Current (2004) Reduction In Streamflow Due to Forestry

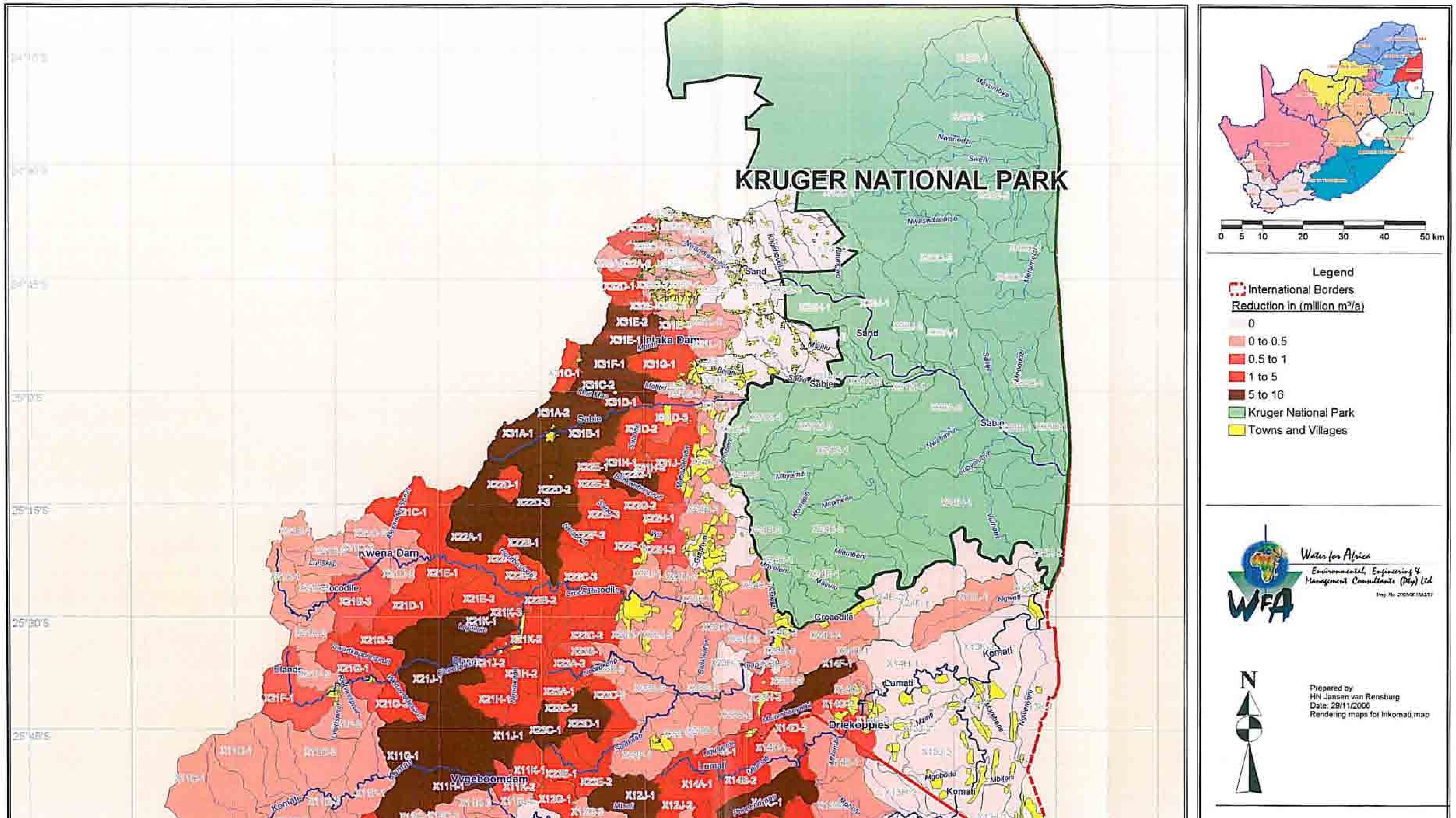



**Figure 6.4**

**Current (2004) Reduction In Streamflow Due to Forestry**

## 6.3 Crocodile catchments

Current (2004) afforestation covers some 18.6 % or 1943 km$^2$ of the Crocodile River catchments. **Table 6.2** provides a summary of the current situation in defined sub-areas. Afforestation is significant (>30%) in the Middle Crocodile catchments of Houtbosloop (62 %), Stats River (56 %), Nelspruit (65 %) and White River (51 %) and in the Kaap catchments of Noordkaap (37%), Suidkaap (37 %) and Queens River (42 %). In the remaining sub-areas afforestation is less significant but maybe locally significant in terms of stream flow reduction and impact on yield. Pine plantations are the dominant forest species at 67 % and the SFR impact of forestry is estimated to be 158 million m$^3$ / annum at current development levels.

The Crocodile land use map, **Figure 1.1b** shows the forestry in the Crocodile catchments and **Figure 6.1** the reduction in runoff caused by forestry. **Table F-2** in **Appendix F** provides quinary catchments details for forestry and the historical growth in forestry. Information about current (2004) forestry was obtained from the **Verification study** (DWAF, 2006) while the growth in area was derived from the Verification study and previous studies, (JIBS study reports, WR90, etc.).

**Table 6.2 Current day (2004) forestry in the Crocodile River catchments**

| Sub-area | Quinary catchments | Quinary area (km$^2$) | Forested area (km$^2$) | 2004 Species Distribution | | | SFR |
|---|---|---|---|---|---|---|---|
| | | | | Pine | Euca-lypt | Wattle | MCM/a |
| Crocodile: Kwena Dam catchments | X21A-1 to X21C-1 | 953 | 57 | 89% | 10% | 1% | **4.8** |
| Crocodile: d/s Kwena dam catchments | X21D-1 to X21E-2 | 564 | 136 | 85% | 14% | 1% | **11.5** |
| Elands River catchments | X21F-1 to X21K-3 | 1573 | 394 | 84% | 15% | 1% | **35.3** |
| Middle Crocodile river catchments | X22B-2 to X22K-3 | 1036 | 100 | 49% | 51% | 0% | **5.3** |
| Houtbosloop catchment | X22A-1, X22A-2 | 251 | 156 | 79% | 21% | 1% | **14.9** |
| Stats River catchment | X22B-1 | 131 | 73 | 65% | 35% | 0% | **6.9** |
| Nelspruit catchments | X22D-1 to X22F-2 | 640 | 416 | 73% | 27% | 0% | **28.9** |
| White River catchments | X22G-1 to X22H-3 | 308 | 156 | 33% | 67% | 0% | **9.8** |
| Noordkaap River catchments | X23A-1 to X23B-3 | 356 | 130 | 43% | 57% | 0% | **11.5** |
| Suidkaap River catchments | X23C-1 to 23F-2 | 430 | 160 | 40% | 60% | 0% | **18.9** |
| Queens River catchments | X23E-1 to X23F-1 | 323 | 137 | 69% | 31% | 0% | **8.6** |
| Kaap River catchments | X23G-1 to X23H-5 | 531 | 17 | 55% | 45% | 0% | **0.8** |
| Lower Crocodile catchments | X24A-1 to X24H-2 | 3349 | 12 | 34% | 66% | 0% | **0.4** |
| **Total Crocodile** | **X2** | **10446** | **1943** | **62%** | **38%** | **0%** | **157.6** |

## 6.4 Sabie catchments

Current (2004) afforestation covers some 14 % or 853 km$^2$ of the Sabie River catchments. **Table 6.3** provides a summary of the current situation in defined sub-areas. Afforestation is particularly significant in the upper Sabie and Marite sub-catchment with more than 50 % forested area in a number of the quinary catchments. In the remaining sub-areas afforestation is less significant but maybe locally significant in terms of stream flow reduction and impact on yield. The Sand River catchment (X32) has much less forestry due mostly to its climatic unsuitability.

The catchments downstream of the Sabie River and Sand River confluence (X33) have no forestry. Pine plantations are the dominant forest species in the Sabie Sand catchments at 61 % of total forestry area. There is no forestry in the Uanetse and Mazimchope (X4) catchments. Forestry is estimated to reduce runoff in the Sabie (X31) catchments by 86 million $m^3$ / annum and in the Sand (X32) catchments by 4 million $m^3$ / annum at current (2004) development levels.

The Sabie land use map, **Figure 1.1bc** shows the forestry in the Sabie catchments and **Figure 6.1** the reduction in runoff caused by forestry. **Table F-3** in **Appendix F** provides quinary catchments details for forestry and the historical growth in forestry. Information about current (2004) forestry was obtained from the **Verification study** (DWAF, 2006) while the growth in area was derived from the Verification study and Sabie River Catchment study (DWAF, 1990).

**Table 6.3 Current day (2004) forestry in the Sabie River catchments**

| Sub-area | Quinary catchments | Quinary area ($km^2$) | Forested area ($km^2$) | Current Species Distribution | | | SFR |
|---|---|---|---|---|---|---|---|
| | | | | Pine | Eucalypt | Wattle | MCM/a |
| Upper Sabie | X31A-1 to X31D-3 | 771 | 453 | 71% | 29% | 0% | 51.77 |
| Marite | X31E-1 to X31G-2 | 474 | 269 | 46% | 54% | 0% | 27.41 |
| White Waters | X31H-1 to X31J-1 | 215 | 74 | 45% | 55% | 0% | 6.64 |
| Sabie | X31K-1 to X31M-3 | 1500 | 1 | 63% | 37% | 0% | 0.01 |
| Sand | X32A-1 to X31J-3 | 1907 | 56 | 76% | 24% | 0% | 3.89 |
| Lower Sabie River | X33A-1 t o X33D-1 | 1448 | 0 | 0% | 0% | 0% | 0.00 |
| **Total Sabie** | **X3** | **6315** | **853** | **61%** | **39%** | **0%** | **89.72** |

## 6.4 Summary

The estimated current (2004) area of forestry in the Inkomati WMA (including Swaziland) is 4000 $km^2$, which is 14 % of the total WMA area. The reduction in runoff from forestry is estimated at 365 million $m^3$ / annum. Pine plantations are the dominant forest species in the all the catchments at over 60 % of total forestry area. The remaining forested area is mostly eucalyptus with small pockets of wattle.

# 7. Inter-basin Transfers

## 7.1 Introduction

When dealing with the transfer of water from one catchment to another it is important to distinguish between the types of transfer. In this study transfers have been divided into transfers ‘out’ of the Inkomati WMA to adjacent WMAs, transfers into the WMA from adjacent WMAs, transfers out of the tertiary catchments but within the WMA and transfers between quinary catchments within each of the Komati, Crocodile and Sabie/Sand catchments.

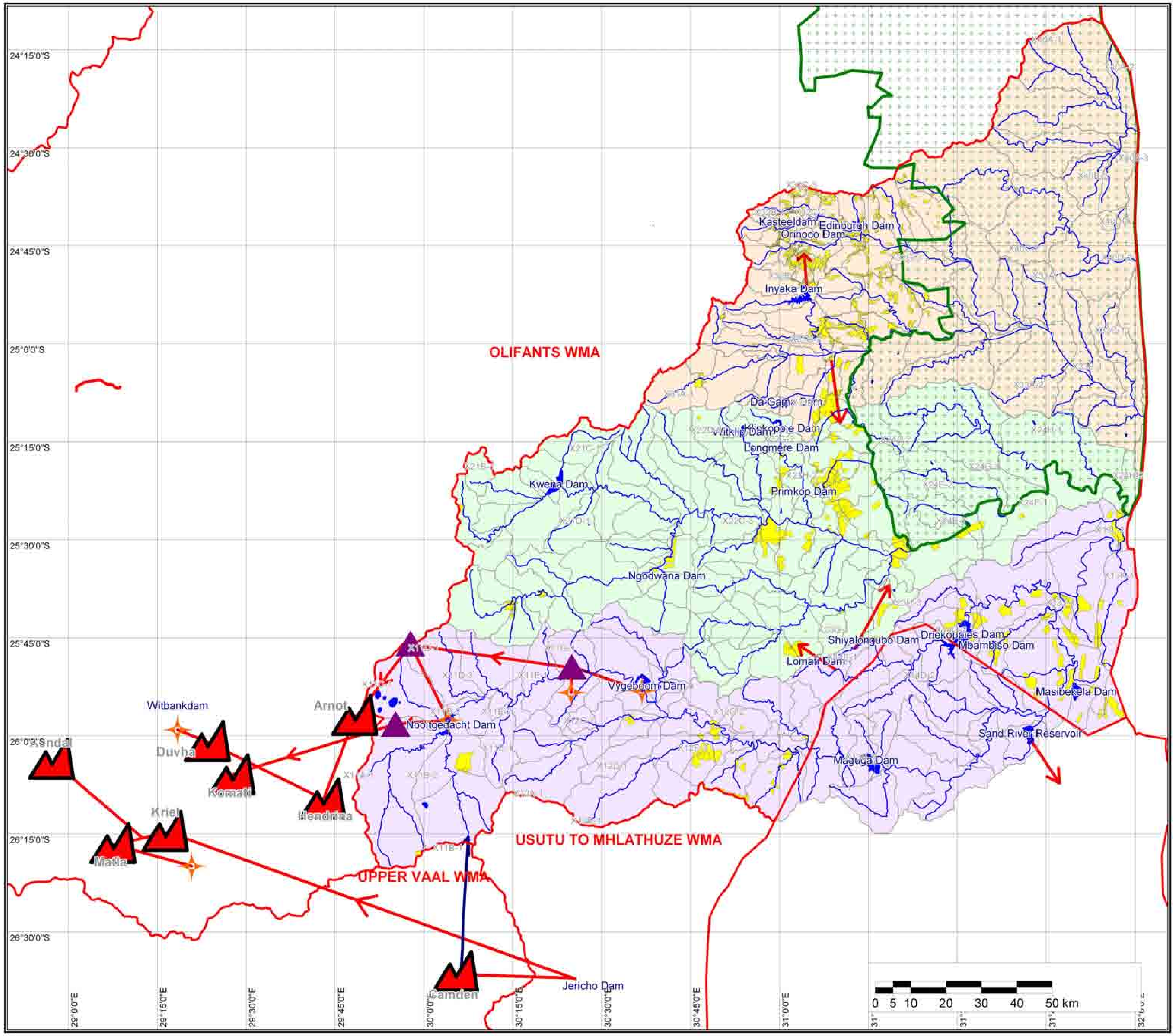
## 7.2 Komati Transfers

The Komati catchment has numerous transfers of water between catchments. The current (2004) transfers are listed in **Table 7.1** and graphically in **Figure 7.1** in **Appendix A**. The most significant being the transfer of water from the upper Komati catchment to strategic water users (power stations) in the Olifants WMA and the transfer from the Komati River in Swaziland to the Mbuluzi (W60) catchment. The transfer records are presented for each catchment in **Appendix G**.

### 7.2.1 Transfers out of Komati to other WMA’s

There are two large transfers of water out of the WMA from the Komati catchment. The transfers from Nooitgedacht Dam, Gemsbokhoek weir and Vygeboom Dam are to strategic users (Arnot, Hendrina and Komati power stations) in the Olifants catchment. This transfer has been operational since the construction of Nooitgedacht Dam in 1962. The data on transfers was obtained from the DWAF, the VRSAU study (DWAF, 1995) and from **Eskom** (A van der Merwe, 2006). The monthly time series of these transfers are presented in **Appendix G** in **Tables G-1, G-2**, and **G-3**.

The Komati Mbuluzi transfer has been operational since 1957 and is mainly for irrigators in the Mbuluzi (W60) catchment. Operated by Mlume Water, water is diverted via canal system with a capacity of 9.7 $m^3/s$ to the Mbuluzi catchment. The historical record (from Oct 1980) was provided by **Mhlume Water** (Peter Scott). There is no electronic information prior to 1980. The transfer varies considerably from year to year, with a maximum of 149 million $m^3$/annum transferred in 2001 and only 41 million $m^3$/annum transferred in 1999. The historical time series is presented in **Table G-4**.

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Date: 22/3/2007

Forestry and crops.map

# Figure 7.1

# Transfer Schemes of the Inkomati WMA

# Appendices

# Appendix A

## Figures / Maps

# Appendix B

## Record of Domestic water requirements

### Komati River catchments



### Crocodile River catchments



### Sabie Sand River catchments

## Table B-1 Carolina WSS: Abstractions from Boesmanskrantz Dam (million $m^3$ / month)

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1976 | **Boesmanskrantz Dam constructed** | | | | | | | | | | | | |
| 1977 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | **0.37** |
| 1978 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | **0.38** |
| 1979 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | **0.39** |
| 1980 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | **0.40** |
| 1981 | 0.04 | 0.03 | 0.04 | 0.04 | 0.03 | 0.04 | 0.03 | 0.04 | 0.03 | 0.04 | 0.04 | 0.03 | **0.43** |
| 1982 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | **0.46** |
| 1983 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | **0.46** |
| 1984 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | **0.46** |
| 1985 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | **0.46** |
| 1986 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | **0.46** |
| 1987 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | **0.46** |
| 1988 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | **0.46** |
| 1989 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | **0.46** |
| 1990 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | **0.46** |
| 1991 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | **0.50** |
| 1992 | 0.05 | 0.05 | 0.05 | 0.05 | 0.04 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | **0.55** |
| 1993 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | **0.60** |
| 1994 | 0.06 | 0.06 | 0.06 | 0.06 | 0.05 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | **0.70** |
| 1995 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | **0.85** |
| 1996 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | **0.70** |
| 1997 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | **0.60** |
| 1998 | 0.05 | 0.04 | 0.05 | 0.05 | 0.04 | 0.05 | 0.04 | 0.05 | 0.04 | 0.05 | 0.05 | 0.04 | **0.53** |
| 1999 | 0.05 | 0.04 | 0.05 | 0.05 | 0.04 | 0.05 | 0.04 | 0.05 | 0.04 | 0.05 | 0.05 | 0.04 | **0.53** |
| 2000 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | **0.53** |
| 2001 | 0.05 | 0.05 | 0.05 | 0.05 | 0.04 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | **0.55** |
| 2002 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | **0.60** |
| 2003 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | **0.61** |
| 2004 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | **0.61** |
| **Average** | **0.04** | **0.04** | **0.04** | **0.04** | **0.04** | **0.04** | **0.04** | **0.04** | **0.04** | **0.04** | **0.04** | **0.04** | **0.52** |
| **Minimum** | **0.03** | **0.03** | **0.03** | **0.03** | **0.03** | **0.03** | **0.03** | **0.03** | **0.03** | **0.03** | **0.03** | **0.03** | **0.37** |
| **Maximum** | **0.07** | **0.07** | **0.07** | **0.07** | **0.07** | **0.07** | **0.07** | **0.07** | **0.07** | **0.07** | **0.07** | **0.07** | **0.85** |

**Data sources:**

Joint Inkomati Basin Study (2001)

Water Situation Assessment Study (1995)

Albert Luthuli Water Services Development Plan (2003)

## Table B-2 Badplaas WSS: Abstractions from Buffelspruit (million $m^3$ / month)

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1960 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **0.04** |
| 1961 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **0.04** |
| 1962 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **0.05** |
| 1963 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **0.05** |
| 1964 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **0.05** |
| 1965 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **0.06** |
| 1966 | 0.01 | 0.01 | 0.01 | 0.01 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.06** |
| 1967 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.07** |
| 1968 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.07** |
| 1969 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.08** |
| 1970 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.08** |
| 1971 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.08** |
| 1972 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.09** |
| 1973 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.09** |
| 1974 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.10** |
| 1975 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.10** |
| 1976 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.11** |
| 1977 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.11** |
| 1978 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.12** |
| 1979 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.12** |
| 1980 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.13** |
| 1981 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.14** |
| 1982 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.14** |
| 1983 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.15** |
| 1984 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.16** |
| 1985 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.17** |
| 1986 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.17** |
| 1987 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | **0.18** |
| 1988 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | **0.19** |
| 1989 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | **0.20** |
| 1990 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | **0.21** |
| 1991 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | **0.22** |
| 1992 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | **0.23** |
| 1993 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | **0.25** |
| 1994 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | **0.26** |
| 1995 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | **0.28** |
| 1996 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | **0.28** |
| 1997 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | **0.28** |
| 1998 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | **0.29** |
| 1999 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | **0.29** |
| 2000 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | **0.29** |
| 2001 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | **0.29** |
| 2002 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | **0.29** |
| 2003 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | **0.29** |
| 2004 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | **0.29** |
| **Average** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.16** |
| **Minimum** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.04** |
| **Maximum** | **0.02** | **0.02** | **0.02** | **0.02** | **0.02** | **0.02** | **0.02** | **0.02** | **0.02** | **0.02** | **0.02** | **0.02** | **0.29** |

**Data sources:**
Water Situation Assessment Study (1995)
Albert Luthuli Water Services Development Plan (2003)

**Table B-3a Elukwatini WSS: Abstractions from Theespruit (million m$^3$ / month)**

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1981 | 0.00 | 0.00 | 0.00 | 0.27 | 0.24 | 0.27 | 0.26 | 0.27 | 0.26 | 0.27 | 0.27 | 0.26 | **2.36** |
| 1982 | 0.27 | 0.26 | 0.27 | 0.27 | 0.24 | 0.27 | 0.26 | 0.27 | 0.26 | 0.27 | 0.27 | 0.26 | **3.15** |
| 1983 | 0.27 | 0.26 | 0.27 | 0.27 | 0.25 | 0.27 | 0.26 | 0.27 | 0.26 | 0.27 | 0.27 | 0.26 | **3.16** |
| 1984 | 0.27 | 0.26 | 0.27 | 0.27 | 0.24 | 0.27 | 0.26 | 0.27 | 0.26 | 0.27 | 0.27 | 0.26 | **3.15** |
| 1985 | 0.27 | 0.26 | 0.27 | 0.27 | 0.24 | 0.27 | 0.26 | 0.27 | 0.26 | 0.27 | 0.27 | 0.26 | **3.15** |
| 1986 | 0.27 | 0.26 | 0.27 | 0.27 | 0.24 | 0.27 | 0.26 | 0.27 | 0.26 | 0.27 | 0.27 | 0.26 | **3.15** |
| 1987 | 0.27 | 0.26 | 0.27 | 0.27 | 0.25 | 0.27 | 0.26 | 0.27 | 0.26 | 0.27 | 0.27 | 0.26 | **3.16** |
| 1988 | 0.27 | 0.26 | 0.27 | 0.27 | 0.24 | 0.27 | 0.26 | 0.27 | 0.26 | 0.27 | 0.27 | 0.26 | **3.15** |
| 1989 | 0.27 | 0.26 | 0.27 | 0.27 | 0.24 | 0.27 | 0.26 | 0.27 | 0.26 | 0.27 | 0.27 | 0.26 | **3.15** |
| 1990 | 0.27 | 0.26 | 0.27 | 0.27 | 0.24 | 0.27 | 0.26 | 0.27 | 0.26 | 0.27 | 0.27 | 0.26 | **3.15** |
| 1991 | 0.27 | 0.26 | 0.27 | 0.27 | 0.25 | 0.27 | 0.26 | 0.27 | 0.26 | 0.27 | 0.27 | 0.26 | **3.16** |
| 1992 | 0.27 | 0.26 | 0.27 | 0.27 | 0.24 | 0.27 | 0.26 | 0.27 | 0.26 | 0.27 | 0.27 | 0.26 | **3.15** |
| 1993 | 0.27 | 0.26 | 0.27 | 0.27 | 0.24 | 0.27 | 0.26 | 0.27 | 0.26 | 0.27 | 0.27 | 0.26 | **3.15** |
| 1994 | 0.27 | 0.26 | 0.27 | 0.27 | 0.24 | 0.27 | 0.26 | 0.27 | 0.26 | 0.27 | 0.27 | 0.26 | **3.15** |
| 1995 | 0.27 | 0.26 | 0.27 | 0.27 | 0.25 | 0.27 | 0.26 | 0.27 | 0.26 | 0.27 | 0.27 | 0.26 | **3.16** |
| 1996 | 0.27 | 0.26 | 0.27 | 0.27 | 0.24 | 0.27 | 0.26 | 0.27 | 0.26 | 0.27 | 0.27 | 0.26 | **3.15** |
| 1997 | 0.27 | 0.26 | 0.27 | 0.27 | 0.24 | 0.27 | 0.26 | 0.27 | 0.26 | 0.27 | 0.27 | 0.26 | **3.15** |
| 1998 | 0.27 | 0.26 | 0.27 | 0.27 | 0.24 | 0.27 | 0.26 | 0.27 | 0.26 | 0.27 | 0.27 | 0.26 | **3.15** |
| 1999 | 0.27 | 0.26 | 0.27 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | **1.98** |
| 2000 | 0.13 | 0.13 | 0.13 | 0.13 | 0.12 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | **1.58** |
| 2001 | 0.13 | 0.13 | 0.13 | 0.13 | 0.12 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | **1.58** |
| 2002 | 0.13 | 0.13 | 0.13 | 0.13 | 0.12 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | **1.58** |
| 2003 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | **1.58** |
| 2004 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | **1.58** |
| **Average** | **0.23** | **0.22** | **0.23** | **0.23** | **0.21** | **0.23** | **0.23** | **0.23** | **0.23** | **0.23** | **0.23** | **0.23** | **2.82** |
| **Minimum** | **0.00** | **0.00** | **0.00** | **0.13** | **0.12** | **0.13** | **0.13** | **0.13** | **0.13** | **0.13** | **0.13** | **0.13** | **1.58** |
| **Maximum** | **0.27** | **0.26** | **0.27** | **0.27** | **0.25** | **0.27** | **0.26** | **0.27** | **0.26** | **0.27** | **0.27** | **0.26** | **3.16** |

Distribution capacity is 8.64 Ml/day (pers comm: John Mabuze, DWAF Mpumlanga

**Table B-3b Elukwatini WSS: Abstractions from Komati River (million m$^3$ / month)**

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1999 | 0.00 | 0.00 | 0.00 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | **1.18** |
| 2000 | 0.13 | 0.13 | 0.13 | 0.13 | 0.12 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | **1.58** |
| 2001 | 0.13 | 0.13 | 0.13 | 0.13 | 0.12 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | **1.58** |
| 2002 | 0.13 | 0.13 | 0.13 | 0.13 | 0.12 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | **1.58** |
| 2003 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | **1.58** |
| 2004 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | **1.58** |
| **Average** | **0.11** | **0.11** | **0.11** | **0.13** | **0.12** | **0.13** | **0.13** | **0.13** | **0.13** | **0.13** | **0.13** | **0.13** | **1.51** |
| **Minimum** | **0.00** | **0.00** | **0.00** | **0.13** | **0.12** | **0.13** | **0.13** | **0.13** | **0.13** | **0.13** | **0.13** | **0.13** | **1.18** |
| **Maximum** | **0.13** | **0.13** | **0.13** | **0.13** | **0.13** | **0.13** | **0.13** | **0.13** | **0.13** | **0.13** | **0.13** | **0.13** | **1.58** |

**Data sources:**
DWAF Mpumalanga
Albert Luthuli Water Services Development Plan (2003)

**Table B-4 Elukindeni WSS: Abstractions from Komati River (million $m^3$ / month)**

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1991 | 0.062 | 0.060 | 0.062 | 0.062 | 0.058 | 0.062 | 0.060 | 0.062 | 0.060 | 0.062 | 0.062 | 0.060 | **0.73** |
| 1992 | 0.062 | 0.060 | 0.062 | 0.062 | 0.056 | 0.062 | 0.060 | 0.062 | 0.060 | 0.062 | 0.062 | 0.060 | **0.73** |
| 1993 | 0.062 | 0.060 | 0.062 | 0.062 | 0.056 | 0.062 | 0.060 | 0.062 | 0.060 | 0.062 | 0.062 | 0.060 | **0.73** |
| 1994 | 0.062 | 0.060 | 0.062 | 0.062 | 0.056 | 0.062 | 0.060 | 0.062 | 0.060 | 0.062 | 0.062 | 0.060 | **0.73** |
| 1995 | 0.081 | 0.078 | 0.081 | 0.081 | 0.076 | 0.081 | 0.078 | 0.081 | 0.078 | 0.081 | 0.081 | 0.078 | **0.95** |
| 1996 | 0.062 | 0.060 | 0.062 | 0.062 | 0.056 | 0.062 | 0.060 | 0.062 | 0.060 | 0.062 | 0.062 | 0.060 | **0.73** |
| 1997 | 0.062 | 0.060 | 0.062 | 0.062 | 0.056 | 0.062 | 0.060 | 0.062 | 0.060 | 0.062 | 0.062 | 0.060 | **0.73** |
| 1998 | 0.062 | 0.060 | 0.062 | 0.062 | 0.056 | 0.062 | 0.060 | 0.062 | 0.060 | 0.062 | 0.062 | 0.060 | **0.73** |
| 1999 | 0.062 | 0.060 | 0.062 | 0.062 | 0.058 | 0.062 | 0.060 | 0.062 | 0.060 | 0.062 | 0.062 | 0.060 | **0.73** |
| 2000 | 0.062 | 0.060 | 0.062 | 0.062 | 0.056 | 0.062 | 0.060 | 0.062 | 0.060 | 0.062 | 0.062 | 0.060 | **0.73** |
| 2001 | 0.062 | 0.060 | 0.062 | 0.062 | 0.056 | 0.062 | 0.060 | 0.062 | 0.060 | 0.062 | 0.062 | 0.060 | **0.73** |
| 2002 | 0.062 | 0.060 | 0.062 | 0.062 | 0.056 | 0.062 | 0.060 | 0.062 | 0.060 | 0.062 | 0.062 | 0.060 | **0.73** |
| 2003 | 0.062 | 0.060 | 0.062 | 0.062 | 0.058 | 0.062 | 0.060 | 0.062 | 0.060 | 0.062 | 0.062 | 0.060 | **0.73** |
| 2004 | 0.062 | 0.060 | 0.062 | 0.062 | 0.058 | 0.062 | 0.060 | 0.062 | 0.060 | 0.062 | 0.062 | 0.060 | **0.73** |
| **Average** | **0.063** | **0.061** | **0.063** | **0.063** | **0.058** | **0.063** | **0.061** | **0.063** | **0.061** | **0.063** | **0.063** | **0.061** | **0.75** |
| **Minimum** | **0.062** | **0.060** | **0.062** | **0.062** | **0.056** | **0.062** | **0.060** | **0.062** | **0.060** | **0.062** | **0.062** | **0.060** | **0.73** |
| **Maximum** | **0.081** | **0.078** | **0.081** | **0.081** | **0.076** | **0.081** | **0.078** | **0.081** | **0.078** | **0.081** | **0.081** | **0.078** | **0.95** |

Not known when WSS started operating
Permitted abstraction: 0.75 million $m^3$/a
**Data sources:**
Albert Luthuli Water Services Development Plan (2003)

**Table B-5 Swaziland: Abstractions from Komati River (million $m^3$ / month)**

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1980 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.319 | **3.79** |
| 1981 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.319 | **3.79** |
| 1982 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.319 | **3.79** |
| 1983 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.319 | **3.79** |
| 1984 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.319 | **3.79** |
| 1985 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.319 | **3.79** |
| 1986 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.319 | **3.79** |
| 1987 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.319 | **3.79** |
| 1988 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.319 | **3.79** |
| 1989 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.319 | **3.79** |
| 1990 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.319 | **3.79** |
| 1991 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.319 | **3.79** |
| 1992 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.319 | **3.79** |
| 1993 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.319 | **3.79** |
| 1994 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.319 | **3.79** |
| 1995 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.319 | **3.79** |
| 1996 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.319 | **3.79** |
| 1997 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.319 | **3.79** |
| 1998 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.319 | **3.79** |
| 1999 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.319 | **3.79** |
| 2000 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.319 | **3.79** |
| 2001 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.319 | **3.79** |
| 2002 | 0.319 | 0.319 | 0.319 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.319 | **3.80** |
| 2003 | 0.319 | 0.319 | 0.319 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.319 | **3.80** |
| 2004 | 0.319 | 0.319 | 0.319 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.319 | **3.80** |
| **Average** | **0.316** | **0.316** | **0.316** | **0.315** | **0.315** | **0.315** | **0.315** | **0.315** | **0.315** | **0.315** | **0.315** | **0.319** | 3.79 |
| **Min** | **0.315** | **0.315** | **0.315** | **0.315** | **0.315** | **0.315** | **0.315** | **0.315** | **0.315** | **0.315** | **0.315** | **0.319** | 3.79 |
| **Max** | **0.319** | **0.319** | **0.319** | **0.315** | **0.315** | **0.315** | **0.315** | **0.315** | **0.315** | **0.315** | **0.315** | **0.319** | 3.80 |

**Data sources:**
Joint Inkomati Basin Study (2001)
KOBWA

**Table B-6 Tonga, Masibekela, Sibange, Madadeni and Magudu WSS's: Abstractions from Komati River (million $m^3$ / month)**

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1970 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | **0.36** |
| 1971 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | **0.36** |
| 1972 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | **0.36** |
| 1973 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | **0.36** |
| 1974 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | **0.36** |
| 1975 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | **0.36** |
| 1976 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | **0.36** |
| 1977 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | **0.36** |
| 1978 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | **0.36** |
| 1979 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | **0.36** |
| 1980 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | **0.48** |
| 1981 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | **0.48** |
| 1982 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | **0.48** |
| 1983 | 0.05 | 0.04 | 0.05 | 0.05 | 0.04 | 0.05 | 0.04 | 0.05 | 0.04 | 0.05 | 0.05 | 0.04 | **0.55** |
| 1984 | 0.05 | 0.05 | 0.05 | 0.05 | 0.04 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | **0.59** |
| 1985 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | **0.60** |
| 1986 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | **0.60** |
| 1987 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | **0.72** |
| 1988 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | **0.72** |
| 1989 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | **0.72** |
| 1990 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | **0.72** |
| 1991 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | **0.72** |
| 1992 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | **0.72** |
| 1993 | 0.07 | 0.07 | 0.07 | 0.07 | 0.06 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | **0.83** |
| 1994 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | **0.84** |
| 1995 | 0.08 | 0.07 | 0.08 | 0.08 | 0.07 | 0.08 | 0.07 | 0.08 | 0.07 | 0.08 | 0.08 | 0.07 | **0.91** |
| 1996 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | **1.92** |
| 1997 | 0.25 | 0.24 | 0.25 | 0.25 | 0.23 | 0.25 | 0.24 | 0.25 | 0.24 | 0.25 | 0.25 | 0.24 | **2.94** |
| 1998 | 0.35 | 0.34 | 0.35 | 0.35 | 0.34 | 0.35 | 0.34 | 0.35 | 0.34 | 0.35 | 0.35 | 0.34 | **4.15** |
| 1999 | 0.51 | 0.48 | 0.51 | 0.51 | 0.47 | 0.51 | 0.48 | 0.51 | 0.48 | 0.51 | 0.51 | 0.48 | **5.96** |
| 2000 | 0.59 | 0.56 | 0.59 | 0.59 | 0.55 | 0.59 | 0.56 | 0.59 | 0.56 | 0.59 | 0.59 | 0.56 | **6.92** |
| 2001 | 0.62 | 0.59 | 0.62 | 0.62 | 0.58 | 0.62 | 0.59 | 0.62 | 0.59 | 0.62 | 0.62 | 0.59 | **7.28** |
| 2002 | 0.62 | 0.60 | 0.62 | 0.62 | 0.58 | 0.62 | 0.60 | 0.62 | 0.60 | 0.62 | 0.62 | 0.60 | **7.32** |
| 2003 | 0.62 | 0.60 | 0.62 | 0.62 | 0.58 | 0.62 | 0.60 | 0.62 | 0.60 | 0.62 | 0.62 | 0.60 | **7.32** |
| 2004 | 0.62 | 0.60 | 0.62 | 0.62 | 0.58 | 0.62 | 0.60 | 0.62 | 0.60 | 0.62 | 0.62 | 0.60 | **7.32** |
| **Average** | **0.16** | **0.15** | **0.16** | **0.16** | **0.15** | **0.16** | **0.15** | **0.16** | **0.15** | **0.16** | **0.16** | **0.15** | **1.87** |
| **Min** | **0.03** | **0.03** | **0.03** | **0.03** | **0.03** | **0.03** | **0.03** | **0.03** | **0.03** | **0.03** | **0.03** | **0.03** | **0.36** |
| **Max** | **0.62** | **0.60** | **0.62** | **0.62** | **0.58** | **0.62** | **0.60** | **0.62** | **0.60** | **0.62** | **0.62** | **0.60** | **7.32** |

**Data sources:**
Joint Inkomati Basin Study (2001)
Nkomazi Water Services Development Plans (2003, 2005)

**Table B-7 Komatipoort WSS: Abstractions from Komati River (million $m^3$ / month)**

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1960 | 0.042 | 0.041 | 0.042 | 0.042 | 0.040 | 0.042 | 0.041 | 0.042 | 0.041 | 0.042 | 0.042 | 0.041 | **0.50** |
| 1961 | 0.042 | 0.041 | 0.042 | 0.042 | 0.040 | 0.042 | 0.041 | 0.042 | 0.041 | 0.042 | 0.042 | 0.041 | **0.50** |
| 1962 | 0.042 | 0.041 | 0.042 | 0.042 | 0.040 | 0.042 | 0.041 | 0.042 | 0.041 | 0.042 | 0.042 | 0.041 | **0.50** |
| 1963 | 0.042 | 0.041 | 0.042 | 0.042 | 0.040 | 0.042 | 0.041 | 0.042 | 0.041 | 0.042 | 0.042 | 0.041 | **0.50** |
| 1964 | 0.042 | 0.041 | 0.042 | 0.042 | 0.040 | 0.042 | 0.041 | 0.042 | 0.041 | 0.042 | 0.042 | 0.041 | **0.50** |
| 1965 | 0.042 | 0.041 | 0.042 | 0.042 | 0.040 | 0.042 | 0.041 | 0.042 | 0.041 | 0.042 | 0.042 | 0.041 | **0.50** |
| 1966 | 0.042 | 0.041 | 0.042 | 0.042 | 0.040 | 0.042 | 0.041 | 0.042 | 0.041 | 0.042 | 0.042 | 0.041 | **0.50** |
| 1967 | 0.042 | 0.041 | 0.042 | 0.042 | 0.040 | 0.042 | 0.041 | 0.042 | 0.041 | 0.042 | 0.042 | 0.041 | **0.50** |
| 1968 | 0.042 | 0.041 | 0.042 | 0.042 | 0.040 | 0.042 | 0.041 | 0.042 | 0.041 | 0.042 | 0.042 | 0.041 | **0.50** |
| 1969 | 0.042 | 0.041 | 0.042 | 0.042 | 0.040 | 0.042 | 0.041 | 0.042 | 0.041 | 0.042 | 0.042 | 0.041 | **0.50** |
| 1970 | 0.042 | 0.041 | 0.042 | 0.042 | 0.040 | 0.042 | 0.041 | 0.042 | 0.041 | 0.042 | 0.042 | 0.041 | **0.50** |
| 1971 | 0.042 | 0.041 | 0.042 | 0.042 | 0.040 | 0.042 | 0.041 | 0.042 | 0.041 | 0.042 | 0.042 | 0.041 | **0.50** |
| 1972 | 0.042 | 0.041 | 0.042 | 0.042 | 0.040 | 0.042 | 0.041 | 0.042 | 0.041 | 0.042 | 0.042 | 0.041 | **0.50** |
| 1973 | 0.042 | 0.041 | 0.042 | 0.042 | 0.040 | 0.042 | 0.041 | 0.042 | 0.041 | 0.042 | 0.042 | 0.041 | **0.50** |
| 1974 | 0.042 | 0.041 | 0.042 | 0.042 | 0.040 | 0.042 | 0.041 | 0.042 | 0.041 | 0.042 | 0.042 | 0.041 | **0.50** |
| 1975 | 0.042 | 0.041 | 0.042 | 0.042 | 0.040 | 0.042 | 0.041 | 0.042 | 0.041 | 0.042 | 0.042 | 0.041 | **0.50** |
| 1976 | 0.042 | 0.041 | 0.042 | 0.042 | 0.040 | 0.042 | 0.041 | 0.042 | 0.041 | 0.042 | 0.042 | 0.041 | **0.50** |
| 1977 | 0.042 | 0.041 | 0.042 | 0.042 | 0.040 | 0.042 | 0.041 | 0.042 | 0.041 | 0.042 | 0.042 | 0.041 | **0.50** |
| 1978 | 0.042 | 0.041 | 0.042 | 0.042 | 0.040 | 0.042 | 0.041 | 0.042 | 0.041 | 0.042 | 0.042 | 0.041 | **0.50** |
| 1979 | 0.042 | 0.041 | 0.042 | 0.042 | 0.040 | 0.042 | 0.041 | 0.042 | 0.041 | 0.042 | 0.042 | 0.041 | **0.50** |
| 1980 | 0.042 | 0.041 | 0.042 | 0.042 | 0.040 | 0.042 | 0.041 | 0.042 | 0.041 | 0.042 | 0.042 | 0.041 | **0.50** |
| 1981 | 0.042 | 0.041 | 0.042 | 0.042 | 0.040 | 0.042 | 0.041 | 0.042 | 0.041 | 0.042 | 0.042 | 0.041 | **0.50** |
| 1982 | 0.042 | 0.041 | 0.042 | 0.042 | 0.040 | 0.042 | 0.041 | 0.042 | 0.041 | 0.042 | 0.042 | 0.041 | **0.50** |
| 1983 | 0.042 | 0.041 | 0.042 | 0.042 | 0.040 | 0.042 | 0.041 | 0.042 | 0.041 | 0.042 | 0.042 | 0.041 | **0.50** |
| 1984 | 0.042 | 0.041 | 0.042 | 0.042 | 0.040 | 0.042 | 0.041 | 0.042 | 0.041 | 0.042 | 0.042 | 0.041 | **0.50** |
| 1985 | 0.042 | 0.041 | 0.042 | 0.042 | 0.040 | 0.042 | 0.041 | 0.042 | 0.041 | 0.042 | 0.042 | 0.041 | **0.50** |
| 1986 | 0.042 | 0.041 | 0.042 | 0.042 | 0.040 | 0.042 | 0.041 | 0.042 | 0.041 | 0.042 | 0.042 | 0.041 | **0.50** |
| 1987 | 0.042 | 0.041 | 0.042 | 0.042 | 0.040 | 0.042 | 0.041 | 0.042 | 0.041 | 0.042 | 0.042 | 0.041 | **0.50** |
| 1988 | 0.047 | 0.045 | 0.047 | 0.047 | 0.044 | 0.047 | 0.045 | 0.047 | 0.045 | 0.047 | 0.047 | 0.045 | **0.55** |
| 1989 | 0.051 | 0.049 | 0.051 | 0.051 | 0.048 | 0.051 | 0.049 | 0.051 | 0.049 | 0.051 | 0.051 | 0.049 | **0.60** |
| 1990 | 0.055 | 0.053 | 0.055 | 0.055 | 0.052 | 0.055 | 0.053 | 0.055 | 0.053 | 0.055 | 0.055 | 0.053 | **0.65** |
| 1991 | 0.058 | 0.056 | 0.058 | 0.058 | 0.054 | 0.058 | 0.056 | 0.058 | 0.056 | 0.058 | 0.058 | 0.056 | **0.68** |
| 1992 | 0.061 | 0.059 | 0.061 | 0.061 | 0.057 | 0.061 | 0.059 | 0.061 | 0.059 | 0.061 | 0.061 | 0.059 | **0.72** |
| 1993 | 0.064 | 0.062 | 0.064 | 0.064 | 0.060 | 0.064 | 0.062 | 0.064 | 0.062 | 0.064 | 0.064 | 0.062 | **0.75** |
| 1994 | 0.068 | 0.066 | 0.068 | 0.068 | 0.064 | 0.068 | 0.066 | 0.068 | 0.066 | 0.068 | 0.068 | 0.066 | **0.80** |
| 1995 | 0.070 | 0.067 | 0.070 | 0.070 | 0.065 | 0.070 | 0.067 | 0.070 | 0.067 | 0.070 | 0.070 | 0.067 | **0.82** |
| 1996 | 0.068 | 0.066 | 0.068 | 0.068 | 0.064 | 0.068 | 0.066 | 0.068 | 0.066 | 0.068 | 0.068 | 0.066 | **0.80** |
| 1997 | 0.065 | 0.062 | 0.065 | 0.065 | 0.060 | 0.065 | 0.062 | 0.065 | 0.062 | 0.065 | 0.065 | 0.062 | **0.76** |
| 1998 | 0.059 | 0.057 | 0.059 | 0.059 | 0.056 | 0.059 | 0.057 | 0.059 | 0.057 | 0.059 | 0.059 | 0.057 | **0.70** |
| 1999 | 0.055 | 0.053 | 0.055 | 0.055 | 0.052 | 0.055 | 0.053 | 0.055 | 0.053 | 0.055 | 0.055 | 0.053 | **0.65** |
| 2000 | 0.051 | 0.049 | 0.051 | 0.051 | 0.048 | 0.051 | 0.049 | 0.051 | 0.049 | 0.051 | 0.051 | 0.049 | **0.60** |
| 2001 | 0.042 | 0.041 | 0.042 | 0.042 | 0.040 | 0.042 | 0.041 | 0.042 | 0.041 | 0.042 | 0.042 | 0.041 | **0.50** |
| 2002 | 0.042 | 0.041 | 0.042 | 0.042 | 0.040 | 0.042 | 0.041 | 0.042 | 0.041 | 0.042 | 0.042 | 0.041 | **0.50** |
| 2003 | 0.042 | 0.041 | 0.042 | 0.042 | 0.040 | 0.042 | 0.041 | 0.042 | 0.041 | 0.042 | 0.042 | 0.041 | **0.50** |
| 2004 | 0.042 | 0.041 | 0.042 | 0.042 | 0.040 | 0.042 | 0.041 | 0.042 | 0.041 | 0.042 | 0.042 | 0.041 | **0.50** |
| **Average** | **0.047** | **0.046** | **0.047** | **0.047** | **0.044** | **0.047** | **0.046** | **0.047** | **0.046** | **0.047** | **0.047** | **0.046** | **0.56** |
| **Minimum** | **0.042** | **0.041** | **0.042** | **0.042** | **0.040** | **0.042** | **0.041** | **0.042** | **0.041** | **0.042** | **0.042** | **0.041** | **0.50** |
| **Maximum** | **0.070** | **0.067** | **0.070** | **0.070** | **0.065** | **0.070** | **0.067** | **0.070** | **0.067** | **0.070** | **0.070** | **0.067** | **0.82** |

Not known when WSS started operating

**Data sources:**

Joint Inkomati Basin Study (2001)

Nkomazi Water Services Development Plans (2003, 2005)

**Table B-8 Driekoppies WSS: Abstractions from Driekoppies Dam (million $m^3$ / month)**

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1998 | 0.238 | 0.230 | 0.238 | 0.238 | 0.215 | 0.238 | 0.230 | 0.238 | 0.230 | 0.238 | 0.238 | 0.230 | **2.80** |
| 1999 | 0.255 | 0.247 | 0.255 | 0.255 | 0.230 | 0.255 | 0.247 | 0.255 | 0.247 | 0.255 | 0.255 | 0.247 | **3.00** |
| 2000 | 0.288 | 0.279 | 0.288 | 0.288 | 0.269 | 0.288 | 0.279 | 0.288 | 0.279 | 0.288 | 0.288 | 0.279 | **3.40** |
| 2001 | 0.289 | 0.279 | 0.289 | 0.289 | 0.261 | 0.289 | 0.279 | 0.289 | 0.279 | 0.289 | 0.289 | 0.279 | **3.40** |
| 2002 | 0.289 | 0.279 | 0.289 | 0.289 | 0.261 | 0.289 | 0.279 | 0.289 | 0.279 | 0.289 | 0.289 | 0.279 | **3.40** |
| 2003 | 0.289 | 0.279 | 0.289 | 0.289 | 0.261 | 0.289 | 0.279 | 0.289 | 0.279 | 0.289 | 0.289 | 0.279 | **3.40** |
| 2004 | 0.289 | 0.279 | 0.289 | 0.289 | 0.261 | 0.289 | 0.279 | 0.289 | 0.279 | 0.289 | 0.289 | 0.279 | **3.40** |
| **Average** | **0.277** | **0.268** | **0.277** | **0.277** | **0.251** | **0.277** | **0.268** | **0.277** | **0.268** | **0.277** | **0.277** | **0.268** | **3.23** |
| **Minimum** | **0.238** | **0.230** | **0.238** | **0.238** | **0.215** | **0.238** | **0.230** | **0.238** | **0.230** | **0.238** | **0.238** | **0.230** | **2.80** |
| **Maximum** | **0.289** | **0.279** | **0.289** | **0.289** | **0.269** | **0.289** | **0.279** | **0.289** | **0.279** | **0.289** | **0.289** | **0.279** | **3.40** |

Not known when WSS started operating

**Data sources:**

Joint Inkomati Basin Study (2001)

Nkomazi Water Services Development Plans (2003, 2005)

KOBWA

**Table B-9 Langeloop / Nyathi WSS: Abstractions from Lomati (million $m^3$ / month) River downstream of Driekoppies Dam**

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1995 | 0.102 | 0.099 | 0.102 | 0.102 | 0.095 | 0.102 | 0.099 | 0.102 | 0.099 | 0.102 | 0.102 | 0.099 | **1.20** |
| 1996 | 0.110 | 0.107 | 0.110 | 0.110 | 0.103 | 0.110 | 0.107 | 0.110 | 0.107 | 0.110 | 0.110 | 0.107 | **1.30** |
| 1997 | 0.115 | 0.111 | 0.115 | 0.115 | 0.107 | 0.115 | 0.111 | 0.115 | 0.111 | 0.115 | 0.115 | 0.111 | **1.35** |
| 1998 | 0.119 | 0.115 | 0.119 | 0.119 | 0.111 | 0.119 | 0.115 | 0.119 | 0.115 | 0.119 | 0.119 | 0.115 | **1.40** |
| 1999 | 0.123 | 0.119 | 0.123 | 0.123 | 0.115 | 0.123 | 0.119 | 0.123 | 0.119 | 0.123 | 0.123 | 0.119 | **1.45** |
| 2000 | 0.127 | 0.123 | 0.127 | 0.127 | 0.119 | 0.127 | 0.123 | 0.127 | 0.123 | 0.127 | 0.127 | 0.123 | **1.50** |
| 2001 | 0.127 | 0.123 | 0.127 | 0.127 | 0.119 | 0.127 | 0.123 | 0.127 | 0.123 | 0.127 | 0.127 | 0.123 | **1.50** |
| 2002 | 0.127 | 0.123 | 0.127 | 0.127 | 0.119 | 0.127 | 0.123 | 0.127 | 0.123 | 0.127 | 0.127 | 0.123 | **1.50** |
| 2003 | 0.127 | 0.123 | 0.127 | 0.127 | 0.119 | 0.127 | 0.123 | 0.127 | 0.123 | 0.127 | 0.127 | 0.123 | **1.50** |
| 2004 | 0.127 | 0.123 | 0.127 | 0.127 | 0.119 | 0.127 | 0.123 | 0.127 | 0.123 | 0.127 | 0.127 | 0.123 | **1.50** |
| **Average** | **0.121** | **0.117** | **0.121** | **0.121** | **0.113** | **0.121** | **0.117** | **0.121** | **0.117** | **0.121** | **0.121** | **0.117** | **1.42** |
| **Min** | **0.102** | **0.099** | **0.102** | **0.102** | **0.095** | **0.102** | **0.099** | **0.102** | **0.099** | **0.102** | **0.102** | **0.099** | **1.20** |
| **Max** | **0.127** | **0.123** | **0.127** | **0.127** | **0.119** | **0.127** | **0.123** | **0.127** | **0.123** | **0.127** | **0.127** | **0.123** | **1.50** |

Not known when WSS started operating

**Data sources:**

Joint Inkomati Basin Study (2001)

Nkomazi Water Services Development Plans (2003, 2005)

## Table B-10 Dullstroom / Sakhelwe WSS: Abstractions from Dam (million $m^3$ / month)

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1966 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | **0.07** |
| 1967 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | **0.07** |
| 1968 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | **0.08** |
| 1969 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | **0.08** |
| 1970 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | **0.08** |
| 1971 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | **0.08** |
| 1972 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | **0.08** |
| 1973 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | **0.09** |
| 1974 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | **0.09** |
| 1975 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | **0.09** |
| 1976 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | **0.09** |
| 1977 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | **0.10** |
| 1978 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | **0.10** |
| 1979 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | **0.10** |
| 1980 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | **0.10** |
| 1981 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | **0.10** |
| 1982 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | **0.11** |
| 1983 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | **0.11** |
| 1984 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | **0.11** |
| 1985 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | **0.13** |
| 1986 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | **0.15** |
| 1987 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | **0.17** |
| 1988 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | **0.19** |
| 1989 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | **0.21** |
| 1990 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 | **0.23** |
| 1991 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | **0.25** |
| 1992 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | **0.27** |
| 1993 | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 | **0.29** |
| 1994 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | **0.31** |
| 1995 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | **0.32** |
| 1996 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | **0.34** |
| 1997 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | **0.36** |
| 1998 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | **0.38** |
| 1999 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 | **0.40** |
| 2000 | 0.035 | 0.035 | 0.035 | 0.035 | 0.035 | 0.035 | 0.035 | 0.035 | 0.035 | 0.035 | 0.035 | 0.035 | **0.42** |
| 2001 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 | **0.44** |
| 2002 | 0.038 | 0.038 | 0.038 | 0.038 | 0.038 | 0.038 | 0.038 | 0.038 | 0.038 | 0.038 | 0.038 | 0.038 | **0.46** |
| 2003 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | **0.48** |
| 2004 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | **0.48** |
| **Average** | **0.02** | **0.02** | **0.02** | **0.02** | **0.02** | **0.02** | **0.02** | **0.02** | **0.02** | **0.02** | **0.02** | **0.02** | **0.21** |
| **Min** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.07** |
| **Max** | **0.04** | **0.04** | **0.04** | **0.04** | **0.04** | **0.04** | **0.04** | **0.04** | **0.04** | **0.04** | **0.04** | **0.04** | **0.48** |

**Data sources:**
Incomati River Basin Study (1990)
WSDP

**Table B-11 Machadorp WSS: Abstractions from Elands River (million $m^3$ / month)**

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1950 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | **0.02** |
| 1951 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | **0.03** |
| 1952 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | **0.04** |
| 1953 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | **0.05** |
| 1954 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | **0.05** |
| 1955 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | **0.06** |
| 1956 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | **0.07** |
| 1957 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | **0.08** |
| 1958 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | **0.08** |
| 1959 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | **0.09** |
| 1960 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | **0.10** |
| 1961 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | **0.11** |
| 1962 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | **0.11** |
| 1963 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | **0.12** |
| 1964 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | **0.13** |
| 1965 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | **0.14** |
| 1966 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | **0.14** |
| 1967 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | **0.15** |
| 1968 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | **0.16** |
| 1969 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | **0.16** |
| 1970 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | **0.17** |
| 1971 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | **0.18** |
| 1972 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | **0.19** |
| 1973 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | **0.19** |
| 1974 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | **0.20** |
| 1975 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | **0.21** |
| 1976 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | **0.22** |
| 1977 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 | **0.22** |
| 1978 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 | **0.23** |
| 1979 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | **0.24** |
| 1980 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | **0.25** |
| 1981 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | **0.25** |
| 1982 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | **0.26** |
| 1983 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | **0.27** |
| 1984 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | **0.28** |
| 1985 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | **0.28** |
| 1986 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | **0.28** |
| 1987 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | **0.28** |
| 1988 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | **0.28** |
| 1989 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | **0.28** |
| 1990 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | **0.28** |
| 1991 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | **0.28** |
| 1992 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | **0.28** |
| 1993 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | **0.28** |
| 1994 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | **0.30** |
| 1995 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | **0.32** |
| 1996 | 0.028 | 0.028 | 0.028 | 0.028 | 0.028 | 0.028 | 0.028 | 0.028 | 0.028 | 0.028 | 0.028 | 0.028 | **0.34** |
| 1997 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | **0.36** |
| 1998 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | **0.38** |
| 1999 | 0.033 | 0.033 | 0.033 | 0.033 | 0.033 | 0.033 | 0.033 | 0.033 | 0.033 | 0.033 | 0.033 | 0.033 | **0.40** |
| 2000 | 0.035 | 0.035 | 0.035 | 0.035 | 0.035 | 0.035 | 0.035 | 0.035 | 0.035 | 0.035 | 0.035 | 0.035 | **0.42** |
| 2001 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 | **0.44** |
| 2002 | 0.038 | 0.038 | 0.038 | 0.038 | 0.038 | 0.038 | 0.038 | 0.038 | 0.038 | 0.038 | 0.038 | 0.038 | **0.46** |
| 2003 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | **0.48** |
| 2004 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | **0.48** |
| **Average** | **0.018** | **0.018** | **0.018** | **0.018** | **0.018** | **0.018** | **0.018** | **0.018** | **0.018** | **0.018** | **0.018** | **0.018** | **0.22** |
| **Min** | **0.002** | **0.002** | **0.002** | **0.002** | **0.002** | **0.002** | **0.002** | **0.002** | **0.002** | **0.002** | **0.002** | **0.002** | **0.02** |
| **Max** | **0.040** | **0.040** | **0.040** | **0.040** | **0.040** | **0.040** | **0.040** | **0.040** | **0.040** | **0.040** | **0.040** | **0.040** | **0.48** |

**Data sources:**
Incomati River Basin Study (1990)
WSDP

**Table B-12 Watervalboven WSS: Abstractions from Elands River (million $m^3$ / month)**

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1947 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | **0.06** |
| 1948 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | **0.07** |
| 1949 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | **0.09** |
| 1950 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | **0.10** |
| 1951 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | **0.12** |
| 1952 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | **0.13** |
| 1953 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | **0.15** |
| 1954 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | **0.16** |
| 1955 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | **0.18** |
| 1956 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | **0.19** |
| 1957 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | **0.21** |
| 1958 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | **0.22** |
| 1959 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | **0.24** |
| 1960 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | **0.25** |
| 1961 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | **0.26** |
| 1962 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | **0.28** |
| 1963 | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 | **0.29** |
| 1964 | 0.026 | 0.026 | 0.026 | 0.026 | 0.026 | 0.026 | 0.026 | 0.026 | 0.026 | 0.026 | 0.026 | 0.026 | **0.31** |
| 1965 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | **0.32** |
| 1966 | 0.028 | 0.028 | 0.028 | 0.028 | 0.028 | 0.028 | 0.028 | 0.028 | 0.028 | 0.028 | 0.028 | 0.028 | **0.34** |
| 1967 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | **0.35** |
| 1968 | 0.031 | 0.031 | 0.031 | 0.031 | 0.031 | 0.031 | 0.031 | 0.031 | 0.031 | 0.031 | 0.031 | 0.031 | **0.37** |
| 1969 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | **0.38** |
| 1970 | 0.033 | 0.033 | 0.033 | 0.033 | 0.033 | 0.033 | 0.033 | 0.033 | 0.033 | 0.033 | 0.033 | 0.033 | **0.40** |
| 1971 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 | **0.41** |
| 1972 | 0.035 | 0.035 | 0.035 | 0.035 | 0.035 | 0.035 | 0.035 | 0.035 | 0.035 | 0.035 | 0.035 | 0.035 | **0.42** |
| 1973 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 | **0.44** |
| 1974 | 0.038 | 0.038 | 0.038 | 0.038 | 0.038 | 0.038 | 0.038 | 0.038 | 0.038 | 0.038 | 0.038 | 0.038 | **0.45** |
| 1975 | 0.039 | 0.039 | 0.039 | 0.039 | 0.039 | 0.039 | 0.039 | 0.039 | 0.039 | 0.039 | 0.039 | 0.039 | **0.47** |
| 1976 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | **0.48** |
| 1977 | 0.041 | 0.041 | 0.041 | 0.041 | 0.041 | 0.041 | 0.041 | 0.041 | 0.041 | 0.041 | 0.041 | 0.041 | **0.50** |
| 1978 | 0.043 | 0.043 | 0.043 | 0.043 | 0.043 | 0.043 | 0.043 | 0.043 | 0.043 | 0.043 | 0.043 | 0.043 | **0.51** |
| 1979 | 0.044 | 0.044 | 0.044 | 0.044 | 0.044 | 0.044 | 0.044 | 0.044 | 0.044 | 0.044 | 0.044 | 0.044 | **0.53** |
| 1980 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | **0.54** |
| 1981 | 0.046 | 0.046 | 0.046 | 0.046 | 0.046 | 0.046 | 0.046 | 0.046 | 0.046 | 0.046 | 0.046 | 0.046 | **0.56** |
| 1982 | 0.048 | 0.048 | 0.048 | 0.048 | 0.048 | 0.048 | 0.048 | 0.048 | 0.048 | 0.048 | 0.048 | 0.048 | **0.57** |
| 1983 | 0.049 | 0.049 | 0.049 | 0.049 | 0.049 | 0.049 | 0.049 | 0.049 | 0.049 | 0.049 | 0.049 | 0.049 | **0.59** |
| 1984 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | **0.60** |
| 1985 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | **0.60** |
| 1986 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.051 | **0.60** |
| 1987 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.051 | **0.60** |
| 1988 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.052 | **0.60** |
| 1989 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.052 | **0.60** |
| 1990 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.053 | **0.60** |
| 1991 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.053 | **0.60** |
| 1992 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.053 | **0.60** |
| 1993 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | **0.60** |
| 1994 | 0.051 | 0.051 | 0.051 | 0.051 | 0.051 | 0.051 | 0.051 | 0.051 | 0.051 | 0.051 | 0.051 | 0.051 | **0.61** |
| 1995 | 0.052 | 0.052 | 0.052 | 0.052 | 0.052 | 0.052 | 0.052 | 0.052 | 0.052 | 0.052 | 0.052 | 0.052 | **0.62** |
| 1996 | 0.052 | 0.052 | 0.052 | 0.052 | 0.052 | 0.052 | 0.052 | 0.052 | 0.052 | 0.052 | 0.052 | 0.052 | **0.63** |
| 1997 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | 0.053 | **0.64** |
| 1998 | 0.054 | 0.054 | 0.054 | 0.054 | 0.054 | 0.054 | 0.054 | 0.054 | 0.054 | 0.054 | 0.054 | 0.054 | **0.65** |
| 1999 | 0.055 | 0.055 | 0.055 | 0.055 | 0.055 | 0.055 | 0.055 | 0.055 | 0.055 | 0.055 | 0.055 | 0.055 | **0.65** |
| 2000 | 0.055 | 0.055 | 0.055 | 0.055 | 0.055 | 0.055 | 0.055 | 0.055 | 0.055 | 0.055 | 0.055 | 0.055 | **0.66** |
| 2001 | 0.056 | 0.056 | 0.056 | 0.056 | 0.056 | 0.056 | 0.056 | 0.056 | 0.056 | 0.056 | 0.056 | 0.056 | **0.67** |
| 2002 | 0.057 | 0.057 | 0.057 | 0.057 | 0.057 | 0.057 | 0.057 | 0.057 | 0.057 | 0.057 | 0.057 | 0.057 | **0.68** |
| 2003 | 0.058 | 0.058 | 0.058 | 0.058 | 0.058 | 0.058 | 0.058 | 0.058 | 0.058 | 0.058 | 0.058 | 0.058 | **0.69** |
| 2004 | 0.060 | 0.060 | 0.060 | 0.060 | 0.060 | 0.060 | 0.060 | 0.060 | 0.060 | 0.060 | 0.060 | 0.060 | **0.72** |
| **Average** | **0.036** | **0.036** | **0.036** | **0.036** | **0.036** | **0.036** | **0.036** | **0.036** | **0.036** | **0.036** | **0.036** | **0.036** | **0.43** |
| **Min** | **0.005** | **0.005** | **0.005** | **0.005** | **0.005** | **0.005** | **0.005** | **0.005** | **0.005** | **0.005** | **0.005** | **0.005** | **0.06** |
| **Max** | **0.060** | **0.060** | **0.060** | **0.060** | **0.060** | **0.060** | **0.060** | **0.060** | **0.060** | **0.060** | **0.060** | **0.060** | **0.72** |

**Data sources:**
Incomati River Basin Study (1990)
WSDP

**Table B-13 Umjindi WSS (Barberton): Transfers from Lomati Dam (million $m^3$ / month) in the Lomati River catchment**

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1990 | 0.29 | 0.29 | 0.27 | 0.28 | 0.28 | 0.28 | 0.29 | 0.28 | 0.29 | 0.28 | 0.35 | 0.31 | **3.49** |
| 1991 | 0.25 | 0.39 | 0.39 | 0.40 | 0.40 | 0.39 | 0.49 | 0.40 | 0.41 | 0.31 | 0.33 | 0.32 | **4.48** |
| 1992 | 0.39 | 0.26 | 0.16 | 0.15 | 0.11 | 0.14 | 0.11 | 0.20 | 0.21 | 0.15 | 0.14 | 0.18 | **2.20** |
| 1993 | 0.17 | 0.20 | 0.13 | 0.24 | 0.19 | 0.32 | 0.21 | 0.17 | 0.19 | 0.18 | 0.19 | 0.27 | **2.46** |
| 1994 | 0.23 | 0.21 | 0.17 | 0.23 | 0.17 | 0.22 | 0.21 | 0.21 | 0.30 | 0.03 | 0.25 | 0.20 | **2.43** |
| 1995 | 0.20 | 0.18 | 0.21 | 0.24 | 0.25 | 0.27 | 0.28 | 0.20 | 0.26 | 0.26 | 0.30 | 0.34 | **2.99** |
| 1996 | 0.39 | 0.36 | 0.32 | 0.34 | 0.32 | 0.28 | 0.28 | 0.29 | 0.28 | 0.28 | 0.30 | 0.29 | **3.73** |
| 1997 | 0.27 | 0.29 | 0.29 | 0.29 | 0.34 | 0.28 | 0.34 | 0.36 | 0.31 | 0.26 | 0.24 | 0.26 | **3.53** |
| 1998 | 0.26 | 0.28 | 0.35 | 0.27 | 0.31 | 0.30 | 0.29 | 0.28 | 0.31 | 0.32 | 0.33 | 0.36 | **3.66** |
| 1999 | 0.32 | 0.31 | 0.30 | 0.28 | 0.29 | 0.25 | 0.38 | 0.30 | 0.29 | 0.29 | 0.28 | 0.36 | **3.65** |
| 2000 | 0.31 | 0.30 | 0.26 | 0.28 | 0.32 | 0.28 | 0.28 | 0.28 | 0.31 | 0.32 | 0.30 | 0.33 | **3.57** |
| 2001 | 0.36 | 0.33 | 0.31 | 0.31 | 0.28 | 0.29 | 0.30 | 0.28 | 0.28 | 0.27 | 0.33 | 0.28 | **3.62** |
| 2002 | 0.34 | 0.36 | 0.29 | 0.31 | 0.32 | 0.26 | 0.30 | 0.33 | 0.33 | 0.29 | 0.30 | 0.31 | **3.74** |
| 2003 | 0.29 | 0.31 | 0.24 | 0.28 | 0.28 | 0.28 | 0.29 | 0.28 | 0.29 | 0.30 | 0.28 | 0.34 | **3.46** |
| 2004 | 0.35 | 0.34 | 0.37 | 0.31 | 0.33 | 0.30 | 0.29 | 0.30 | 0.33 | 0.31 | 0.28 | 0.36 | **3.87** |
| **Average** | **0.29** | **0.29** | **0.27** | **0.28** | **0.28** | **0.28** | **0.29** | **0.28** | **0.29** | **0.26** | **0.28** | **0.30** | **3.39** |
| **Min** | **0.17** | **0.18** | **0.13** | **0.15** | **0.11** | **0.14** | **0.11** | **0.17** | **0.19** | **0.03** | **0.14** | **0.18** | **2.20** |
| **Max** | **0.39** | **0.39** | **0.39** | **0.40** | **0.40** | **0.39** | **0.49** | **0.40** | **0.41** | **0.32** | **0.35** | **0.36** | **4.48** |

**Note:**
Alternative source of water is the Suidkaap River
Approx. 20 % to 30 % of water transferred from Lomati Dam is lost.
The information represents the transfer out of the Lomati catchment.
**Data sources:**
Incomati River Basin Study (1990)
Umjindi LM WSDP (2005)
Umjindi LM; F de Wet (2006)

## Table B-14 Mbombela WSS (Nelspruit): Abstractions from Crocodile River (million $m^3$ / month)

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1900 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **0.00** |
| 1901 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **0.03** |
| 1902 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.07** |
| 1903 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.10** |
| 1904 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.13** |
| 1905 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.16** |
| 1906 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | **0.20** |
| 1907 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | **0.23** |
| 1908 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | **0.26** |
| 1909 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | **0.29** |
| 1910 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | **0.33** |
| 1911 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | **0.36** |
| 1912 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | **0.39** |
| 1913 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | **0.43** |
| 1914 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | **0.46** |
| 1915 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | **0.49** |
| 1916 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | **0.52** |
| 1917 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | **0.56** |
| 1918 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | **0.59** |
| 1919 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | **0.62** |
| 1920 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | **0.66** |
| 1921 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | **0.69** |
| 1922 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | **0.72** |
| 1923 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | **0.75** |
| 1924 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | **0.79** |
| 1925 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | **0.82** |
| 1926 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | **0.85** |
| 1927 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | **0.89** |
| 1928 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | **0.92** |
| 1929 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | **0.95** |
| 1930 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | **0.98** |
| 1931 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | **1.02** |
| 1932 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | **1.05** |
| 1933 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | **1.08** |
| 1934 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | **1.11** |
| 1935 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | **1.15** |
| 1936 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | **1.18** |
| 1937 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | **1.21** |
| 1938 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | **1.25** |
| 1939 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | **1.28** |
| 1940 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | **1.31** |
| 1941 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | **1.34** |
| 1942 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | **1.38** |
| 1943 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | **1.41** |
| 1944 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | **1.44** |
| 1945 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | **1.48** |
| 1946 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | **1.51** |
| 1947 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | **1.54** |
| 1948 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | **1.57** |
| 1949 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | **1.61** |
| 1950 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | **1.64** |
| 1951 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | **1.67** |
| 1952 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | **1.70** |
| 1953 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | **1.74** |
| 1954 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | **1.77** |
| 1955 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | **1.80** |
| 1956 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | **1.84** |
| 1957 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | **1.87** |

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1958 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | **1.90** |
| 1959 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | **1.93** |
| 1960 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | **1.97** |
| 1961 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | **2.00** |
| 1962 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | **2.03** |
| 1963 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | **2.07** |
| 1964 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | **2.10** |
| 1965 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | **2.13** |
| 1966 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | **2.16** |
| 1967 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | **2.20** |
| 1968 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | **2.43** |
| 1969 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | **2.66** |
| 1970 | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 | **2.89** |
| 1971 | 0.26 | 0.26 | 0.26 | 0.26 | 0.26 | 0.26 | 0.26 | 0.26 | 0.26 | 0.26 | 0.26 | 0.26 | **3.13** |
| 1972 | 0.28 | 0.28 | 0.28 | 0.28 | 0.28 | 0.28 | 0.28 | 0.28 | 0.28 | 0.28 | 0.28 | 0.28 | **3.36** |
| 1973 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | **3.59** |
| 1974 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | **3.82** |
| 1975 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | **4.05** |
| 1976 | 0.36 | 0.36 | 0.36 | 0.36 | 0.36 | 0.36 | 0.36 | 0.36 | 0.36 | 0.36 | 0.36 | 0.36 | **4.29** |
| 1977 | 0.38 | 0.38 | 0.38 | 0.38 | 0.38 | 0.38 | 0.38 | 0.38 | 0.38 | 0.38 | 0.38 | 0.38 | **4.52** |
| 1978 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | **4.75** |
| 1979 | 0.42 | 0.42 | 0.42 | 0.42 | 0.42 | 0.42 | 0.42 | 0.42 | 0.42 | 0.42 | 0.42 | 0.42 | **4.98** |
| 1980 | 0.43 | 0.43 | 0.43 | 0.43 | 0.43 | 0.43 | 0.43 | 0.43 | 0.43 | 0.43 | 0.43 | 0.43 | **5.21** |
| 1981 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 | **5.45** |
| 1982 | 0.47 | 0.47 | 0.47 | 0.47 | 0.47 | 0.47 | 0.47 | 0.47 | 0.47 | 0.47 | 0.47 | 0.47 | **5.68** |
| 1983 | 0.49 | 0.49 | 0.49 | 0.49 | 0.49 | 0.49 | 0.49 | 0.49 | 0.49 | 0.49 | 0.49 | 0.49 | **5.91** |
| 1984 | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 | **6.14** |
| 1985 | 0.53 | 0.53 | 0.53 | 0.53 | 0.53 | 0.53 | 0.53 | 0.53 | 0.53 | 0.53 | 0.53 | 0.53 | **6.37** |
| 1986 | 0.55 | 0.55 | 0.55 | 0.55 | 0.55 | 0.55 | 0.55 | 0.55 | 0.55 | 0.55 | 0.55 | 0.55 | **6.61** |
| 1987 | 0.57 | 0.57 | 0.57 | 0.57 | 0.57 | 0.57 | 0.57 | 0.57 | 0.57 | 0.57 | 0.57 | 0.57 | **6.84** |
| 1988 | 0.59 | 0.59 | 0.59 | 0.59 | 0.59 | 0.59 | 0.59 | 0.59 | 0.59 | 0.59 | 0.59 | 0.59 | **7.07** |
| 1989 | 0.61 | 0.61 | 0.61 | 0.61 | 0.61 | 0.61 | 0.61 | 0.61 | 0.61 | 0.61 | 0.61 | 0.61 | **7.30** |
| 1990 | 0.63 | 0.63 | 0.63 | 0.63 | 0.63 | 0.63 | 0.63 | 0.63 | 0.63 | 0.63 | 0.63 | 0.63 | **7.54** |
| 1991 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | **7.77** |
| 1992 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | **8.00** |
| 1993 | 0.69 | 0.69 | 0.69 | 0.69 | 0.69 | 0.69 | 0.69 | 0.69 | 0.69 | 0.69 | 0.69 | 0.69 | **8.23** |
| 1994 | 0.71 | 0.71 | 0.71 | 0.71 | 0.71 | 0.71 | 0.71 | 0.71 | 0.71 | 0.71 | 0.71 | 0.71 | **8.51** |
| 1995 | 0.73 | 0.73 | 0.73 | 0.73 | 0.73 | 0.73 | 0.73 | 0.73 | 0.73 | 0.73 | 0.73 | 0.73 | **8.79** |
| 1996 | 0.76 | 0.76 | 0.76 | 0.76 | 0.76 | 0.76 | 0.76 | 0.76 | 0.76 | 0.76 | 0.76 | 0.76 | **9.08** |
| 1997 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | **9.36** |
| 1998 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | **9.64** |
| 1999 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | **9.92** |
| 2000 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.98 | 1.00 | **10.48** |
| 2001 | 1.02 | 0.78 | 0.86 | 1.03 | 0.82 | 0.96 | 0.89 | 1.00 | 0.92 | 0.91 | 0.88 | 0.92 | **10.98** |
| 2002 | 0.95 | 0.85 | 0.76 | 0.87 | 0.85 | 1.03 | 0.94 | 0.95 | 0.92 | 0.93 | 1.00 | 0.91 | **10.95** |
| 2003 | 0.81 | 0.73 | 0.82 | 0.72 | 0.68 | 0.73 | 0.69 | 0.70 | 0.83 | 0.83 | 0.86 | 0.90 | **9.32** |
| 2004 | 0.94 | 0.88 | 0.91 | 0.68 | 0.78 | 0.88 | 0.93 | 1.04 | 1.03 | 1.03 | 1.24 | 1.28 | **11.62** |
| **Average** | **0.26** | **0.25** | **0.25** | **0.25** | **0.25** | **0.26** | **0.25** | **0.26** | **0.26** | **0.26** | **0.26** | **0.26** | **3.07** |
| **Min** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** |
| **Max** | **1.02** | **0.88** | **0.91** | **1.03** | **0.85** | **1.03** | **0.94** | **1.04** | **1.03** | **1.03** | **1.24** | **1.28** | **11.62** |

**Data sources:**
Incomati River Basin Study (1990)
Mbombela LM WSDP (2003)

**Table B-15 White River Regional Water Supply Scheme: Abstractions from Longmere Dam on the White River and Witklip Dam on the Sand River (million $m^3$ / month)**

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1900 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | **0.00** |
| 1901 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | **0.00** |
| 1902 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | **0.00** |
| 1903 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | **0.00** |
| 1904 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | **0.00** |
| 1905 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | **0.01** |
| 1906 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | **0.01** |
| 1907 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | **0.01** |
| 1908 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | **0.01** |
| 1909 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | **0.01** |
| 1910 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | **0.01** |
| 1911 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | **0.01** |
| 1912 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | **0.01** |
| 1913 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | **0.02** |
| 1914 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | **0.02** |
| 1915 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | **0.02** |
| 1916 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | **0.02** |
| 1917 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | **0.02** |
| 1918 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | **0.02** |
| 1919 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | **0.02** |
| 1920 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | **0.02** |
| 1921 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | **0.03** |
| 1922 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | **0.03** |
| 1923 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | **0.03** |
| 1924 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | **0.03** |
| 1925 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | **0.03** |
| 1926 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | **0.03** |
| 1927 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | **0.03** |
| 1928 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | **0.03** |
| 1929 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | **0.04** |
| 1930 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | **0.04** |
| 1931 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | **0.04** |
| 1932 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | **0.04** |
| 1933 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | **0.04** |
| 1934 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | **0.04** |
| 1935 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | **0.04** |
| 1936 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | **0.04** |
| 1937 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | **0.05** |
| 1938 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | **0.05** |
| 1939 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | **0.05** |
| 1940 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | **0.05** |
| 1941 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | **0.05** |
| 1942 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | **0.05** |
| 1943 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | **0.05** |
| 1944 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | **0.05** |
| 1945 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | **0.06** |
| 1946 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | **0.06** |
| 1947 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | **0.06** |
| 1948 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | **0.06** |
| 1949 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | **0.06** |
| 1950 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | **0.06** |
| 1951 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | **0.08** |
| 1952 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | **0.10** |
| 1953 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | **0.13** |
| 1954 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | **0.15** |
| 1955 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | **0.17** |
| 1956 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | **0.19** |
| 1957 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | **0.21** |
| 1958 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | **0.24** |
| 1959 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | **0.26** |

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1960 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.28 |
| 1961 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.30 |
| 1962 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | 0.32 |
| 1963 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | 0.34 |
| 1964 | 0.031 | 0.031 | 0.031 | 0.031 | 0.031 | 0.031 | 0.031 | 0.031 | 0.031 | 0.031 | 0.031 | 0.031 | 0.37 |
| 1965 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.39 |
| 1966 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 | 0.41 |
| 1967 | 0.036 | 0.036 | 0.036 | 0.036 | 0.036 | 0.036 | 0.036 | 0.036 | 0.036 | 0.036 | 0.036 | 0.036 | 0.43 |
| 1968 | 0.038 | 0.038 | 0.038 | 0.038 | 0.038 | 0.038 | 0.038 | 0.038 | 0.038 | 0.038 | 0.038 | 0.038 | 0.45 |
| 1969 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.48 |
| 1970 | 0.041 | 0.041 | 0.041 | 0.041 | 0.041 | 0.041 | 0.041 | 0.041 | 0.041 | 0.041 | 0.041 | 0.041 | 0.50 |
| 1971 | 0.043 | 0.043 | 0.043 | 0.043 | 0.043 | 0.043 | 0.043 | 0.043 | 0.043 | 0.043 | 0.043 | 0.043 | 0.52 |
| 1972 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.54 |
| 1973 | 0.047 | 0.047 | 0.047 | 0.047 | 0.047 | 0.047 | 0.047 | 0.047 | 0.047 | 0.047 | 0.047 | 0.047 | 0.56 |
| 1974 | 0.049 | 0.049 | 0.049 | 0.049 | 0.049 | 0.049 | 0.049 | 0.049 | 0.049 | 0.049 | 0.049 | 0.049 | 0.59 |
| 1975 | 0.051 | 0.051 | 0.051 | 0.051 | 0.051 | 0.051 | 0.051 | 0.051 | 0.051 | 0.051 | 0.051 | 0.051 | 0.61 |
| 1976 | 0.052 | 0.052 | 0.052 | 0.052 | 0.052 | 0.052 | 0.052 | 0.052 | 0.052 | 0.052 | 0.052 | 0.052 | 0.63 |
| 1977 | 0.054 | 0.054 | 0.054 | 0.054 | 0.054 | 0.054 | 0.054 | 0.054 | 0.054 | 0.054 | 0.054 | 0.054 | 0.65 |
| 1978 | 0.056 | 0.056 | 0.056 | 0.056 | 0.056 | 0.056 | 0.056 | 0.056 | 0.056 | 0.056 | 0.056 | 0.056 | 0.67 |
| 1979 | 0.058 | 0.058 | 0.058 | 0.058 | 0.058 | 0.058 | 0.058 | 0.058 | 0.058 | 0.058 | 0.058 | 0.058 | 0.69 |
| 1980 | 0.060 | 0.060 | 0.060 | 0.060 | 0.060 | 0.060 | 0.060 | 0.060 | 0.060 | 0.060 | 0.060 | 0.060 | 0.72 |
| 1981 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | **0.74** |
| 1982 | 0.063 | 0.063 | 0.063 | 0.063 | 0.063 | 0.063 | 0.063 | 0.063 | 0.063 | 0.063 | 0.063 | 0.063 | **0.76** |
| 1983 | 0.065 | 0.065 | 0.065 | 0.065 | 0.065 | 0.065 | 0.065 | 0.065 | 0.065 | 0.065 | 0.065 | 0.065 | **0.78** |
| 1984 | 0.067 | 0.067 | 0.067 | 0.067 | 0.067 | 0.067 | 0.067 | 0.067 | 0.067 | 0.067 | 0.067 | 0.067 | **0.80** |
| 1985 | 0.069 | 0.069 | 0.069 | 0.069 | 0.069 | 0.069 | 0.069 | 0.069 | 0.069 | 0.069 | 0.069 | 0.069 | **0.82** |
| 1986 | 0.070 | 0.070 | 0.070 | 0.070 | 0.070 | 0.070 | 0.070 | 0.070 | 0.070 | 0.070 | 0.070 | 0.070 | **0.84** |
| 1987 | 0.072 | 0.072 | 0.072 | 0.072 | 0.072 | 0.072 | 0.072 | 0.072 | 0.072 | 0.072 | 0.072 | 0.072 | **0.86** |
| 1988 | 0.074 | 0.074 | 0.074 | 0.074 | 0.074 | 0.074 | 0.074 | 0.074 | 0.074 | 0.074 | 0.074 | 0.074 | **0.88** |
| 1989 | 0.075 | 0.075 | 0.075 | 0.075 | 0.075 | 0.075 | 0.075 | 0.075 | 0.075 | 0.075 | 0.075 | 0.075 | **0.90** |
| 1990 | 0.077 | 0.077 | 0.077 | 0.077 | 0.077 | 0.077 | 0.077 | 0.077 | 0.077 | 0.077 | 0.077 | 0.077 | **0.92** |
| 1991 | 0.078 | 0.078 | 0.078 | 0.078 | 0.078 | 0.078 | 0.078 | 0.078 | 0.078 | 0.078 | 0.078 | 0.078 | **0.94** |
| 1992 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | **0.96** |
| 1993 | 0.082 | 0.082 | 0.082 | 0.082 | 0.082 | 0.082 | 0.082 | 0.082 | 0.082 | 0.082 | 0.082 | 0.082 | **0.98** |
| 1994 | 0.089 | 0.089 | 0.089 | 0.089 | 0.089 | 0.089 | 0.089 | 0.089 | 0.089 | 0.089 | 0.089 | 0.089 | **1.06** |
| 1995 | 0.096 | 0.096 | 0.096 | 0.096 | 0.096 | 0.096 | 0.096 | 0.096 | 0.096 | 0.096 | 0.096 | 0.096 | **1.15** |
| 1996 | 0.103 | 0.103 | 0.103 | 0.103 | 0.103 | 0.103 | 0.103 | 0.103 | 0.103 | 0.103 | 0.103 | 0.103 | **1.23** |
| 1997 | 0.110 | 0.110 | 0.110 | 0.110 | 0.110 | 0.110 | 0.110 | 0.110 | 0.110 | 0.110 | 0.110 | 0.110 | **1.31** |
| 1998 | 0.117 | 0.117 | 0.117 | 0.117 | 0.117 | 0.117 | 0.117 | 0.117 | 0.117 | 0.117 | 0.117 | 0.117 | **1.40** |
| 1999 | 0.123 | 0.123 | 0.123 | 0.123 | 0.123 | 0.123 | 0.123 | 0.123 | 0.123 | 0.123 | 0.123 | 0.123 | **1.48** |
| 2000 | 0.130 | 0.130 | 0.130 | 0.130 | 0.130 | 0.130 | 0.130 | 0.130 | 0.130 | 0.130 | 0.130 | 0.130 | **1.57** |
| 2001 | 0.137 | 0.137 | 0.137 | 0.137 | 0.137 | 0.137 | 0.137 | 0.137 | 0.137 | 0.137 | 0.137 | 0.137 | **1.65** |
| 2002 | 0.144 | 0.144 | 0.144 | 0.144 | 0.144 | 0.144 | 0.144 | 0.144 | 0.144 | 0.144 | 0.144 | 0.144 | **1.73** |
| 2003 | 0.151 | 0.151 | 0.151 | 0.151 | 0.151 | 0.151 | 0.151 | 0.151 | 0.151 | 0.151 | 0.151 | 0.151 | **1.82** |
| 2004 | 0.158 | 0.158 | 0.158 | 0.158 | 0.158 | 0.158 | 0.158 | 0.158 | 0.158 | 0.158 | 0.158 | 0.158 | **1.90** |
| **Average** | **0.033** | **0.033** | **0.033** | **0.033** | **0.033** | **0.033** | **0.033** | **0.033** | **0.033** | **0.033** | **0.033** | **0.033** | **0.39** |
| **Min** | **0.000** | **0.000** | **0.000** | **0.000** | **0.000** | **0.000** | **0.000** | **0.000** | **0.000** | **0.000** | **0.000** | **0.000** | **0.00** |
| **Max** | **0.158** | **0.158** | **0.158** | **0.158** | **0.158** | **0.158** | **0.158** | **0.158** | **0.158** | **0.158** | **0.158** | **0.158** | **1.90** |

**Note:**

Water abstracted from Witklip Dam in the Sand River catchment at 0.75 million $m^3$/a.

Remainder abstracted from Longmere Dam in the White River catchment.

Net abstractions provided

**Data sources:**

Incomati River Basin Study (1990)

**Table B-16 Nsikazi South Water Supply Scheme: Abstractions from middle Crocodile River (million $m^3$ / month)**

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1966 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | **0.89** |
| 1967 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | **0.89** |
| 1968 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | **0.89** |
| 1969 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | **0.89** |
| 1970 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | **0.89** |
| 1971 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | **0.89** |
| 1972 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | **0.89** |
| 1973 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | **0.89** |
| 1974 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | **0.89** |
| 1975 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | **1.61** |
| 1976 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | **1.61** |
| 1977 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | **1.61** |
| 1978 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | **1.61** |
| 1979 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | **1.61** |
| 1980 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | **1.61** |
| 1981 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | **1.61** |
| 1982 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | **1.61** |
| 1983 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | **1.61** |
| 1984 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | **1.61** |
| 1985 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | **2.61** |
| 1986 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | **3.60** |
| 1987 | 0.38 | 0.38 | 0.38 | 0.38 | 0.38 | 0.38 | 0.38 | 0.38 | 0.38 | 0.38 | 0.38 | 0.38 | **4.60** |
| 1988 | 0.47 | 0.47 | 0.47 | 0.47 | 0.47 | 0.47 | 0.47 | 0.47 | 0.47 | 0.47 | 0.47 | 0.47 | **5.60** |
| 1989 | 0.55 | 0.55 | 0.55 | 0.55 | 0.55 | 0.55 | 0.55 | 0.55 | 0.55 | 0.55 | 0.55 | 0.55 | **6.60** |
| 1990 | 0.63 | 0.63 | 0.63 | 0.63 | 0.63 | 0.63 | 0.63 | 0.63 | 0.63 | 0.63 | 0.63 | 0.63 | **7.60** |
| 1991 | 0.72 | 0.72 | 0.72 | 0.72 | 0.72 | 0.72 | 0.72 | 0.72 | 0.72 | 0.72 | 0.72 | 0.72 | **8.60** |
| 1992 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | **9.60** |
| 1993 | 0.88 | 0.88 | 0.88 | 0.88 | 0.88 | 0.88 | 0.88 | 0.88 | 0.88 | 0.88 | 0.88 | 0.88 | **10.60** |
| 1994 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | **11.61** |
| 1995 | 1.05 | 1.05 | 1.05 | 1.05 | 1.05 | 1.05 | 1.05 | 1.05 | 1.05 | 1.05 | 1.05 | 1.05 | **12.61** |
| 1996 | 1.13 | 1.13 | 1.13 | 1.13 | 1.13 | 1.13 | 1.13 | 1.13 | 1.13 | 1.13 | 1.13 | 1.13 | **13.61** |
| 1997 | 1.22 | 1.22 | 1.22 | 1.22 | 1.22 | 1.22 | 1.22 | 1.22 | 1.22 | 1.22 | 1.22 | 1.22 | **14.61** |
| 1998 | 1.30 | 1.30 | 1.30 | 1.30 | 1.30 | 1.30 | 1.30 | 1.30 | 1.30 | 1.30 | 1.30 | 1.30 | **15.62** |
| 1999 | 1.38 | 1.38 | 1.38 | 1.38 | 1.38 | 1.38 | 1.38 | 1.38 | 1.38 | 1.38 | 1.38 | 1.38 | **16.62** |
| 2000 | 1.47 | 1.47 | 1.47 | 1.47 | 1.47 | 1.47 | 1.47 | 1.47 | 1.47 | 1.47 | 1.47 | 1.47 | **17.62** |
| 2001 | 1.55 | 1.55 | 1.55 | 1.55 | 1.55 | 1.55 | 1.55 | 1.55 | 1.55 | 1.55 | 1.55 | 1.55 | **18.63** |
| 2002 | 1.98 | 1.98 | 1.98 | 1.98 | 1.98 | 1.98 | 1.98 | 1.98 | 1.98 | 1.98 | 1.98 | 1.98 | **23.81** |
| 2003 | 2.05 | 2.05 | 2.05 | 2.05 | 2.05 | 2.05 | 2.05 | 2.05 | 2.05 | 2.05 | 2.05 | 2.05 | **24.66** |
| 2004 | 2.13 | 2.13 | 2.13 | 2.13 | 2.13 | 2.13 | 2.13 | 2.13 | 2.13 | 2.13 | 2.13 | 2.13 | **25.565** |
| **Average** | **0.59** | **0.59** | **0.59** | **0.59** | **0.59** | **0.59** | **0.59** | **0.59** | **0.59** | **0.59** | **0.59** | **0.59** | **7.14** |
| **Min** | **0.07** | **0.07** | **0.07** | **0.07** | **0.07** | **0.07** | **0.07** | **0.07** | **0.07** | **0.07** | **0.07** | **0.07** | **0.89** |
| **Max** | **2.13** | **2.13** | **2.13** | **2.13** | **2.13** | **2.13** | **2.13** | **2.13** | **2.13** | **2.13** | **2.13** | **2.13** | **25.57** |

**Note:**

Water abstracted from Crocodile River (X22K) for users are in the Nsikazi catchment (X24B).

**Data sources:**

Incomati River Basin Study (1990)

Mbombela LM WSDP (2003)

**Table B-17 Nsikazi North Water Supply Scheme: Abstractions from Sabie Canal (million $m^3$ / month) in the Sabie River**

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1994 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.09 |
| 1995 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.12 |
| 1996 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.12 |
| 1997 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 6.48 |
| 1998 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 6.48 |
| 1999 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 6.48 |
| 2000 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 6.48 |
| 2001 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 6.48 |
| 2002 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 6.48 |
| 2003 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 6.48 |
| 2004 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 6.48 |
| **Average** | **0.39** | **0.39** | **0.39** | **0.40** | **0.40** | **0.40** | **0.40** | **0.40** | **0.40** | **0.40** | **0.40** | **0.40** | **4.74** |
| **Min** | **0.00** | **0.00** | **0.00** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.09** |
| **Max** | **0.54** | **0.54** | **0.54** | **0.54** | **0.54** | **0.54** | **0.54** | **0.54** | **0.54** | **0.54** | **0.54** | **0.54** | **6.48** |

**Note:**
Water transferred from Sabie canal (X31K) to users are in the Nsikazi catchment (X24A).
**Data sources:**
Joint Inkomati Basin Study (2001)

**Table B-18 Matsulu Water Supply Scheme: Abstractions from lower Crocodile River (million $m^3$ / month)**

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1966 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | **0.89** |
| 1967 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | **0.89** |
| 1968 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | **0.89** |
| 1969 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | **0.89** |
| 1970 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | **0.89** |
| 1971 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | **0.89** |
| 1972 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | **0.89** |
| 1973 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | **0.89** |
| 1974 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | **0.89** |
| 1975 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | **1.61** |
| 1976 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | **1.61** |
| 1977 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | **1.61** |
| 1978 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | **1.61** |
| 1979 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | **1.61** |
| 1980 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | **1.61** |
| 1981 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | **1.61** |
| 1982 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | **1.61** |
| 1983 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | **1.61** |
| 1984 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | **1.61** |
| 1985 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | **1.71** |
| 1986 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | **1.81** |
| 1987 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | **1.91** |
| 1988 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | **2.02** |
| 1989 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | **2.12** |
| 1990 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | **2.22** |
| 1991 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | **2.32** |
| 1992 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | **2.42** |
| 1993 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | **2.52** |
| 1994 | 0.23 | 0.23 | 0.23 | 0.23 | 0.23 | 0.23 | 0.23 | 0.23 | 0.23 | 0.24 | 0.23 | 0.24 | **2.77** |
| 1995 | 0.26 | 0.25 | 0.25 | 0.25 | 0.24 | 0.26 | 0.25 | 0.24 | 0.25 | 0.26 | 0.26 | 0.26 | **3.02** |
| 1996 | 0.28 | 0.26 | 0.27 | 0.27 | 0.26 | 0.28 | 0.28 | 0.26 | 0.26 | 0.29 | 0.28 | 0.28 | **3.27** |
| 1997 | 0.30 | 0.28 | 0.29 | 0.29 | 0.28 | 0.30 | 0.30 | 0.27 | 0.28 | 0.31 | 0.30 | 0.31 | **3.52** |
| 1998 | 0.33 | 0.30 | 0.31 | 0.31 | 0.29 | 0.32 | 0.32 | 0.29 | 0.30 | 0.34 | 0.33 | 0.33 | **3.77** |
| 1999 | 0.35 | 0.32 | 0.33 | 0.34 | 0.31 | 0.35 | 0.34 | 0.30 | 0.32 | 0.36 | 0.35 | 0.36 | **4.01** |
| 2000 | 0.37 | 0.34 | 0.35 | 0.36 | 0.33 | 0.37 | 0.36 | 0.32 | 0.33 | 0.39 | 0.38 | 0.47 | **4.36** |
| 2001 | 0.36 | 0.25 | 0.30 | 0.32 | 0.36 | 0.49 | 0.46 | 0.46 | 0.43 | 0.45 | 0.49 | 0.47 | **4.83** |
| 2002 | 0.50 | 0.48 | 0.52 | 0.45 | 0.45 | 0.46 | 0.42 | 0.47 | 0.52 | 0.48 | 0.54 | 0.51 | **5.80** |
| 2003 | 0.43 | 0.41 | 0.49 | 0.44 | 0.42 | 0.46 | 0.54 | 0.47 | 0.39 | 0.45 | 0.47 | 0.45 | **5.42** |
| 2004 | 0.46 | 0.41 | 0.43 | 0.44 | 0.39 | 0.46 | 0.45 | 0.38 | 0.40 | 0.49 | 0.47 | 0.48 | **5.25** |
| **Average** | **0.19** | **0.18** | **0.19** | **0.19** | **0.18** | **0.19** | **0.19** | **0.19** | **0.19** | **0.20** | **0.20** | **0.20** | **2.29** |
| **Min** | **0.07** | **0.07** | **0.07** | **0.07** | **0.07** | **0.07** | **0.07** | **0.07** | **0.07** | **0.07** | **0.07** | **0.07** | **0.89** |
| **Max** | **0.50** | **0.48** | **0.52** | **0.45** | **0.45** | **0.49** | **0.54** | **0.47** | **0.52** | **0.49** | **0.54** | **0.51** | **5.80** |

**Data sources:**
Incomati River Basin Study (1990)
Mbombela LM WSDP (2003)

**Table B-19 Malelane / KaapmuidenWater Supply Scheme: Abstractions from lower Crocodile River (million $m^3$ / month)**

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1966 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | **0.24** |
| 1967 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | **0.25** |
| 1968 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | **0.26** |
| 1969 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | **0.27** |
| 1970 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | **0.28** |
| 1971 | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 | **0.29** |
| 1972 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | **0.30** |
| 1973 | 0.026 | 0.026 | 0.026 | 0.026 | 0.026 | 0.026 | 0.026 | 0.026 | 0.026 | 0.026 | 0.026 | 0.026 | **0.31** |
| 1974 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | **0.32** |
| 1975 | 0.028 | 0.028 | 0.028 | 0.028 | 0.028 | 0.028 | 0.028 | 0.028 | 0.028 | 0.028 | 0.028 | 0.028 | **0.33** |
| 1976 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | **0.34** |
| 1977 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | **0.35** |
| 1978 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | **0.36** |
| 1979 | 0.031 | 0.031 | 0.031 | 0.031 | 0.031 | 0.031 | 0.031 | 0.031 | 0.031 | 0.031 | 0.031 | 0.031 | **0.37** |
| 1980 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | 0.032 | **0.38** |
| 1981 | 0.033 | 0.033 | 0.033 | 0.033 | 0.033 | 0.033 | 0.033 | 0.033 | 0.033 | 0.033 | 0.033 | 0.033 | **0.39** |
| 1982 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 | **0.40** |
| 1983 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 | 0.034 | **0.41** |
| 1984 | 0.035 | 0.035 | 0.035 | 0.035 | 0.035 | 0.035 | 0.035 | 0.035 | 0.035 | 0.035 | 0.035 | 0.035 | **0.42** |
| 1985 | 0.036 | 0.036 | 0.036 | 0.036 | 0.036 | 0.036 | 0.036 | 0.036 | 0.036 | 0.036 | 0.036 | 0.036 | **0.43** |
| 1986 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 | **0.44** |
| 1987 | 0.038 | 0.038 | 0.038 | 0.038 | 0.038 | 0.038 | 0.038 | 0.038 | 0.038 | 0.038 | 0.038 | 0.038 | **0.45** |
| 1988 | 0.039 | 0.039 | 0.039 | 0.039 | 0.039 | 0.039 | 0.039 | 0.039 | 0.039 | 0.039 | 0.039 | 0.039 | **0.46** |
| 1989 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | **0.47** |
| 1990 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | **0.49** |
| 1991 | 0.041 | 0.041 | 0.041 | 0.041 | 0.041 | 0.041 | 0.041 | 0.041 | 0.041 | 0.041 | 0.041 | 0.041 | **0.50** |
| 1992 | 0.042 | 0.042 | 0.042 | 0.042 | 0.042 | 0.042 | 0.042 | 0.042 | 0.042 | 0.042 | 0.042 | 0.042 | **0.51** |
| 1993 | 0.043 | 0.043 | 0.043 | 0.043 | 0.043 | 0.043 | 0.043 | 0.043 | 0.043 | 0.043 | 0.043 | 0.043 | **0.52** |
| 1994 | 0.058 | 0.058 | 0.058 | 0.058 | 0.058 | 0.058 | 0.058 | 0.058 | 0.058 | 0.058 | 0.058 | 0.058 | **0.70** |
| 1995 | 0.074 | 0.074 | 0.074 | 0.074 | 0.074 | 0.074 | 0.074 | 0.074 | 0.074 | 0.074 | 0.074 | 0.074 | **0.89** |
| 1996 | 0.089 | 0.089 | 0.089 | 0.089 | 0.089 | 0.089 | 0.089 | 0.089 | 0.089 | 0.089 | 0.089 | 0.089 | **1.07** |
| 1997 | 0.105 | 0.105 | 0.105 | 0.105 | 0.105 | 0.105 | 0.105 | 0.105 | 0.105 | 0.105 | 0.105 | 0.105 | **1.26** |
| 1998 | 0.120 | 0.120 | 0.120 | 0.120 | 0.120 | 0.120 | 0.120 | 0.120 | 0.120 | 0.120 | 0.120 | 0.120 | **1.45** |
| 1999 | 0.136 | 0.136 | 0.136 | 0.136 | 0.136 | 0.136 | 0.136 | 0.136 | 0.136 | 0.136 | 0.136 | 0.136 | **1.63** |
| 2000 | 0.151 | 0.151 | 0.151 | 0.151 | 0.151 | 0.151 | 0.151 | 0.151 | 0.151 | 0.151 | 0.151 | 0.151 | **1.82** |
| 2001 | 0.167 | 0.167 | 0.167 | 0.167 | 0.167 | 0.167 | 0.167 | 0.167 | 0.167 | 0.167 | 0.167 | 0.167 | **2.00** |
| 2002 | 0.183 | 0.183 | 0.183 | 0.183 | 0.183 | 0.183 | 0.183 | 0.183 | 0.183 | 0.183 | 0.183 | 0.183 | **2.19** |
| 2003 | 0.180 | 0.180 | 0.180 | 0.180 | 0.180 | 0.180 | 0.180 | 0.180 | 0.180 | 0.180 | 0.180 | 0.180 | **2.16** |
| 2004 | 0.180 | 0.180 | 0.180 | 0.180 | 0.180 | 0.180 | 0.180 | 0.180 | 0.180 | 0.180 | 0.180 | 0.180 | **2.16** |
| **Average** | **0.060** | **0.060** | **0.060** | **0.060** | **0.060** | **0.060** | **0.060** | **0.060** | **0.060** | **0.060** | **0.060** | **0.060** | **0.72** |
| **Min** | **0.020** | **0.020** | **0.020** | **0.020** | **0.020** | **0.020** | **0.020** | **0.020** | **0.020** | **0.020** | **0.020** | **0.020** | **0.24** |
| **Max** | **0.183** | **0.183** | **0.183** | **0.183** | **0.183** | **0.183** | **0.183** | **0.183** | **0.183** | **0.183** | **0.183** | **0.183** | **2.19** |

**Data sources:**
Incomati River Basin Study (1990)
Nkomazi LM WSDPs (2003, 2005)

**Table B-20 Hectorspruit / Marloth Park Water Supply Scheme: Abstractions from lower Crocodile River (million $m^3$ / month)**

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1966 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | **0.12** |
| 1967 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | **0.13** |
| 1968 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | **0.13** |
| 1969 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | **0.14** |
| 1970 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | **0.15** |
| 1971 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | **0.15** |
| 1972 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | **0.16** |
| 1973 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | **0.17** |
| 1974 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | **0.17** |
| 1975 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | **0.18** |
| 1976 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | **0.19** |
| 1977 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | **0.19** |
| 1978 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | **0.20** |
| 1979 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | **0.21** |
| 1980 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | **0.21** |
| 1981 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | **0.22** |
| 1982 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 | **0.23** |
| 1983 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 | **0.23** |
| 1984 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | **0.24** |
| 1985 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | **0.25** |
| 1986 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | **0.25** |
| 1987 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | **0.26** |
| 1988 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | 0.022 | **0.27** |
| 1989 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | **0.27** |
| 1990 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | **0.28** |
| 1991 | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 | **0.29** |
| 1992 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | **0.29** |
| 1993 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | **0.30** |
| 1994 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | **0.30** |
| 1995 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | **0.30** |
| 1996 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | **0.30** |
| 1997 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | **0.30** |
| 1998 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | **0.30** |
| 1999 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | **0.30** |
| 2000 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | **0.36** |
| 2001 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | **0.36** |
| 2002 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | **0.36** |
| 2003 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | **0.36** |
| 2004 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | **0.36** |
| **Average** | **0.020** | **0.020** | **0.020** | **0.020** | **0.020** | **0.020** | **0.020** | **0.020** | **0.020** | **0.020** | **0.020** | **0.020** | **0.24** |
| **Min** | **0.010** | **0.010** | **0.010** | **0.010** | **0.010** | **0.010** | **0.010** | **0.010** | **0.010** | **0.010** | **0.010** | **0.010** | **0.12** |
| **Max** | **0.030** | **0.030** | **0.030** | **0.030** | **0.030** | **0.030** | **0.030** | **0.030** | **0.030** | **0.030** | **0.030** | **0.030** | **0.36** |

**Data sources:**
Incomati River Basin Study (1990)
Nkomazi LM WSDPs (2003, 2005)

**Table B-21 Sabie Water Supply Scheme: Abstractions from upper Sabie River (million $m^3$ / month)**

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1976 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 1.55 |
| 1977 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 1.55 |
| 1978 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 1.55 |
| 1979 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 1.55 |
| 1980 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 1.55 |
| 1981 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 1.55 |
| 1982 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 1.55 |
| 1983 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 1.55 |
| 1984 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 1.55 |
| 1985 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 1.55 |
| 1986 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 1.55 |
| 1987 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 1.55 |
| 1988 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 1.55 |
| 1989 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 1.55 |
| 1990 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 1.55 |
| 1991 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 1.55 |
| 1992 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 1.55 |
| 1993 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 1.55 |
| 1994 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 1.55 |
| 1995 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 1.55 |
| 1996 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 1.55 |
| 1997 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 1.55 |
| 1998 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 1.55 |
| 1999 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 1.55 |
| 2000 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 1.55 |
| 2001 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 1.55 |
| 2002 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 1.55 |
| 2003 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 1.55 |
| 2004 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 0.129 | 1.55 |
| **Average** | **0.129** | **0.129** | **0.129** | **0.129** | **0.129** | **0.129** | **0.129** | **0.129** | **0.129** | **0.129** | **0.129** | **0.129** | **1.55** |
| **Min** | **0.129** | **0.129** | **0.129** | **0.129** | **0.129** | **0.129** | **0.129** | **0.129** | **0.129** | **0.129** | **0.129** | **0.129** | **1.55** |
| **Max** | **0.129** | **0.129** | **0.129** | **0.129** | **0.129** | **0.129** | **0.129** | **0.129** | **0.129** | **0.129** | **0.129** | **0.129** | **1.55** |

Abstractions from mine shaft

**Data sources:**

Thaba Chweu LM WSDP (2003)

**Table B-22 Graskop Water Supply Scheme: Abstractions from springs (million $m^3$ / month) in the upper Mac-Mac River catchment**

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1975 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.36 |
| 1976 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.36 |
| 1977 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.36 |
| 1978 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.36 |
| 1979 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.36 |
| 1980 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.36 |
| 1981 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.36 |
| 1982 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.36 |
| 1983 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.36 |
| 1984 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.36 |
| 1985 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.36 |
| 1986 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.36 |
| 1987 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.36 |
| 1988 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.36 |
| 1989 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.36 |
| 1990 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.36 |
| 1991 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.36 |
| 1992 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.36 |
| 1993 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.36 |
| 1994 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.36 |
| 1995 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.36 |
| 1996 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.36 |
| 1997 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.36 |
| 1998 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.36 |
| 1999 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.36 |
| 2000 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.36 |
| 2001 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.36 |
| 2002 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.36 |
| 2003 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.36 |
| 2004 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.36 |
| **Average** | **0.030** | **0.030** | **0.030** | **0.030** | **0.030** | **0.030** | **0.030** | **0.030** | **0.030** | **0.030** | **0.030** | **0.030** | **0.36** |
| **Min** | **0.030** | **0.030** | **0.030** | **0.030** | **0.030** | **0.030** | **0.030** | **0.030** | **0.030** | **0.030** | **0.030** | **0.030** | **0.36** |
| **Max** | **0.030** | **0.030** | **0.030** | **0.030** | **0.030** | **0.030** | **0.030** | **0.030** | **0.030** | **0.030** | **0.030** | **0.030** | **0.36** |

**Data sources:**
Thaba Chweu LM WSDP (2003)

**Table B-23 Inyaka Dam Supply Schemes: Abstractions from Inyaka Dam (million $m^3$ / month) in the Marite catchment**

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2002 | 1.02 | 0.99 | 1.02 | 1.02 | 0.92 | 1.02 | 0.99 | 1.02 | 0.99 | 1.02 | 1.02 | 0.99 | **12.02** |
| 2003 | 1.19 | 1.15 | 1.19 | 1.19 | 1.07 | 1.19 | 1.15 | 1.19 | 1.15 | 1.19 | 1.19 | 1.15 | **14.00** |
| 2004 | 1.36 | 1.31 | 1.36 | 1.36 | 1.23 | 1.36 | 1.31 | 1.36 | 1.31 | 1.36 | 1.36 | 1.31 | **15.99** |
| **Average** | **1.19** | **1.15** | **1.19** | **1.19** | **1.07** | **1.19** | **1.15** | **1.19** | **1.15** | **1.19** | **1.19** | **1.15** | **14.00** |
| **Min** | **1.02** | **0.99** | **1.02** | **1.02** | **0.92** | **1.02** | **0.99** | **1.02** | **0.99** | **1.02** | **1.02** | **0.99** | **12.02** |
| **Max** | **1.36** | **1.31** | **1.36** | **1.36** | **1.23** | **1.36** | **1.31** | **1.36** | **1.31** | **1.36** | **1.36** | **1.31** | **15.99** |

**Note:**
Water transferred from Inyaka Dam (X31E) to users in the Sabie (X31) and Sand catchments (X32).
The split assumed at 5 million $m^3$ to domestic users in the Sabie and 11 million $m^3$ to domestic users in the Sand.
**Data sources:**
Joint Inkomati Basin Study (2001)

**Table B-24 Sand River Supply Schemes: Combined abstractions from local surface water resources (million $m^3$ / month) in the Sand River catchment**

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1950 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | **0.24** |
| 1951 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | **0.24** |
| 1952 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | **0.24** |
| 1953 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | **0.24** |
| 1954 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | **0.24** |
| 1955 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | **0.24** |
| 1956 | 0.030 | 0.030 | 0.030 | 0.030 | 0.020 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | **0.35** |
| 1957 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | **0.36** |
| 1958 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | **0.36** |
| 1959 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | **0.36** |
| 1960 | 0.041 | 0.041 | 0.041 | 0.041 | 0.041 | 0.041 | 0.041 | 0.041 | 0.041 | 0.041 | 0.041 | 0.041 | **0.49** |
| 1961 | 0.071 | 0.071 | 0.071 | 0.071 | 0.061 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | **0.84** |
| 1962 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | **0.85** |
| 1963 | 0.072 | 0.071 | 0.072 | 0.072 | 0.071 | 0.072 | 0.071 | 0.072 | 0.071 | 0.072 | 0.072 | 0.071 | **0.86** |
| 1964 | 0.082 | 0.082 | 0.082 | 0.082 | 0.071 | 0.082 | 0.082 | 0.082 | 0.082 | 0.082 | 0.082 | 0.082 | **0.97** |
| 1965 | 0.092 | 0.092 | 0.092 | 0.092 | 0.082 | 0.092 | 0.092 | 0.092 | 0.092 | 0.092 | 0.092 | 0.092 | **1.09** |
| 1966 | 0.102 | 0.092 | 0.102 | 0.102 | 0.092 | 0.102 | 0.092 | 0.102 | 0.092 | 0.102 | 0.102 | 0.092 | **1.17** |
| 1967 | 0.112 | 0.112 | 0.112 | 0.112 | 0.092 | 0.112 | 0.112 | 0.112 | 0.112 | 0.112 | 0.112 | 0.112 | **1.32** |
| 1968 | 0.112 | 0.112 | 0.112 | 0.112 | 0.112 | 0.112 | 0.112 | 0.112 | 0.112 | 0.112 | 0.112 | 0.112 | **1.34** |
| 1969 | 0.122 | 0.112 | 0.122 | 0.122 | 0.112 | 0.122 | 0.112 | 0.122 | 0.112 | 0.122 | 0.122 | 0.112 | **1.41** |
| 1970 | 0.123 | 0.122 | 0.123 | 0.123 | 0.112 | 0.123 | 0.122 | 0.123 | 0.122 | 0.123 | 0.123 | 0.122 | **1.46** |
| 1971 | 0.143 | 0.123 | 0.143 | 0.143 | 0.122 | 0.143 | 0.123 | 0.143 | 0.123 | 0.143 | 0.143 | 0.123 | **1.62** |
| 1972 | 0.153 | 0.153 | 0.153 | 0.153 | 0.143 | 0.153 | 0.153 | 0.153 | 0.153 | 0.153 | 0.153 | 0.153 | **1.83** |
| 1973 | 0.163 | 0.163 | 0.163 | 0.163 | 0.153 | 0.163 | 0.163 | 0.163 | 0.163 | 0.163 | 0.163 | 0.163 | **1.95** |
| 1974 | 0.173 | 0.163 | 0.173 | 0.173 | 0.163 | 0.173 | 0.163 | 0.173 | 0.163 | 0.173 | 0.173 | 0.163 | **2.03** |
| 1975 | 0.184 | 0.184 | 0.184 | 0.184 | 0.163 | 0.184 | 0.184 | 0.184 | 0.184 | 0.184 | 0.184 | 0.184 | **2.19** |
| 1976 | 0.194 | 0.194 | 0.194 | 0.194 | 0.184 | 0.194 | 0.194 | 0.194 | 0.194 | 0.194 | 0.194 | 0.194 | **2.32** |
| 1977 | 0.224 | 0.214 | 0.224 | 0.224 | 0.194 | 0.224 | 0.214 | 0.224 | 0.214 | 0.224 | 0.224 | 0.214 | **2.62** |
| 1978 | 0.235 | 0.224 | 0.235 | 0.235 | 0.214 | 0.235 | 0.224 | 0.235 | 0.224 | 0.235 | 0.235 | 0.224 | **2.76** |
| 1979 | 0.245 | 0.235 | 0.245 | 0.245 | 0.224 | 0.245 | 0.235 | 0.245 | 0.235 | 0.245 | 0.245 | 0.235 | **2.88** |
| 1980 | 0.275 | 0.255 | 0.275 | 0.275 | 0.235 | 0.275 | 0.255 | 0.275 | 0.255 | 0.275 | 0.275 | 0.255 | **3.18** |
| 1981 | 0.286 | 0.276 | 0.286 | 0.286 | 0.255 | 0.286 | 0.276 | 0.286 | 0.276 | 0.286 | 0.286 | 0.276 | **3.36** |
| 1982 | 0.306 | 0.306 | 0.306 | 0.306 | 0.286 | 0.306 | 0.306 | 0.306 | 0.306 | 0.306 | 0.306 | 0.306 | **3.65** |
| 1983 | 0.337 | 0.326 | 0.337 | 0.337 | 0.306 | 0.337 | 0.326 | 0.337 | 0.326 | 0.337 | 0.337 | 0.326 | **3.97** |
| 1984 | 0.357 | 0.347 | 0.357 | 0.357 | 0.326 | 0.357 | 0.347 | 0.357 | 0.347 | 0.357 | 0.357 | 0.347 | **4.21** |
| 1985 | 0.388 | 0.377 | 0.388 | 0.388 | 0.347 | 0.388 | 0.377 | 0.388 | 0.377 | 0.388 | 0.388 | 0.377 | **4.57** |
| 1986 | 0.418 | 0.398 | 0.418 | 0.418 | 0.377 | 0.418 | 0.398 | 0.418 | 0.398 | 0.418 | 0.418 | 0.398 | **4.90** |
| 1987 | 0.459 | 0.429 | 0.459 | 0.459 | 0.398 | 0.459 | 0.429 | 0.459 | 0.429 | 0.459 | 0.459 | 0.429 | **5.33** |
| 1988 | 0.479 | 0.469 | 0.479 | 0.479 | 0.429 | 0.479 | 0.469 | 0.479 | 0.469 | 0.479 | 0.479 | 0.469 | **5.66** |
| 1989 | 0.520 | 0.510 | 0.520 | 0.520 | 0.469 | 0.520 | 0.510 | 0.520 | 0.510 | 0.520 | 0.520 | 0.510 | **6.15** |
| 1990 | 0.561 | 0.541 | 0.561 | 0.561 | 0.510 | 0.561 | 0.541 | 0.561 | 0.541 | 0.561 | 0.561 | 0.541 | **6.60** |
| 1991 | 0.592 | 0.581 | 0.592 | 0.592 | 0.541 | 0.592 | 0.581 | 0.592 | 0.581 | 0.592 | 0.592 | 0.581 | **7.01** |
| 1992 | 0.653 | 0.622 | 0.653 | 0.653 | 0.581 | 0.653 | 0.622 | 0.653 | 0.622 | 0.653 | 0.653 | 0.622 | **7.64** |
| 1993 | 0.694 | 0.663 | 0.694 | 0.694 | 0.622 | 0.694 | 0.663 | 0.694 | 0.663 | 0.694 | 0.694 | 0.663 | **8.13** |
| 1994 | 0.775 | 0.745 | 0.775 | 0.775 | 0.694 | 0.775 | 0.745 | 0.775 | 0.745 | 0.775 | 0.775 | 0.745 | **9.10** |
| 1995 | 0.847 | 0.816 | 0.847 | 0.847 | 0.765 | 0.847 | 0.816 | 0.847 | 0.816 | 0.847 | 0.847 | 0.816 | **9.96** |
| 1996 | 0.929 | 0.898 | 0.929 | 0.929 | 0.837 | 0.929 | 0.898 | 0.929 | 0.898 | 0.929 | 0.929 | 0.898 | **10.93** |
| 1997 | 0.990 | 0.960 | 0.990 | 0.990 | 0.898 | 0.990 | 0.960 | 0.990 | 0.960 | 0.990 | 0.990 | 0.960 | **11.67** |
| 1998 | 1.082 | 1.041 | 1.082 | 1.082 | 0.980 | 1.082 | 1.041 | 1.082 | 1.041 | 1.082 | 1.082 | 1.041 | **12.72** |
| 1999 | 1.164 | 1.133 | 1.164 | 1.164 | 1.041 | 1.164 | 1.133 | 1.164 | 1.133 | 1.164 | 1.164 | 1.133 | **13.72** |
| 2000 | 1.235 | 1.205 | 1.235 | 1.235 | 1.113 | 1.235 | 1.205 | 1.235 | 1.205 | 1.235 | 1.235 | 1.205 | **14.58** |
| 2001 | 1.317 | 1.276 | 1.317 | 1.317 | 1.195 | 1.317 | 1.276 | 1.317 | 1.276 | 1.317 | 1.317 | 1.276 | **15.52** |
| 2002 | 1.389 | 1.338 | 1.389 | 1.389 | 1.246 | 1.389 | 1.338 | 1.389 | 1.338 | 1.389 | 1.389 | 1.338 | **16.32** |
| 2003 | 0.191 | 0.190 | 0.191 | 0.191 | 0.178 | 0.191 | 0.190 | 0.191 | 0.190 | 0.191 | 0.191 | 0.190 | **2.28** |
| 2004 | 0.192 | 0.191 | 0.192 | 0.192 | 0.179 | 0.192 | 0.191 | 0.192 | 0.191 | 0.192 | 0.192 | 0.191 | **2.29** |
| **Average** | **0.359** | **0.347** | **0.359** | **0.359** | **0.324** | **0.359** | **0.347** | **0.359** | **0.347** | **0.359** | **0.359** | **0.347** | **4.22** |
| **Min** | **0.020** | **0.020** | **0.020** | **0.020** | **0.020** | **0.020** | **0.020** | **0.020** | **0.020** | **0.020** | **0.020** | **0.020** | **0.24** |
| **Max** | **1.389** | **1.338** | **1.389** | **1.389** | **1.246** | **1.389** | **1.338** | **1.389** | **1.338** | **1.389** | **1.389** | **1.338** | **16.32** |

**Data sources:**
Joint Inkomati Basin Study (2001)

# Appendix C

## Record of Industrial and Mining water requirements

**Industrial:**

| | |
|---|---|
| Table C-1: | Sappi Ngodwana Paper Mill |
| Table C-2: | TSB Malelane Sugar Mill |
| Table C-3: | TSB Komati Sugar Mill |

**Mining:**

| | |
|---|---|
| Table C-4: | Komati mine in Gladdespruit |

**Table C-1 Sappi Ngodwana Paper Mill: Abstractions from Ngodwana Dam (million $m^3$ / month)**

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1966 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.13** |
| 1967 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.13** |
| 1968 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.13** |
| 1969 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.13** |
| 1970 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.13** |
| 1971 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.13** |
| 1972 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.13** |
| 1973 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.13** |
| 1974 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.13** |
| 1975 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.13** |
| 1976 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.13** |
| 1977 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.13** |
| 1978 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.13** |
| 1979 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.13** |
| 1980 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.13** |
| 1981 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.13** |
| 1982 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.17 | 0.17 | 0.17 | 0.17 | **0.75** |
| 1983 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | **6.44** |
| 1984 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.83 | 0.83 | 0.82 | 0.83 | 0.83 | 0.83 | 0.83 | **9.91** |
| 1985 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.86 | 0.86 | 0.84 | 0.85 | 0.86 | 0.86 | 0.86 | **10.22** |
| 1986 | 0.87 | 0.87 | 0.87 | 0.87 | 0.87 | 0.89 | 0.88 | 0.86 | 0.88 | 0.89 | 0.90 | 0.89 | **10.54** |
| 1987 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.92 | 0.91 | 0.88 | 0.90 | 0.92 | 0.93 | 0.92 | **10.85** |
| 1988 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.95 | 0.94 | 0.90 | 0.93 | 0.95 | 0.96 | 0.95 | **11.16** |
| 1989 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.98 | 0.97 | 0.92 | 0.95 | 0.98 | 0.99 | 0.98 | **11.47** |
| 1990 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 1.01 | 0.99 | 0.94 | 0.98 | 1.01 | 1.03 | 1.01 | **11.78** |
| 1991 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 1.04 | 1.02 | 0.96 | 1.00 | 1.04 | 1.06 | 1.04 | **12.09** |
| 1992 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.07 | 1.05 | 0.98 | 1.03 | 1.07 | 1.09 | 1.06 | **12.41** |
| 1993 | 1.03 | 1.03 | 1.03 | 1.10 | 1.01 | 1.10 | 1.08 | 1.00 | 1.05 | 1.10 | 1.12 | 1.09 | **12.76** |
| 1994 | 1.11 | 1.09 | 1.10 | 1.11 | 1.02 | 1.11 | 1.04 | 0.90 | 1.03 | 1.07 | 1.08 | 1.07 | **12.72** |
| 1995 | 1.09 | 0.98 | 1.04 | 1.03 | 0.92 | 0.71 | 0.72 | 0.78 | 0.97 | 1.09 | 1.08 | 1.08 | **11.49** |
| 1996 | 1.10 | 1.05 | 1.05 | 1.06 | 0.98 | 1.08 | 0.99 | 1.09 | 1.05 | 1.11 | 1.16 | 0.98 | **12.69** |
| 1997 | 1.04 | 0.98 | 1.04 | 1.11 | 1.06 | 1.16 | 1.13 | 1.55 | 1.10 | 1.02 | 1.09 | 1.12 | **13.39** |
| 1998 | 1.09 | 0.98 | 1.04 | 1.08 | 0.94 | 1.09 | 1.01 | 0.79 | 1.08 | 1.11 | 1.08 | 1.95 | **13.24** |
| 1999 | 1.06 | 1.05 | 1.11 | 1.13 | 1.04 | 0.95 | 1.04 | 1.13 | 1.03 | 1.14 | 1.20 | 1.10 | **12.99** |
| 2000 | 1.14 | 1.08 | 1.09 | 0.98 | 1.00 | 1.12 | 1.09 | 1.10 | 1.07 | 1.05 | 1.13 | 1.15 | **12.99** |
| 2001 | 0.99 | 0.89 | 1.17 | 1.21 | 1.02 | 1.30 | 1.14 | 1.20 | 1.12 | 1.16 | 1.20 | 1.09 | **13.50** |
| 2002 | 1.19 | 1.16 | 1.20 | 1.21 | 1.10 | 1.08 | 1.13 | 1.20 | 1.16 | 1.16 | 1.14 | 1.06 | **13.78** |
| 2003 | 1.11 | 1.11 | 1.16 | 1.16 | 1.10 | 1.16 | 1.11 | 1.01 | 1.12 | 1.16 | 1.16 | 1.14 | **13.50** |
| 2004 | 1.19 | 1.08 | 1.18 | 1.11 | 1.07 | 1.13 | 1.11 | 0.91 | 1.12 | 1.16 | 1.15 | 1.15 | **13.36** |
| **Average** | **0.56** | **0.54** | **0.56** | **0.56** | **0.53** | **0.58** | **0.56** | **0.56** | **0.57** | **0.59** | **0.60** | **0.61** | **6.82** |
| **Min** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.13** |
| **Max** | **1.19** | **1.16** | **1.20** | **1.21** | **1.10** | **1.30** | **1.14** | **1.55** | **1.16** | **1.16** | **1.20** | **1.95** | **13.78** |

**Data sources:**
Sappi (2006) spreadsheet of abstractions provided
Incomati River Basin Report (1990)

**Table C-2 TSB Malelane Sugar Mill: Abstractions from lower Crocodile River (million $m^3$ / month)**

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1967 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | **7.41** |
| 1968 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | **7.41** |
| 1969 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | **7.41** |
| 1970 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | **7.41** |
| 1971 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | **7.41** |
| 1972 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | **7.41** |
| 1973 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | **7.41** |
| 1974 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | **7.41** |
| 1975 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | **7.41** |
| 1976 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | **7.41** |
| 1977 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | **7.41** |
| 1978 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | **7.41** |
| 1979 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | **7.41** |
| 1980 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | **7.41** |
| 1981 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | **7.41** |
| 1982 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | **7.41** |
| 1983 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | **7.41** |
| 1984 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | **7.41** |
| 1985 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | **7.41** |
| 1986 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | **7.41** |
| 1987 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | **7.41** |
| 1988 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | **7.41** |
| 1989 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | **7.41** |
| 1990 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | **7.41** |
| 1991 | 0.87 | 0.86 | 0.85 | 0.62 | 0.63 | 0.62 | 0.62 | 0.89 | 0.71 | 0.70 | 0.85 | 0.76 | **8.98** |
| 1992 | 0.87 | 0.86 | 0.85 | 0.62 | 0.63 | 0.62 | 0.28 | 0.89 | 0.86 | 1.01 | 0.82 | 0.93 | **9.23** |
| 1993 | 0.93 | 0.97 | 0.77 | 0.12 | 0.16 | 0.59 | 0.49 | 0.71 | 0.90 | 0.79 | 0.63 | 0.81 | **7.87** |
| 1994 | 0.85 | 0.71 | 0.67 | 0.55 | 0.67 | 0.49 | 0.38 | 1.06 | 0.00 | 1.02 | 1.02 | 1.02 | **8.45** |
| 1995 | 0.80 | 0.83 | 0.78 | 0.77 | 0.40 | 0.31 | 0.38 | 0.71 | 0.46 | 0.36 | 0.69 | 0.40 | **6.91** |
| 1996 | 0.53 | 0.62 | 0.72 | 0.66 | 0.40 | 0.29 | 0.47 | 0.96 | 0.72 | 0.35 | 0.88 | 0.55 | **7.15** |
| 1997 | 1.02 | 0.99 | 0.76 | 0.12 | 0.74 | 0.41 | 0.95 | 0.93 | 1.00 | 0.10 | 1.05 | 0.81 | **8.88** |
| 1998 | 1.18 | 0.41 | 1.04 | 0.99 | 0.95 | 0.95 | 0.62 | 0.89 | 0.71 | 0.70 | 0.85 | 0.76 | **10.05** |
| 1999 | 0.87 | 0.86 | 0.85 | 0.62 | 0.63 | 0.62 | 0.20 | 0.96 | 1.04 | 1.29 | 0.88 | 0.83 | **9.63** |
| 2000 | 0.77 | 1.51 | 1.21 | 1.04 | 1.04 | 0.58 | 0.62 | 0.89 | 0.71 | 0.70 | 0.85 | 0.76 | **10.68** |
| 2001 | 0.87 | 0.86 | 0.85 | 0.62 | 0.63 | 0.62 | 0.62 | 0.89 | 0.71 | 0.70 | 0.85 | 0.76 | **8.98** |
| 2002 | 0.87 | 0.86 | 0.85 | 0.62 | 0.63 | 0.62 | 0.62 | 0.89 | 0.71 | 0.70 | 0.85 | 0.76 | **8.98** |
| 2003 | 0.87 | 0.86 | 0.85 | 0.62 | 0.63 | 0.62 | 0.62 | 0.89 | 0.71 | 0.70 | 0.85 | 0.76 | **8.98** |
| 2004 | 0.87 | 0.86 | 0.85 | 0.62 | 0.63 | 0.62 | 0.62 | 0.89 | 0.71 | 0.70 | 0.85 | 0.76 | **8.98** |
| **Average** | **0.71** | **0.71** | **0.70** | **0.62** | **0.62** | **0.60** | **0.59** | **0.72** | **0.65** | **0.65** | **0.70** | **0.67** | **7.94** |
| **Min** | **0.53** | **0.41** | **0.62** | **0.12** | **0.16** | **0.29** | **0.20** | **0.62** | **0.00** | **0.10** | **0.62** | **0.40** | **6.91** |
| **Max** | **1.18** | **1.51** | **1.21** | **1.04** | **1.04** | **0.95** | **0.95** | **1.06** | **1.04** | **1.29** | **1.05** | **1.02** | **10.68** |

**Data sources:**
DWAF (Mpumalanga) spreadsheet of abstractions provided
Incomati River Basin Report (1990)

**Table C-3 TSB Komati Sugar Mill: Abstractions from lower Komati River (million $m^3$ / month)**

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1993 | 0.026 | 0.026 | 0.025 | 0.005 | 0.004 | 0.005 | 0.015 | 0.025 | 0.021 | 0.025 | 0.023 | 0.025 | **0.225** |
| 1994 | 0.026 | 0.026 | 0.025 | 0.005 | 0.004 | 0.005 | 0.022 | 0.042 | 0.039 | 0.041 | 0.039 | 0.041 | **0.315** |
| 1995 | 0.044 | 0.044 | 0.042 | 0.005 | 0.004 | 0.005 | 0.023 | 0.042 | 0.039 | 0.042 | 0.040 | 0.040 | **0.37** |
| 1996 | 0.044 | 0.044 | 0.042 | 0.005 | 0.004 | 0.005 | 0.023 | 0.042 | 0.039 | 0.042 | 0.040 | 0.040 | **0.37** |
| 1997 | 0.044 | 0.044 | 0.042 | 0.005 | 0.004 | 0.005 | 0.032 | 0.054 | 0.047 | 0.052 | 0.049 | 0.047 | **0.425** |
| 1998 | 0.058 | 0.058 | 0.052 | 0.005 | 0.004 | 0.005 | 0.032 | 0.054 | 0.047 | 0.052 | 0.049 | 0.047 | **0.463** |
| 1999 | 0.058 | 0.058 | 0.052 | 0.005 | 0.004 | 0.005 | 0.032 | 0.054 | 0.047 | 0.052 | 0.049 | 0.047 | **0.463** |
| 2000 | 0.058 | 0.058 | 0.052 | 0.005 | 0.004 | 0.005 | 0.032 | 0.054 | 0.047 | 0.052 | 0.049 | 0.047 | **0.463** |
| 2001 | 0.053 | 0.052 | 0.050 | 0.005 | 0.004 | 0.006 | 0.055 | 0.061 | 0.044 | 0.039 | 0.042 | 0.047 | **0.458** |
| 2002 | 0.058 | 0.055 | 0.014 | 0.005 | 0.004 | 0.006 | 0.038 | 0.045 | 0.040 | 0.054 | 0.035 | 0.036 | **0.389** |
| 2003 | 0.046 | 0.040 | 0.064 | 0.005 | 0.004 | 0.005 | 0.022 | 0.042 | 0.041 | 0.047 | 0.044 | 0.040 | **0.401** |
| 2004 | 0.059 | 0.064 | 0.046 | 0.005 | 0.004 | 0.005 | 0.015 | 0.050 | 0.040 | 0.039 | 0.040 | 0.048 | **0.414** |
| **Average** | **0.048** | **0.047** | **0.042** | **0.005** | **0.004** | **0.005** | **0.028** | **0.047** | **0.041** | **0.045** | **0.042** | **0.042** | **0.41** |
| **Min** | **0.026** | **0.026** | **0.014** | **0.005** | **0.004** | **0.005** | **0.015** | **0.025** | **0.021** | **0.025** | **0.023** | **0.025** | **0.32** |
| **Max** | **0.059** | **0.064** | **0.064** | **0.005** | **0.004** | **0.006** | **0.055** | **0.061** | **0.047** | **0.054** | **0.049** | **0.048** | **0.46** |

**Note:**
Estimate of consumptive abstractions, actual abstractions are higher
**Data sources:**
TSB Komati Sugar Mill

**Table C-4 Inkomati Mine: Abstractions from Gladdespruit (million $m^3$ / month) in the Upper Komati catchment**

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1994 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.09** |
| 1995 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.12** |
| 1996 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.12** |
| 1997 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.12** |
| 1998 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.12** |
| 1999 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.12** |
| 2000 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.12** |
| 2001 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.12** |
| 2002 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.12** |
| 2003 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.12** |
| 2004 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | **0.12** |
| **Average** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | 0.12 |
| **Min** | **0.00** | **0.00** | **0.00** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | 0.09 |
| **Max** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | 0.12 |

**Data sources:**

SRK (P Odendaal involved in Water Resources Assessment for expansion plans)

# Appendix D

## Irrigation data

**Table D1: Komati River quinary catchments: Crop information required by WQT irrigation model and WRSM2000 results at current (2004) development levels**

| Catchment | | Growth in Irrigation area ($km^2$) | | | | | | | | Distribution of crops | | | | WQT model results$_{(2004)}$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Quinary | Area ($km^2$) | Start | JIBS 1955 | JIBS 1967 | JIBS 1972 | JIBS 1991 | VS 1996 | VS 1998 | VS 2004 | Sugar cane | Citrus | Maize | Veg | Required (mill $m^3$) | Supplied (mill $m^3$) |
| **Upper Komati (X11)** | | | | | | | | | | | | | | | |
| X11A-1 | 672 | 1955 | 0.00 | 1.70 | 1.00 | 1.00 | 0.94 | 0.62 | 2.10 | 0% | 0% | 100% | 0% | 0.95 | 0.95 |
| X11B-1 | 361 | 1955 | 0.00 | 1.50 | 1.00 | 1.00 | 1.26 | 1.59 | 1.89 | 0% | 0% | 100% | 0% | 0.76 | 0.76 |
| X11B-2 | 236 | 1991 | | | | 0.00 | 0.28 | 0.70 | 0.61 | 0% | 0% | 100% | 0% | 0.27 | 0.27 |
| X11C-1 | 319 | 1955 | 0.00 | 1.50 | 2.00 | 2.00 | 2.87 | 4.30 | 1.36 | 0% | 0% | 82% | 18% | 0.61 | 0.61 |
| X11D-1 | 256 | 1955 | 0.00 | 1.80 | 1.50 | 2.00 | 1.81 | 2.15 | 2.33 | 0% | 0% | 99% | 1% | 0.89 | 0.89 |
| X11D-2 | 96 | 1996 | | | | 0.00 | 0.01 | 0.30 | 0.27 | 0% | 0% | 100% | 0% | 0.12 | 0.12 |
| X11D-3 | 238 | 1991 | | | | 0.00 | 0.40 | 0.08 | 0.27 | 0% | 0% | 100% | 0% | 0.11 | 0.11 |
| X11E-1 | 156 | 1991 | | | | 0.00 | 0.27 | 1.78 | 0.15 | 0% | 0% | 100% | 0% | 0.06 | 0.06 |
| X11G-1 | 264 | 1991 | | | 0.00 | 0.00 | 0.37 | 0.60 | 0.19 | 0% | 0% | 0% | 100% | 0.09 | 0.09 |
| X11H-1 | 265 | 1955 | 0.00 | 3.00 | 4.10 | 6.50 | 7.59 | 9.51 | 3.76 | 0% | 0% | 67% | 33% | 1.47 | 1.47 |
| X11J-1 | 186 | 1955 | 0.00 | 1.10 | 1.00 | 1.00 | 1.31 | 0.75 | 1.47 | 0% | 0% | 97% | 3% | 0.36 | 0.36 |
| X11K-1 | 65 | 1955 | 0.00 | 2.00 | 1.90 | 3.00 | 3.79 | 2.99 | 2.70 | 0% | 0% | 100% | 0% | 0.82 | 0.82 |
| X11K-2 | 58 | 1955 | 0.00 | 4.60 | 4.00 | 4.60 | 3.81 | 4.40 | 5.74 | 0% | 77% | 21% | 2% | 4.16 | 4.02 |
| X11K-3 | 48 | 1955 | 0.00 | 1.50 | 1.00 | 2.00 | 1.56 | 3.30 | 2.15 | 0% | 50% | 46% | 4% | 1.28 | 1.28 |
| X11K-4 | 40 | 1955 | 0.00 | 3.00 | 3.00 | 4.00 | 6.17 | 5.88 | 3.89 | 0% | 17% | 79% | 4% | 1.97 | 1.75 |
| **X11 sub-total** | | **1955** | **0.00** | **21.70** | **20.50** | **27.10** | **32.45** | **38.96** | **28.89** | **0%** | **21%** | **71%** | **7%** | **13.92** | **13.56** |
| **Middle Komati (X12)** | | | | | | | | | | | | | | | |
| X12A-1 | 244 | 1991 | | | | 0.00 | 0.12 | 0.26 | 0.26 | 0% | 0% | 100% | 0% | 0.10 | 0.10 |
| X12B-1 | 155 | 1991 | | | | 0.00 | 0.52 | 1.93 | 0.27 | 0% | 0% | 100% | 0% | 0.09 | 0.09 |
| X12C-2 | 144 | 1996 | | | | | 0.00 | | 0.10 | 0% | 0% | 100% | 0% | 0.04 | 0.04 |
| X12D-1 | 139 | 1972 | | | 0.00 | 1.00 | 1.87 | 2.21 | 0.54 | 0% | 0% | 100% | 0% | 0.18 | 0.18 |
| X12D-2 | 84 | 1955 | 0.00 | 1.10 | 1.00 | 1.00 | 1.15 | 1.60 | 1.76 | 0% | 0% | 100% | 0% | 0.71 | 0.71 |
| X12F-1 | 95 | 1998 | | | | | 0.00 | 0.09 | 0.00 | | | | | | |
| X12F-2 | 64 | 1998 | | | | | 0.00 | 0.07 | 0.00 | | | | | | |
| X12F-3 | 154 | 1955 | 0.00 | 1.00 | 1.00 | 1.00 | 1.62 | 7.29 | 1.14 | 0% | 0% | 46% | 54% | 0.56 | 0.56 |
| X12G-1 | 81 | 1995 | | | | 0.00 | 0.02 | 0.00 | 0.01 | | | | | | |
| X12G-3 | 126 | 1955 | 0.00 | 3.10 | 4.00 | 5.00 | 5.06 | 5.21 | 4.17 | 0% | 0% | 96% | 4% | 1.90 | 1.90 |
| **X12 sub-total** | | **1955** | **1955** | **5.20** | **6.00** | **8.00** | **10.36** | **18.66** | **8.24** | **0%** | **0%** | **90%** | **10%** | **3.58** | **3.58** |
| **Lower Komati (X13)** | | | | | | | | | | | | | | | |
| **X13E-1** | 224 | 1991 | | | | 0.00 | 0.17 | 0.13 | 8.23 | 100% | 0% | 0% | 0% | 7.81 | 7.81 |
| **X13G-1** | 71 | 1998 | | | | | | 0.00 | 6.26 | 100% | 0% | 0% | 0% | 7.11 | 7.11 |
| **X13G-2** | 213 | 1996 | | | | | 0.00 | 3.39 | 1.40 | 100% | 0% | 0% | 0% | 1.51 | 1.47 |
| **X13G-3** | 51 | 1991 | | | | 0.00 | 0.46 | 2.90 | 6.02 | 100% | 0% | 0% | 0% | 7.69 | 7.69 |
| **X13H-2** | 206 | 1946 | 2.60 | 20.00 | 24.00 | 26.00 | 20.30 | 22.22 | 34.92 | 67% | 33% | 0% | 0% | 38.93 | 35.56 |
| **Swaziland** | | **1946** | **2.60** | **20.00** | **24.00** | **26.00** | **20.93** | **28.64** | **56.83** | **80%** | **20%** | **0%** | **0%** | **63.05** | **59.64** |

VS Inkomati Verification and Validation Study (DWAF, 2006)
JIBS Joint Inkomati Basin Study (1996)

## Table D1: Komati River quinary catchments: (cont)

| Catchment | | Growth in Irrigation area (km²) | | | | | | | | Distribution of crops (2004) | | | | WQT model results(2004) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Quinary | Area (km²) | Start | JIBS 1955 | JIBS 1967 | JIBS 1972 | JIBS 1991 | VS 1996 | VS 1998 | VS 2004 | Sugar cane | Citrus | Maize | Veg | Required (mill m³) | Supplied (mill m³) |
| X13J-1 | 70 | 1996 | | | | | 0.00 | 1.30 | 0.23 | 0% | 0% | 0% | 100% | 0.13 | 0.12 |
| X13J-2 | 161 | 1972 | | | 0.00 | 0.55 | 2.86 | 3.09 | 5.83 | 100% | 0% | 0% | 0% | 7.01 | 3.06 |
| X13J-3 | 524 | 1946 | 2.00 | 7.00 | 11.10 | 25.85 | 33.54 | 56.65 | 62.97 | 98% | 0% | 0% | 2% | 77.41 | 56.17 |
| X13J-4 | 34 | 1946 | 0.20 | 0.40 | 0.70 | 1.43 | | 3.25 | 5.97 | 99% | 0% | 0% | 1% | 7.71 | 6.43 |
| X13K-1 | 255 | 1946 | 1.20 | 3.20 | 3.20 | 3.20 | 3.20 | 3.20 | 3.20 | 100% | 0% | 0% | 0% | 4.00 | 1.71 |
| X13K-2 | 366 | 1946 | 8.20 | 21.40 | 41.65 | 92.82 | 137.02 | 185.58 | 185.58 | 82% | 18% | 0% | 0% | 233.37 | 125.98 |
| X13L-1 | 218 | 1967 | | 0.00 | 0.50 | 1.10 | 1.30 | 2.25 | 2.24 | 24% | 76% | 0% | 0% | 2.49 | 1.89 |
| X13L-2 | 68 | 1946 | 1.40 | 7.60 | 6.90 | 14.83 | 29.95 | 36.18 | 36.10 | 91% | 9% | 0% | 0% | 49.20 | 35.15 |
| **South Africa** | | **1946** | **13.00** | 39.60 | 64.05 | 139.78 | 207.87 | 291.51 | 302.12 | 87% | 13% | 0% | 0% | 381.32 | 230.51 |
| **X13 sub-total** | | **1946** | **15.60** | **59.60** | **88.05** | **165.78** | **228.79** | **320.13** | **358.95** | **86%** | **14%** | **0%** | **0%** | **444.37** | **290.15** |
| **Lomati (X14)** | | | | | | | | | | | | | | | |
| **X14D-2** | 66 | 1972 | | | 0.00 | 1.00 | 0.77 | 0.78 | 1.17 | 64% | 36% | 0% | 0% | 0.92 | 0.92 |
| **X14E-1** | 177 | 1967 | | 0.00 | 1.00 | 1.00 | 3.48 | 4.24 | 4.59 | 6% | 94% | 0% | 0% | 3.79 | 3.79 |
| **X14G-2** | 110 | 1972 | | | 0.00 | 1.40 | 0.86 | 0.80 | 1.90 | 64% | 36% | 0% | 0% | 1.76 | 1.76 |
| **Swaziland** | | **1967** | | **0.00** | **1.00** | **3.40** | **5.11** | **5.81** | **7.66** | **29%** | **71%** | **0%** | **0%** | **6.47** | **6.47** |
| X14F-1 | 117 | 1991 | | | | 0.00 | 0.31 | 0.50 | 0.21 | 100% | 0% | 0% | 0% | 0.15 | 0.15 |
| X14G-1 | 74 | 1955 | 0.00 | 4.00 | 8.00 | 5.10 | 8.56 | 9.86 | 14.58 | 95% | 5% | 0% | 0% | 15.29 | 15.29 |
| X14G-3 | 20 | 1967 | | 0.00 | 0.60 | 5.00 | 2.98 | 3.00 | 3.95 | 73% | 27% | 0% | 0% | 4.65 | 4.63 |
| X14H-1 | 360 | 1946 | 2.00 | 10.00 | 20.00 | 86.00 | 96.53 | 112.96 | 89.90 | 72% | 25% | 0% | 3% | 99.55 | 68.49 |
| **South Africa** | | **1955** | **2.00** | **14.00** | **28.60** | **96.10** | **108.38** | **126.32** | **108.64** | **75%** | **22%** | | **3%** | **119.64** | **88.56** |
| **X13 sub-total** | | **1946** | **2.00** | **14.00** | **29.60** | **99.50** | **113.50** | **132.10** | **116.30** | **72%** | **26%** | **0%** | **2%** | **126.11** | **95.03** |
| **X1 Total** | | **1946** | **17.60** | **100.50** | **144.15** | **300.38** | **385.09** | **509.89** | **512.38** | **76%** | **17%** | **5%** | **1%** | **587.98** | **402.32** |

VS Inkomati Verification and Validation Study (DWAF, 2006)
JIBS Joint Inkomati Basin Study (1996)

# Table D2: Crocodile River catchments: Crop information required by WQT irrigation model and WRSM2000 results at current (2004) development levels

| Catchment | | Growth in Irrigation area (km2) | | | | | | Distribution of crops | | | | WQT model results(2004) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Quinary | Area (km²) | Start | HCR 1950 | HCR 1964 | HCR 1981 | HCR 1991 | VS 2004 | Sugar cane | Citrus | Maize | Veg | Required (mill m³) | Supplied (mill m³) |
| X21A-1 | 124.9 | 1950 | 0.00 | 0.02 | 0.03 | 0.03 | 0.01 | 0.0% | 0.0% | 100.0% | 0.0% | not modelled | |
| X21A-2 | 139.3 | | | | | | 0.00 | | | | | No irrigation | |
| X21B-1 | 76.7 | 1950 | 0.00 | 0.00 | 0.01 | 0.01 | 0.00 | 0.0% | 0.0% | 100.0% | 0.0% | not modelled | |
| X21B-2 | 115.8 | 1950 | 0.00 | 4.45 | 7.56 | 7.56 | 1.83 | 0.0% | 0.0% | 100.0% | 0.0% | 0.76 | 0.76 |
| X21B-3 | 185.8 | 1950 | 0.00 | 5.73 | 9.72 | 9.72 | 2.35 | 0.0% | 2.0% | 98.0% | 0.0% | 1.25 | 1.14 |
| X21C-1 | 162.4 | 1950 | 0.00 | 5.91 | 10.04 | 10.04 | 2.43 | 0.0% | 6.4% | 80.5% | 13.1% | 1.14 | 1.13 |
| X21C-2 | 92.7 | 1950 | 0.00 | 4.91 | 8.33 | 8.33 | 2.01 | 0.0% | 0.0% | 100.0% | 0.0% | 0.98 | 0.92 |
| X21C-3 | 55.9 | 1950 | 0.00 | 0.77 | 1.30 | 1.30 | 0.32 | 0.0% | 0.0% | 100.0% | 0.0% | 0.16 | 0.16 |
| X21D-1 | 147.9 | 1949 | 0.25 | 2.50 | 2.42 | 2.42 | 3.46 | 0.0% | 1.3% | 98.7% | 0.0% | 1.52 | 1.47 |
| X21D-2 | 71.3 | 2000 | | | | 0.00 | 0.08 | 0.0% | 11.7% | 88.3% | 0.0% | not modelled | |
| X21E-1 | 209.0 | 1949 | 0.34 | 3.42 | 3.31 | 3.31 | 4.72 | 0.0% | 35.7% | 5.3% | 59.0% | 3.25 | 3.25 |
| X21E-2 | 136.1 | 1949 | 0.45 | 4.50 | 4.36 | 4.36 | 6.22 | 0.0% | 43.5% | 0.0% | 56.5% | 4.25 | 4.25 |
| X21F-1 | 206.5 | | | | | | 0.00 | | | | | No irrigation | |
| X21F-2 | 190.1 | | | | | | 0.00 | | | | | No irrigation | |
| X21G-1 | 132.9 | | | | | | 0.00 | | | | | No irrigation | |
| X21G-2 | 214.5 | | | | | | 0.00 | | | | | No irrigation | |
| X21H-1 | 146.1 | | | | | | 0.00 | | | | | No irrigation | |
| X21H-2 | 82.8 | 1949 | 0.01 | 2.80 | 1.83 | 1.83 | 0.15 | 0.0% | 0.0% | 100.0% | 0.0% | 0.04 | 0.04 |
| X21J-1 | 312.0 | 1920 | 2.15 | 9.78 | 5.36 | 5.36 | 7.69 | 0.0% | 29.7% | 5.8% | 64.6% | 4.68 | 4.68 |
| X21J-2 | 42.6 | 1920 | 2.03 | 9.25 | 5.06 | 5.06 | 7.27 | 0.0% | 6.4% | 66.6% | 27.0% | 3.11 | 3.11 |
| X21K-1 | 111.7 | | | | | | | | | | | Added to K2 | |
| X21K-2 | 106.6 | 1949 | 0.03 | 0.15 | 0.08 | 0.08 | 0.12 | 0.0% | 0.1% | 11.4% | 88.5% | 0.06 | 0.06 |
| X21K-3 | 26.9 | 1950 | 0.02 | 0.04 | 0.05 | 0.05 | 0.09 | 0.0% | 0.0% | 0.0% | 100.0% | 0.05 | 0.05 |
| **Upper Croc** | | | **4.25** | **22.02** | **12.38** | **12.38** | **38.74** | **0.0%** | **19.1%** | **45.4%** | **35.5%** | **21.25** | **21.02** |
| X22A-1 | 208.2 | | | | | | 0.00 | 0.0% | 0.0% | 0.0% | 0.0% | No irrigation | |
| X22A-2 | 43.1 | 1950 | 0.01 | 1.00 | 0.95 | 0.95 | 0.10 | 0.0% | 8.1% | 0.0% | 91.9% | 0.06 | 0.06 |
| X22B-1 | 131.2 | 1940 | 2.34 | 7.30 | 5.64 | 5.64 | 4.78 | 7.5% | 7.2% | 0.0% | 85.3% | 2.92 | 2.92 |
| X22B-2 | 95.5 | 1940 | 1.04 | 1.95 | 1.85 | 1.85 | 5.38 | 4.8% | 14.2% | 0.0% | 81.0% | 3.34 | 3.34 |
| X22C-1 | 46.3 | 1949 | 0.46 | 0.84 | 0.95 | 0.95 | 1.64 | 37.1% | 2.4% | 0.0% | 60.5% | 1.23 | 1.17 |
| X22C-2 | 114.5 | 1940 | 2.88 | 5.25 | 5.98 | 5.98 | 10.28 | 56.7% | 15.7% | 0.0% | 27.6% | 8.07 | 2.69 |
| X22C-3 | 205.4 | 1920 | 16.45 | 30.01 | 34.16 | 34.16 | 58.77 | 34.6% | 25.1% | 0.0% | 40.3% | 45.54 | 45.54 |
| X22D-1 | 41.0 | | | | | | 0.00 | | | | | No irrigation | |
| X22D-2 | 97.3 | 2000 | | | | 0.00 | 0.02 | 0.0% | 84.5% | 0.0% | 15.5% | not modelled | |
| X22D-3 | 136.2 | 2000 | | | | 0.00 | 0.30 | 0.0% | 71.5% | 0.0% | 28.5% | not modelled | |
| X22E-1 | 16.0 | | | | | | 0.00 | | | | | No irrigation | |
| X22E-2 | 48.3 | 2000 | | | | 0.00 | 0.05 | 0.0% | 99.9% | 0.0% | 0.1% | not modelled | |
| X22E-3 | 88.6 | 2000 | | | | 0.00 | 0.67 | 93.7% | 2.1% | 0.0% | 4.2% | not modelled | |
| X22F-1 | 105.9 | 1940 | 3.05 | 8.70 | 7.32 | 7.32 | 16.80 | 7.8% | 12.0% | 0.0% | 80.2% | 10.36 | 7.11 |
| X22F-2 | 106.5 | 1940 | 4.94 | 14.10 | 11.61 | 11.61 | 21.70 | 25.5% | 16.3% | 0.0% | 58.2% | 15.38 | 14.43 |
| X22G-1 | 77.0 | 2000 | | | | 0.00 | 0.17 | 0.0% | 0.9% | 0.0% | 99.1% | not modelled | |
| X22G-2 | 30.5 | 2000 | | | | 0.00 | 0.08 | 0.0% | 0.0% | 0.0% | 100.0% | not modelled | |
| X22H-1 | 66.2 | 1940 | 4.48 | 7.00 | 11.03 | 11.03 | 3.68 | 0.0% | 6.4% | 0.0% | 93.6% | 2.07 | 1.51 |
| X22H-2 | 90.2 | 1950 | 0.00 | 13.49 | 12.84 | 12.84 | 22.35 | 0.0% | 0.5% | 0.0% | 99.5% | 12.49 | 3.37 |
| X22H-3 | 43.8 | 1940 | 4.51 | 9.02 | 9.23 | 9.23 | 15.06 | 1.7% | 16.5% | 0.0% | 81.8% | 9.60 | 2.50 |
| X22J-1 | 104.5 | 1920 | 5.88 | 10.72 | 12.20 | 12.20 | 20.99 | 11.4% | 12.6% | 0.0% | 76.0% | 14.05 | 14.04 |
| X22J-2 | 135.4 | 1940 | 3.42 | 6.23 | 7.09 | 7.09 | 12.21 | 6.7% | 63.7% | 0.0% | 29.6% | 9.77 | 9.72 |
| X22K-1 | 102.7 | 1940 | 1.85 | 8.39 | 10.12 | 10.12 | 13.74 | 11.3% | 54.9% | 0.0% | 33.8% | 11.16 | 0.84 |
| X22K-2 | 156.4 | 1949 | 0.13 | 0.61 | 0.74 | 0.74 | 1.00 | 52.6% | 3.8% | 0.0% | 43.6% | 0.84 | 10.65 |
| X22K-3 | 75.8 | 1949 | 0.39 | 1.36 | 1.23 | 1.23 | 2.70 | 41.1% | 35.2% | 0.0% | 23.7% | 2.15 | 2.07 |
| **Middle Croc** | | **1920** | **51.81** | **125.98** | **132.94** | **132.94** | **212.48** | **19.5%** | **21.2%** | **0.0%** | **59.2%** | **149.03** | **121.96** |

VS Inkomati Verification and Validation Study (DWAF, 2006)

HCR – Hydrology of the Crocodile River (DWA, 1985)

## Table D2: Crocodile River quinary catchments: (cont)

| Catchment | | Growth in Irrigation area (km2) | | | | | | Distribution of crops | | | | WQT model results(2004) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Quinary | Area ($km^2$) | Start | HCR 1950 | HCR 1964 | HCR 1981 | HCR 1991 | VS 2004 | Sugar cane | Citrus | Maize | Veg | Required (mill $m^3$) | Supplied (mill $m^3$) |
| X23A-1 | 51.6 | | | | | | 0.00 | | | | | No irrigation | |
| X23A-2 | 75.2 | 1950 | 0.00 | 3.09 | 1.08 | 1.08 | 1.30 | 83.4% | 3.6% | 0.4% | 12.6% | 1.14 | 1.13 |
| X23B-1 | 33.9 | 1920 | 0.03 | 0.14 | 0.27 | 0.27 | 0.00 | 91.1% | 1.8% | 0.2% | 6.8% | 0.00 | 0.00 |
| X23B-2 | 97.3 | 1920 | 2.40 | 10.29 | 20.32 | 20.32 | 10.20 | 88.5% | 0.6% | 0.1% | 10.7% | 10.61 | 8.60 |
| X23B-3 | 97.9 | 1920 | 0.37 | 1.57 | 3.10 | 3.10 | 1.60 | 85.8% | 2.0% | 0.6% | 11.5% | 1.61 | 1.60 |
| X23C-1 | 81.3 | | | | | | 0.00 | | | | | No irrigation | |
| X23D-1 | 98.4 | 1940 | 1.71 | 2.90 | 3.28 | 3.28 | 4.30 | 23.0% | 11.7% | 1.4% | 63.9% | 3.45 | 3.44 |
| X23D-2 | 83.4 | 1940 | 1.69 | 3.60 | 4.63 | 4.63 | 14.30 | 14.2% | 9.9% | 1.4% | 74.6% | 12.36 | 9.03 |
| X23E-1 | 86.7 | 1964 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.0% | 0.0% | 100.0% | 0.0% | 0.00 | 0.00 |
| X23E-2 | 93.7 | 1964 | 0.00 | 0.01 | 0.61 | 0.61 | 0.97 | 70.1% | 3.2% | 0.5% | 26.3% | 0.81 | 0.81 |
| X23F-1 | 142.6 | 1920 | 0.62 | 2.66 | 5.24 | 5.24 | 11.10 | 30.7% | 15.1% | 10.9% | 43.3% | 8.75 | 6.63 |
| X23F-2 | 167.0 | 1920 | 0.79 | 3.40 | 6.71 | 6.71 | 14.17 | 68.8% | 10.3% | 8.9% | 12.0% | 13.44 | 8.55 |
| X23G-1 | 75.9 | | | | | | 0.00 | | | | | No irrigation | |
| X23G-2 | 149.2 | | 0.00 | 0.00 | 0.00 | 0.00 | 10.17 | 88.1% | 6.5% | 0.0% | 5.4% | 10.31 | 7.31 |
| X23H-1 | 81.3 | | 0.00 | 0.00 | 0.00 | 0.00 | 2.74 | 73.6% | 5.7% | 0.0% | 20.7% | 2.38 | 1.96 |
| X23H-2 | 110.2 | 1940 | 5.52 | 6.82 | 10.95 | 10.48 | 14.13 | 70.3% | 25.4% | 0.0% | 4.4% | 13.50 | 6.51 |
| X23H-3 | 30.0 | 1940 | 0.20 | 0.25 | 0.40 | 0.39 | 0.52 | 60.4% | 32.4% | 0.0% | 7.2% | 0.48 | 0.48 |
| X23H-4 | 11.0 | 1940 | 0.84 | 1.03 | 1.66 | 1.59 | 2.14 | 81.0% | 18.1% | 0.0% | 0.9% | 2.48 | 1.14 |
| X23H-5 | 73.5 | 1940 | 4.05 | 5.00 | 8.03 | 7.68 | 10.36 | 62.4% | 16.9% | 0.0% | 20.6% | 10.38 | 4.53 |
| **Kaap** | | | **18.23** | **40.76** | **66.28** | **65.38** | **98.00** | **58.9%** | **12.2%** | **2.8%** | **26.1%** | **91.70** | **61.72** |
| X24A-1 | 89.3 | | | | | | 0.00 | | | | | No irrigation | |
| X24A-2 | 159.2 | | | | | | 0.00 | | | | | No irrigation | |
| X24B-1 | 35.2 | 1949 | 0.08 | 0.28 | 0.26 | 0.26 | 0.56 | 0.0% | 0.0% | 0.0% | 100.0% | 0.47 | 0.44 |
| X24B-2 | 117.4 | 1940 | 0.01 | 0.04 | 0.04 | 0.04 | 0.08 | 0.0% | 0.0% | 0.0% | 100.0% | 0.04 | 0.04 |
| X24B-3 | 182.4 | 1950 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.0% | 0.0% | 0.0% | 100.0% | 0.00 | 0.00 |
| X24C-1 | 258.9 | 1940 | 0.00 | 0.02 | 0.02 | 0.02 | 6.13 | 97.2% | 2.8% | 0.0% | 0.0% | 7.32 | 6.77 |
| X24C-2 | 26.8 | 1940 | 1.31 | 4.51 | 4.07 | 4.07 | 3.95 | 95.5% | 4.5% | 0.0% | 0.1% | 4.51 | 4.14 |
| X24D-1 | 25.2 | 1949 | 0.02 | 0.06 | 0.06 | 0.06 | 0.13 | 98.9% | 1.1% | 0.0% | 0.0% | 0.12 | 0.12 |
| X24D-2 | 276.6 | 1920 | 11.83 | 40.87 | 36.89 | 36.89 | 53.57 | 87.1% | 11.9% | 0.0% | 1.1% | 58.80 | 50.83 |
| X24E-1 | 139.1 | 1940 | 1.47 | 5.09 | 4.59 | 4.59 | 7.02 | 87.7% | 12.3% | 0.0% | 0.0% | 8.37 | 6.45 |
| X24E-2 | 387.0 | 1940 | 2.73 | 9.42 | 8.50 | 8.50 | 13.76 | 59.4% | 40.6% | 0.0% | 0.0% | 16.24 | 12.53 |
| X24F-1 | 262.1 | 1950 | 0.00 | 6.00 | 18.04 | 18.04 | 16.81 | 64.1% | 35.2% | 0.0% | 0.7% | 19.09 | 13.35 |
| X24G-1 | 620.0 | | | | | | 0.00 | | | | | No irrigation | |
| X24H-1 | 672.5 | 1950 | 0.00 | 11.50 | 34.60 | 44.34 | 60.82 | 66.0% | 34.0% | 0.0% | 0.0% | 77.47 | 50.91 |
| X24H-2 | 97.0 | | | | | | | | | | | Added to H1 | |
| **Lower Croc** | | | **17.46** | **77.80** | **107.06** | **116.80** | **162.83** | **74.8%** | **24.4%** | **0.0%** | **0.8%** | **192.43** | **145.58** |
| **Total** | **10445.7** | | **91.75** | **266.56** | **318.66** | **327.49** | **512.05** | **50.4%** | **18.7%** | **3.3%** | **27.6%** | **454.41** | |

VS Inkomati Verification and Validation Study (DWAF, 2006)
HCR – Hydrology of the Crocodile River (DWA, 1985)

## Table D3: Sabie catchments: Crop information required by WQT irrigation model and WRSM2000 results at current (2004) development levels

| Catchment | | Growth in Irrigation area ($km^2$) | | | | | | | | | Distribution of crops (2004) | | | | WQT model results(2004) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Quinary | Area ($km^2$) | Start | SRC 1954 | SRC 1965 | SRC 1970 | SRC 1978 | SRC 1985 | VS 1998 | VS 1998 | VS 2004 | Sugar cane | Citrus | Maize | Veg | Required (mill $m^3$) | Supplied (mill $m^3$) |
| X31A-1 | 174 | | | | | | | | | 0.0 | | | | | No irrigation | |
| X31A-2 | 56 | | | | | | | | | 0.0 | | | | | No irrigation | |
| X31B-1 | 198 | 2000 | | | | | | | 0.0 | 0.2 | 0% | 63% | 0% | 37% | not modelled | |
| X31C-1 | 54 | | | | | | | | | 0.0 | | | | | No irrigation | |
| X31C-2 | 100 | 2000 | | | | | | | 0.0 | 0.0 | 0% | 0% | 0% | 100% | not modelled | |
| X31D-2 | 100 | 1950 | 2.2 | 4.7 | 7.0 | 9.4 | 10.5 | 18.2 | 17.9 | 20.2 | 0% | 91% | 0% | 9% | 15.46 | 13.60 |
| X31D-3 | 90 | 1950 | 2.2 | 8.9 | 13.2 | 17.6 | 19.7 | 28.8 | 36.9 | 36.4 | 0% | 82% | 0% | 18% | 27.23 | 21.55 |
| X31E-1 | 98 | | | | | | | | | 0.0 | | | | | No irrigation | |
| X31E-2 | 80 | 1990 | | | | | 0.0 | 2.0 | 2.3 | 2.0 | 0% | 96% | 0% | 4% | 1.16 | 1.16 |
| X31E-3 | 36 | 1990 | | | | | 0.0 | 1.9 | 2.2 | 1.8 | 0% | 100% | 0% | 0% | 1.45 | 1.45 |
| X31F-1 | 93 | | | | | | | | | 0.0 | | | | | No irrigation | |
| X31G-1 | 116 | 1950 | 0.1 | 0.1 | 0.7 | 2.1 | 1.7 | 1.8 | 1.5 | 1.9 | 0% | 85% | 0% | 15% | 1.59 | 1.59 |
| X31G-2 | 10 | 1950 | 0.0 | 0.0 | 0.1 | 0.2 | 0.2 | 0.0 | 0.0 | 0.2 | 0% | 77% | 0% | 23% | not modelled | |
| X31G-3 | 42 | 1950 | 0.0 | 0.0 | 0.2 | 0.8 | 0.6 | 3.9 | 4.7 | 3.8 | 0% | 17% | 0% | 83% | 2.34 | 2.34 |
| X31H-1 | 45 | | | | | | | | | | | | | | Added to X31H-2 | |
| X31H-2 | 16 | 1950 | 0.1 | 0.0 | 0.0 | 0.3 | 0.7 | 0.0 | 0.0 | 0.2 | 0% | 100% | 0% | 0% | 0.13 | 0.13 |
| X31J-1 | 154 | 1950 | 5.4 | 7.6 | 9.4 | 15.0 | 17.7 | 17.9 | 19.5 | 20.9 | 0% | 78% | 0% | 22% | 16.20 | 13.62 |
| X31K-1 | 80 | 1950 | 0.9 | 1.2 | 1.3 | 1.7 | 2.6 | 0.7 | 2.7 | 3.2 | 0% | 77% | 0% | 23% | 2.93 | 2.93 |
| X31K-2 | 100 | 1950 | 1.3 | 1.8 | 1.9 | 2.5 | 3.7 | 0.0 | 0.0 | 0.0 | | | | | not modelled | |
| X31K-3 | 51 | 1950 | 0.6 | 0.9 | 0.9 | 1.2 | 1.8 | 0.0 | 0.0 | 0.0 | 0% | 20% | 0% | 80% | not modelled | |
| X31K-4 | 260 | | | | | | | | | | | | | | Added to M1 | |
| X31L-1 | 67 | 1990 | | | | | 0.0 | 0.0 | 0.0 | 0.0 | 0% | 100% | 0% | 0% | not modelled | |
| X31L-2 | 70 | 2000 | | | | | | | 0.0 | 0.0 | 0% | 100% | 0% | 0% | not modelled | |
| X31L-3 | 158 | 1990 | | | | | 0.0 | 0.5 | 0.5 | 0.7 | 0% | 100% | 0% | 0% | 0.72 | 0.72 |
| X31M-1 | 215 | 1950 | 3.5 | 4.6 | 5.0 | 6.6 | 9.9 | 11.7 | 11.8 | 11.7 | 0% | 99% | 0% | 1% | 13.03 | 12.89 |
| X31M-2 | 142 | 2000 | | | | | | | 0.0 | 0.0 | 0% | 80% | 0% | 20% | not modelled | |
| X31M-3 | 357 | 1990 | | | | | 0.0 | 0.0 | 0.0 | 0.0 | 0% | 80% | 0% | 20% | not modelled | |
| **Upper S** | **2960** | | **16.3** | **29.9** | **39.7** | **57.3** | **69.2** | **87.6** | **99.9** | **103.4** | **0%** | **84%** | **0%** | **16%** | **82.24** | **71.98** |
| X32A-1 | 38 | | | | | | | | | 0.0 | | | | | No irrigation | |
| X32A-2 | 72 | | | | | | | | | 0.0 | | | | | No irrigation | |
| X32B-1 | 54 | | | | | | | | | 0.0 | | | | | No irrigation | |
| X32C-1 | 16 | 2000 | | | | | | | 0.0 | 0.9 | 0% | 81% | 0% | 19% | 0.42 | 0.42 |
| X32C-2 | 13 | 1950 | 0.2 | 0.2 | 0.2 | 0.2 | 0.3 | 2.8 | 3.0 | 1.2 | 0% | 81% | 0% | 19% | 1.11 | 1.11 |
| X32C-3 | 11 | | | | | | | | | 0.0 | | | | | No irrigation | |
| X32C-4 | 47 | 1950 | 0.9 | 0.9 | 0.9 | 0.9 | 1.0 | 1.1 | 1.4 | 1.1 | 0% | 86% | 0% | 14% | 0.96 | 0.96 |
| X32C-5 | 67 | 1950 | 0.9 | 0.9 | 0.9 | 0.9 | 1.0 | 9.2 | 10.0 | 9.8 | 0% | 2% | 0% | 98% | 5.71 | 5.24 |
| X32C-6 | 59 | 1950 | 1.1 | 1.1 | 1.1 | 1.1 | 1.2 | 0.2 | 0.9 | 0.3 | 0% | 75% | 0% | 25% | 0.30 | 0.30 |
| X32C-7 | 18 | | | | | | | | | | | | | | Added to | |
| X32D-1 | 62 | | | | | | | | | | | | | | Added to D-2 | |
| X32D-2 | 36 | 1950 | 1.6 | 1.6 | 1.6 | 1.6 | 1.8 | 1.6 | 0.5 | 0.5 | 0% | 38% | 0% | 62% | 0.40 | 0.40 |
| X32E-1 | 28 | | | | | | | | | 0.0 | | | | | No irrigation | |
| X32E-2 | 51 | 2000 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0% | 99% | 0% | 1% | No irrigation | |
| X32F-1 | 65 | 1920 | 1.4 | 1.4 | 1.4 | 1.4 | 1.5 | 1.1 | 1.2 | 1.5 | 0% | 84% | 0% | 16% | 1.49 | 1.49 |
| X32F-2 | 14 | 1920 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.0 | 0.0 | 1.1 | 0% | 69% | 0% | 31% | added to | |
| X32F-3 | 26 | 1950 | 0.5 | 0.5 | 0.5 | 0.5 | 0.6 | 7.1 | 8.5 | 5.5 | 0% | 18% | 0% | 82% | 4.38 | 0.58 |
| X32F-4 | 57 | 1990 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.8 | 0.9 | 0.6 | 0% | 0% | 0% | 100% | 0.35 | 0.35 |
| X32G-1 | 198 | 1920 | 3.9 | 3.9 | 3.9 | 3.9 | 4.5 | 1.8 | 1.8 | 2.1 | 0% | 76% | 0% | 24% | 1.94 | 1.93 |
| X32G-2 | 112 | | | | | | | | | | | | | | Added to G-1 | |
| X32G-3 | 29 | 1950 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.0 | 0.0 | 0.0 | 0% | 0% | 0% | 0% | not modelled | |
| **Sand** | **1907** | | **11.1** | **11.1** | **11.1** | **11.1** | **12.6** | **25.8** | **28.3** | **24.6** | **0%** | **30%** | **0%** | **70%** | **17.06** | **12.78** |
| **Lower S** | **1448** | | **0.0** | **0.0** | **0.0** | **0.0** | **0.0** | **0.0** | **0.0** | **0.1** | **0%** | **80%** | **0%** | **20%** | 0.00 | 0.00 |
| **Total X3** | **6315** | | **27.4** | **41.0** | **50.8** | **68.4** | **81.8** | **113.4** | **128.2** | **128.2** | | **73%** | **0%** | **27%** | **99.3** | **84.76** |
| **Total X4** | **3197** | | | | | | | | | **0.0** | | | | | **0.00** | |

VS Inkomati Verification and Validation Study (DWAF, 2006)
SRC Sabie River catchment study (DWAF, 1990)

**Table D3: Sabie / Sand catchment: Irrigation water requirements vs supplied as determined using the WQT model**

| Quinary Catchment | Area (km2) | Demand (million m³/a) | Supplied (million m³/a) |
|---|---|---|---|
| X31D-2 | 16.88 | 12.33 | 11.13 |
| X31D-3 | 32.50 | 23.24 | 18.12 |
| X31E-2 | 0.50 | 0.27 | 0.27 |
| X31G-3 | 3.00 | 1.77 | 1.77 |
| X31H-1 | 0.00 | 0.00 | 0.00 |
| X31H-2 | 0.00 | 0.00 | 0.00 |
| X31J-1 | 19.50 | 14.43 | 12.68 |
| X31K-1 | 2.60 | 2.27 | 2.27 |
| X31M-1 | 11.53 | 12.37 | 12.37 |
| X31M-2 | 0.00 | 0.00 | 0.00 |
| X31M-3[M-4] | 0.00 | 0.00 | 0.00 |
| ***Tertiary*** | ***86.5*** | ***66.7*** | ***58.6*** |
| X32C-1 | 0.58 | 0.38 | 0.33 |
| X32C-4 | 1.08 | 0.93 | 0.93 |
| X32C-5 | 5.76 | 3.26 | 3.23 |
| X32C-6 | 0.23 | 0.19 | 0.19 |
| X32F-1 | 1.52 | 1.44 | 1.44 |
| X32F-2 | 1.52 | 0.91 | 0.23 |
| X32F-3 | 0.00 | 0.00 | 0.00 |
| X32F-4 | 1.52 | 0.91 | 0.91 |
| X32G-1 | 1.95 | 1.76 | 1.75 |
| ***Tertiary*** | ***14.2*** | ***9.8*** | ***9.0*** |
| | | | |
| **Total X3** | | **76.5** | **67.6** |

# Appendix E: Crop water requirements

The crop water requirements (CWR) can be calculated on any day or month ($CWR_i$) as follows:

$$CWR_i = kc \times E \qquad (1)$$

Where *kc* is the crop coefficient and E is the A-pan evaporation.

In order to calculate the total crop requirement, it is necessary to sum the daily (or monthly) requirements. This then requires the crop factors for every month and knowledge of when the crop is to be planted and when it will be harvested. This is referred to as the cropping pattern. The total requirement for a particular crop is therefore given by the sum of all the daily (or monthly) requirements, i.e.

$$CWR_{total} = \Sigma kc_i \times E_i \qquad (2)$$

Taking rainfall into account is difficult to do accurately without a daily hydrological model which carries out daily soil moisture budgeting and keeps track of how the soil moisture changes with rainfall. The simpler monthly irrigation models assume that unless a certain threshold of rainfall occurs, the farmer will continue to irrigate. A typical value used is 25 mm/month. In other words the first 25mm of rain every month can be ignored, but any rainfall above this can be assumed to contributing to the crops water requirements and hence less irrigation will be required when the rainfall exceeds 25 mm. The difference between measured rainfall and the rainfall that is contributing to the crop is referred as effective rainfall, $R_{eff.}$. Including this concept into the crop water requirement calculation:

$$CWR_{total} = \Sigma(kc_i \times E_i - R_{eff.}) \qquad (3)$$

Crop water requirements also affected by the application efficiency (Eff) of the irrigation method used and is included in the crop water requirement calculation as follows:

$$CWR_{total} = \frac{\Sigma(kc_i \times E_i - R_{eff.})}{Eff} \qquad (4)$$

The parameter Eff is generally expressed of a proportion of maximum efficiency, i.e. if Eff = 1 then the irrigation application method is 100% efficient. Typical values range from 0.65 to 0.95.

Source: **Water Resources Modelling Platform: User Guide** (Mallory, et al, 2008)

# Appendix F

## Forestry data

Table F-1 Komati River quinary catchments: Growth in forestry area from 1920, current (2004) distribution, SFR parameters and estimated streamflow reduction

Table F-2 Crocodile River quinary catchments: Growth in forestry area from 1920, current (2004) distribution, SFR parameters and estimated streamflow reduction

Table F-3 Sabie River quinary catchments: Growth in forestry area from 1920, current (2004) distribution, SFR parameters and estimated streamflow reduction

## Table F-1 Komati River quinary catchments: Growth in forestry area from 1920, current (2004) distribution, SFR parameters and estimated streamflow reduction

| Catchment | | Growth in forestry area (km²) | | | | | | | | Species Distribution | | | SFR parameters & SFR | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Quinary | Area (km²) | Start 1921 | JIBS 1956 | JIBS 1972 | JIBS 1975 | JIBS 1991 | VS 1996 | VS 1998 | VS 2004 | Pine | Euca lypt | Wattle | MAR red (%) | Low fl red (%) | SFR MCM |
| X11A-1 | 672 | | | | 0.0 | 0.0 | 0.5 | 0.9 | 1.6 | 49% | 44% | 7% | 67.97 | 72.41 | 0.00 |
| X11B-1 | 361 | | | | | 0.0 | 1.1 | 1.8 | 1.7 | 52% | 12% | 37% | 75.17 | 91.63 | 0.00 |
| X11B-2 | 236 | | | | | 0.0 | 0.6 | 1.0 | 1.1 | 61% | 14% | 25% | 75.17 | 91.63 | 0.00 |
| X11C-1 | 319 | 1946 | 1.0 | 1.0 | 1.0 | 1.5 | 1.2 | 2.0 | 2.5 | 57% | 25% | 18% | 72.37 | 93.88 | 0.15 |
| **Nooit** | **1588** | **1946** | **1.0** | **1.0** | **1.0** | **1.5** | **3.4** | **5.7** | **6.8** | **54%** | **24%** | **21%** | | | **0.15** |
| X11D-1 | 256 | 1946 | 1.0 | 1.0 | 2.0 | 3.0 | 4.1 | 6.1 | 6.7 | 60% | 23% | 17% | 59.50 | 69.18 | 0.52 |
| X11D-2 | 96 | | | | | 0.0 | 0.2 | 0.3 | 0.4 | 70% | 20% | 9% | 59.50 | 69.18 | 0.00 |
| X11D-3 | 238 | | | | | 0.0 | 2.0 | 3.4 | 3.3 | 71% | 17% | 12% | 59.50 | 69.18 | 0.21 |
| X11E-1 | 156 | 1946 | 0.5 | 1.0 | 1.0 | 1.5 | 1.4 | 2.3 | 2.8 | 66% | 23% | 12% | 72.90 | 91.28 | 0.22 |
| X11E-2 | 86 | | | | 0.0 | 0.5 | 1.1 | 1.3 | 1.5 | 85% | 7% | 8% | 72.90 | 91.28 | 0.09 |
| X11F-1 | 183 | 1946 | 1.0 | 1.5 | 2.0 | 3.0 | 4.3 | 5.4 | 6.9 | 88% | 8% | 4% | 59.20 | 61.22 | 0.54 |
| X11G-1 | 264 | 1946 | 9.5 | 11.5 | 16.5 | 39.0 | 53.5 | 51.5 | 60.1 | 85% | 14% | 1% | 51.60 | 43.65 | 5.95 |
| X11H-1 | 265 | 1946 | 8.0 | 10.0 | 14.0 | 42.0 | 45.6 | 46.5 | 50.7 | 87% | 13% | 0% | 54.90 | 58.09 | 6.84 |
| **Vyge** | **1544** | **1946** | **20.0** | **25.0** | **35.5** | **89.0** | **112.2** | **116.8** | **132.3** | **84%** | **14%** | **2%** | | | **14.37** |
| X11J-1 | 186 | 1946 | 15.0 | 19.0 | 26.0 | 45.0 | 95.3 | 97.1 | 96.6 | 95% | 5% | 0% | 44.79 | 48.00 | 12.79 |
| X11K-1 | 65 | 1946 | 2.0 | 3.0 | 5.0 | 13.6 | 13.7 | 13.3 | 13.3 | 94% | 6% | 0% | 55.85 | 56.10 | 2.25 |
| X11K-2 | 58 | 1946 | 1.0 | 1.0 | 2.0 | 2.5 | 2.6 | 5.4 | 6.1 | 99% | 1% | 0% | 55.85 | 56.10 | 1.14 |
| X11K-3 | 48 | | | | 0.0 | 0.4 | 0.4 | 0.3 | 0.4 | 36% | 64% | 0% | 55.85 | 56.10 | 0.00 |
| X11K-4 | 40 | | | | 0.0 | 0.2 | 0.2 | 0.8 | 0.8 | 98% | 2% | 0% | 55.85 | 56.10 | 0.37 |
| X12A-1 | 244 | 1.2 | 38.0 | 42.0 | 50.0 | 72.0 | 78.2 | 80.1 | 103.1 | 94% | 4% | 2% | 62.95 | 72.96 | 9.91 |
| X12B-1 | 155 | 0.7 | 25.0 | 27.5 | 40.0 | 50.0 | 52.7 | 57.2 | 66.1 | 96% | 4% | 1% | 49.19 | 50.00 | 5.87 |
| X12C-1 | 42 | | | | 0.0 | 0.5 | 0.5 | 0.6 | 3.3 | 98% | 2% | 0% | 45.63 | 28.37 | 0.32 |
| X12C-2 | 144 | | | | 0.0 | 0.5 | 0.9 | 1.2 | 3.7 | 83% | 16% | 1% | 45.63 | 28.37 | 0.38 |
| X12D-1 | 139 | 1946 | 4.0 | 5.0 | 8.0 | 10.0 | 11.1 | 11.5 | 11.0 | 81% | 19% | 0% | 61.76 | 74.39 | 0.71 |
| X12D-2 | 84 | | | | | 0.0 | 0.2 | 0.3 | 0.4 | 66% | 34% | 0% | 61.76 | 74.39 | 0.00 |
| X12E-1 | 333 | 1.3 | 42.0 | 47.0 | 60.0 | 88.0 | 98.2 | 108.3 | 111.3 | 94% | 6% | 0% | 61.41 | 59.90 | 7.85 |
| X12F-1 | 95 | 1946 | 15.0 | 16.0 | 20.0 | 35.0 | 35.6 | 42.6 | 40.4 | 78% | 22% | 0% | 60.83 | 74.31 | 3.32 |
| X12F-2 | 64 | | 0.0 | 1.0 | 1.0 | 1.0 | 1.3 | 2.2 | 1.9 | 46% | 54% | 0% | 60.83 | 74.31 | 0.13 |
| X12F-3 | 154 | | | | | | | | 0.0 | | | | 60.83 | 74.31 | 0.00 |
| X12G-1 | 81 | 1946 | 1.5 | 2.0 | 2.0 | 2.6 | 5.2 | 7.2 | 19.1 | 93% | 7% | 0% | 54.95 | 53.72 | 1.53 |
| X12G-2 | 32 | 1946 | 0.0 | 0.5 | 0.5 | 0.5 | 2.3 | 2.6 | 3.1 | 98% | 2% | 0% | 54.95 | 53.72 | 0.31 |
| X12G-3 | 126 | | | | | | | | 0.0 | | | | 54.95 | 53.72 | 0.00 |
| X12H-1 | 70 | | | | | | | 0.0 | 1.0 | 98% | 2% | 0% | 61.20 | 87.19 | 0.11 |
| X12H-2 | 140 | | | | | 0.0 | 0.5 | 0.7 | 0.6 | 7% | 93% | 0% | 61.20 | 87.19 | 0.00 |
| X12H-3 | 76 | | | | | | | | 0.0 | | | | 61.20 | 87.19 | 0.00 |
| X12J-1 | 175 | | 29.0 | 33.0 | 35.0 | 61.0 | 63.2 | 73.5 | 78.5 | 86% | 14% | 0% | 35.78 | 38.44 | 6.95 |
| X12J-2 | 68 | | 4.0 | 5.0 | 6.0 | 10.2 | 13.0 | 13.7 | 12.4 | 96% | 4% | 0% | 35.78 | 38.44 | 1.40 |
| X12J-3 | 53 | | 0.0 | 1.0 | 1.0 | 2.6 | 0.8 | 0.9 | 3.1 | 96% | 4% | 0% | 35.78 | 38.44 | 0.34 |
| X12K-1 | 239 | | 0.0 | 1.0 | 1.0 | 2.0 | 2.3 | 2.8 | 2.6 | 87% | 13% | 0% | 51.95 | 59.58 | 0.20 |
| X12K-2 | 47 | | | | | | | | 0.0 | | | | 51.95 | 59.58 | 0.00 |
| **Vyge 2 sw** | **2958** | **3.2** | **176.5** | **204.0** | **257.5** | **397.5** | **478.0** | **522.3** | **578.4** | **92%** | **8%** | **1%** | | | **55.88** |

**0.00 – No forestry or forestry less than 0.5km² or less then 1% of catchment area**

VS – Verification study (DWAF, 2006)

JIBS – Joint Inkomati Basin Study (TPTC, 2001)

## Table F-1 Komati River quinary catchments: (cont)

| Catchment | | Growth in forestry area (km²) | | | | | | | | Species Distribution | | | SFR parameters & SFR | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Quinary | Area (km²) | Start 1921 | JIBS 1956 | JIBS 1972 | JIBS 1975 | JIBS 1991 | VS 1996 | VS 1998 | VS 2004 | Pine | Euca lypt | Wattle | MAR red (%) | Low fl red (%) | SFR MCM |
| X13A-1 | 245 | 1946 | 30.0 | 36.0 | 36.0 | 36.0 | 36.3 | 37.6 | 44.1 | 82% | 18% | 0% | 28.12 | 36.30 | **5.10** |
| X13B-1 | 149 | 1946 | 25.0 | 30.0 | 30.0 | 30.0 | 30.0 | 30.7 | 33.2 | 80% | 20% | 0% | 30.59 | 47.88 | **3.68** |
| X13B-2 | 88 | 1946 | 35.0 | 39.0 | 39.0 | 39.0 | 40.0 | 67.4 | 45.0 | 72% | 28% | 0% | 30.59 | 47.88 | **3.68** |
| X13C-1 | 195 | 1946 | 0.0 | 2.0 | 2.0 | 2.0 | 2.7 | 4.3 | 3.8 | 66% | 34% | 0% | 29.07 | 50.11 | **0.50** |
| X13D-1 | 181 | 1946 | 5.0 | 7.0 | 7.0 | 7.0 | 7.3 | 9.0 | 10.4 | 62% | 38% | 0% | 29.47 | 47.36 | **1.19** |
| X13E-1 | 224 | | | | | | | 0.0 | 0.0 | 100% | 0% | 0% | 28.00 | 29.86 | **0.00** |
| X13F-1 | 205 | 1946 | 20.0 | 36.0 | 36.0 | 36.0 | 35.8 | 40.3 | 43.2 | 58% | 42% | 0% | 31.17 | 38.24 | **3.75** |
| X13G-1 | 71 | | | | | | | | 0.0 | | | | 41.51 | 48.34 | **0.00** |
| X13G-2 | 213 | 1946 | 5.0 | 7.0 | 7.0 | 7.0 | 7.5 | 8.9 | 9.4 | 51% | 49% | 0% | 41.51 | 48.34 | **0.52** |
| X13G-3 | 51 | | | | | | | | 0.0 | | | | 41.51 | 48.34 | **0.00** |
| X13H-1 | 100 | | | | | | | | 0.0 | | | | 34.79 | 51.04 | **0.00** |
| X13H-2 | 206 | | | | | | | | 0.0 | | | | 34.79 | 51.04 | **0.00** |
| **X13 - sw** | **1928** | **1946** | **120.0** | **157.0** | **157.0** | **157.0** | **159.6** | **198.2** | **189.2** | **71%** | **29%** | **0%** | | | **18.42** |
| X13J-1 | 70 | | | | | | | | 0.0 | | | | 33.86 | 55.96 | **0.00** |
| X13J-2 | 161 | | | | | | | | 0.0 | | | | 33.86 | 55.96 | **0.00** |
| X13J-3 | 524 | | | | | | | | 0.0 | | | | 33.86 | 55.96 | **0.00** |
| X13J-4 | 34 | | | | | | | | 0.0 | | | | 33.86 | 55.96 | **0.00** |
| X13K-1 | 255 | | | | | | | | 0.0 | | | | 37.97 | 43.78 | **0.00** |
| X13K-2 | 366 | | | | | | | | 0.0 | | | | 37.97 | 43.78 | **0.00** |
| X13L-1 | 218 | | | | | | | 0.0 | 0.0 | 0% | 100% | 0% | 37.98 | 44.85 | **0.00** |
| X13L-2 | 68 | | | | | | | | 0.0 | | | | 37.98 | 44.85 | **0.00** |
| **X13 - SA** | **1696** | | | | | | | **0.0** | **0.0** | **0%** | **100%** | **0%** | | | **0.00** |
| X14A-1 | 141 | 1946 | 30.0 | 43.0 | 45.0 | 47.0 | 42.7 | 44.6 | 49.2 | 84% | 16% | 0% | 27.72 | 34.48 | **5.44** |
| X14B-1 | 37 | 1946 | 14.0 | 25.5 | 26.0 | 26.0 | 19.2 | 18.6 | 22.8 | 90% | 10% | 0% | 25.76 | 23.79 | **2.38** |
| X14B-2 | 148 | 1946 | 20.0 | 25.0 | 25.0 | 25.0 | 24.1 | 27.0 | 30.6 | 49% | 51% | 0% | 25.76 | 40.00 | **2.84** |
| X14C-1 | 166 | 1946 | 75.0 | 90.0 | 90.0 | 90.0 | 65.0 | 68.2 | 72.2 | 68% | 32% | 0% | 31.75 | 47.76 | **6.63** |
| X14D-1 | 63 | 1946 | 4.0 | 5.0 | 5.0 | 5.0 | 4.2 | 4.9 | 4.9 | 56% | 44% | 0% | 34.54 | 56.70 | **0.54** |
| X14D-2 | 66 | 1946 | 8.0 | 10.0 | 10.0 | 10.0 | 9.0 | 10.4 | 11.1 | 57% | 43% | 0% | 34.54 | 56.70 | **1.15** |
| X14E-1 | 177 | 1946 | 6.0 | 7.0 | 7.0 | 7.0 | 4.8 | 5.1 | 7.2 | 48% | 52% | 0% | 41.67 | 63.70 | **0.49** |
| X14G-2 | 110 | 1946 | 10.0 | 13.0 | 15.0 | 18.0 | 12.0 | 13.2 | 15.1 | 27% | 73% | 0% | 31.83 | 76.16 | **0.80** |
| **Driekoppies** | **908** | **1946** | **167.0** | **218.5** | **223.0** | **228.0** | **181.1** | **192.0** | **213.1** | **67%** | **33%** | **0%** | | | **20.27** |
| X14F-1 | 117 | 1946 | 50.0 | 70.0 | 83.0 | 97.0 | 67.1 | 72.5 | 81.3 | 38% | 62% | 0% | 27.73 | 54.86 | **8.19** |
| X14G-1 | 74 | | | | | 0.0 | 0.1 | 0.2 | 0.2 | 20% | 80% | 0% | 38.02 | 76.16 | **0.00** |
| X14G-3 | 20 | | | | | | | | 0.0 | | | | | 76.16 | **0.00** |
| X14H-1 | 360 | | | | | | 0.0 | 0.2 | 2.2 | 76% | 24% | 0% | | 49.09 | **0.00** |
| **d/s Driek** | **571** | | **50.0** | **70.0** | **83.0** | **97.0** | **67.2** | **72.8** | **83.6** | **39%** | **61%** | **0%** | | | **8.19** |
| **Total X** | **11193** | **3.2** | **534.5** | **675.5** | **757.0** | **970.0** | **1001.5** | **1107.9** | **1203.4** | **79%** | **20%** | **1%** | | | **117.3** |
| **Swaziland** | **2836** | **1946** | **287.0** | **375.5** | **380.0** | **385.0** | **340.7** | **390.2** | **402.3** | **69%** | **31%** | **0%** | | | **38.7** |
| **SA** | **8357** | **3.2** | **247.5** | **300.0** | **377.0** | **585.0** | **660.8** | **717.6** | **801.1** | **85%** | **14%** | **1%** | | | **78.6** |

**0.00 – No forestry or forestry less than 0.5km² or less then 1% of catchment area**

VS – Verification study (DWAF, 2006)

JIBS – Joint Inkomati Basin Study (TPTC, 2001)

# Table F-2 Crocodile River quinary catchments: Growth in forestry area from 1920, current (2004) distribution, SFR parameters and estimated streamflow reduction

| Catchment | | Growth in forestry area (km²) | | | | | | | Species Distribution | | | SFR parameters & SFR | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Quinary | Area (km²) | HCR 1950 | HCR 1964 | HCR 1972 | HCR 1982 | 1991 | CSIR 1995 | VS 2004 | Pine | Eucalypt | Wattle | MAR red (%) | Low fl red (%) | SFR MCM |
| X21A-1 | 125 | 0.0 | 1.5 | 1.7 | 2.4 | 3.9 | 0.1 | 2.9 | 79% | 19% | 2% | 51.17 | 34.47 | 0.34 |
| X21A-2 | 139 | 0.0 | 0.9 | 1.0 | 1.3 | 2.2 | 0.1 | 1.6 | 73% | 25% | 3% | 51.17 | 34.47 | 0.16 |
| X21B-1 | 77 | 0.0 | 2.1 | 2.4 | 3.3 | 5.3 | 1.8 | 3.9 | 89% | 10% | 1% | 55.15 | 48.90 | 0.48 |
| X21B-2 | 116 | 0.0 | 4.0 | 4.6 | 6.3 | 10.2 | 2.7 | 7.5 | 80% | 18% | 2% | 55.15 | 48.90 | 0.60 |
| X21B-3 | 186 | 0.0 | 4.3 | 5.0 | 6.8 | 11.0 | 4.3 | 8.2 | 85% | 15% | 1% | 55.15 | 48.90 | 0.58 |
| X21C-1 | 162 | 0.0 | 15.0 | 17.2 | 23.6 | 38.2 | 17.3 | 28.3 | 95% | 5% | 1% | 47.06 | 35.69 | 2.37 |
| X21C-2 | 93 | 0.0 | 1.9 | 2.1 | 3.0 | 4.8 | 9.9 | 3.5 | 93% | 6% | 1% | 47.06 | 35.69 | 0.24 |
| X21C-3 | 56 | 0.0 | 0.3 | 0.4 | 0.5 | 0.8 | 6.0 | 0.6 | 32% | 66% | 2% | 47.06 | 35.69 | 0.04 |
| **Kwena** | **953** | **0.0** | **30.0** | **34.3** | **47.2** | **76.3** | **42.1** | **56.5** | **89%** | **10%** | **1%** | | | **4.81** |
| X21D-1 | 148 | 0.0 | 14.4 | 21.8 | 30.5 | 41.2 | 21.0 | 34.4 | 95% | 5% | 1% | 56.94 | 67.97 | 2.61 |
| X21D-2 | 71 | 0.0 | 0.0 | 0.0 | 0.0 | 2.0 | 10.1 | 5.5 | 95% | 4% | 1% | 56.94 | 67.97 | 0.36 |
| X21E-1 | 209 | 0.0 | 22.0 | 33.4 | 46.8 | 63.2 | 48.5 | 52.7 | 86% | 13% | 1% | 46.90 | 50.67 | 4.23 |
| X21E-2 | 136 | 0.0 | 18.3 | 27.8 | 38.9 | 52.6 | 31.6 | 43.9 | 65% | 35% | 0% | 46.90 | 50.67 | 4.32 |
| **d/s Kwena** | **564** | **0.0** | **54.7** | **82.9** | **116.2** | **159.0** | **111.3** | **136.4** | **82%** | **18%** | **1%** | | | **11.52** |
| X21F-1 | 207 | 0.0 | 2.1 | 2.1 | 2.1 | 2.1 | 0.1 | 10.0 | 81% | 15% | 4% | 69.80 | 96.73 | 0.99 |
| X21F-2 | 190 | 0.0 | 0.7 | 0.7 | 0.7 | 0.7 | 0.1 | 3.3 | 88% | 9% | 3% | 69.80 | 96.73 | 0.35 |
| X21G-1 | 133 | 1.8 | 3.6 | 5.9 | 7.2 | 10.1 | 22.1 | 8.7 | 91% | 5% | 4% | 48.70 | 29.30 | 0.66 |
| X21G-2 | 214 | 11.8 | 24.2 | 40.2 | 48.9 | 68.1 | 35.7 | 58.7 | 93% | 6% | 2% | 48.70 | 29.30 | 4.31 |
| X21H-1 | 146 | 4.4 | 5.8 | 9.7 | 18.2 | 44.7 | 40.6 | 42.3 | 90% | 10% | 0% | 34.42 | 28.91 | 4.52 |
| X21H-2 | 83 | 3.6 | 4.8 | 7.9 | 14.9 | 36.4 | 23.0 | 34.5 | 91% | 9% | 0% | 34.42 | 28.91 | 3.22 |
| X21J-1 | 312 | 18.7 | 38.3 | 63.6 | 77.4 | 107.7 | 68.8 | 92.8 | 85% | 15% | 1% | 44.08 | 39.02 | 8.55 |
| X21J-2 | 43 | 3.1 | 6.4 | 10.5 | 12.8 | 17.9 | 9.4 | 15.4 | 85% | 15% | 0% | 44.08 | 39.02 | 1.47 |
| X21K-1 | 112 | 14.4 | 29.4 | 48.8 | 59.4 | 82.7 | 46.3 | 71.3 | 72% | 28% | 0% | 32.68 | 35.21 | 6.51 |
| X21K-2 | 107 | 10.2 | 20.8 | 34.5 | 42.0 | 58.6 | 44.1 | 50.5 | 90% | 11% | 0% | 32.68 | 35.21 | 4.15 |
| X21K-3 | 27 | 0.7 | 7.3 | 7.4 | 7.5 | 7.7 | 11.1 | 6.6 | 37% | 63% | 0% | 32.68 | 35.21 | 0.53 |
| **Elands** | **1573** | **68.7** | **143.4** | **231.4** | **291.2** | **436.7** | **301.4** | **394.1** | **84%** | **15%** | **1%** | | | **35.26** |
| X22A-1 | 208 | 0.0 | 88.8 | 106.7 | 129.7 | 146.2 | 128.4 | 130.5 | 86% | 13% | 1% | 34.96 | 34.80 | 12.77 |
| X22A-2 | 43 | 0.0 | 17.2 | 20.6 | 25.1 | 28.3 | 26.6 | 25.2 | 38% | 61% | 1% | 34.96 | 34.80 | 2.10 |
| **Houtbosl** | **251** | **0.0** | **106.0** | **127.3** | **154.8** | **174.5** | **154.9** | **155.7** | **79%** | **21%** | **1%** | | | **14.87** |
| X22B-1 | 131 | 15.0 | 55.0 | 55.0 | 55.0 | 60.3 | 83.3 | 73.2 | 65% | 35% | 0% | 35.83 | 17.16 | 6.90 |
| **Stats** | **131** | **15.0** | **55.0** | **55.0** | **55.0** | **60.3** | **83.3** | **73.2** | **65%** | **35%** | **0%** | | | **6.90** |
| X22B-2 | 95 | 0.0 | 2.5 | 2.5 | 2.5 | 2.5 | 35.0 | 15.6 | 42% | 58% | 0% | 35.83 | 17.16 | 1.28 |
| X22C-1 | 46 | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 | 13.1 | 0.1 | 0% | 100% | 0% | 38.13 | 49.10 | 0.00 |
| X22C-2 | 115 | 5.0 | 49.7 | 50.2 | 51.2 | 52.0 | 32.3 | 45.0 | 54% | 46% | 0% | 38.13 | 49.10 | 2.28 |
| X22C-3 | 205 | 4.2 | 42.3 | 42.7 | 43.5 | 44.2 | 58.0 | 38.2 | 48% | 52% | 0% | 38.13 | 49.10 | 1.71 |
| X22J-1 | 104 | 0.0 | 0.4 | 0.4 | 0.4 | 0.4 | 0.0 | 0.3 | 0% | 100% | 0% | 42.83 | 56.99 | 0.01 |
| X22J-2 | 135 | 0.0 | 0.2 | 0.2 | 0.2 | 0.2 | 0.0 | 0.2 | 59% | 41% | 0% | 42.83 | 56.99 | 0.00 |
| X22K-1 | 103 | 0.0 | 0.1 | 0.7 | 0.7 | 0.7 | 0.3 | 0.1 | 95% | 5% | 0% | 31.29 | 22.96 | 0.00 |
| X22K-2 | 156 | 0.0 | 0.9 | 4.1 | 4.1 | 4.1 | 0.5 | 0.7 | 16% | 84% | 0% | 31.29 | 22.96 | 0.00 |
| X22K-3 | 76 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.2 | 0.1 | 99% | 1% | 0% | 31.29 | 22.96 | 0.00 |
| **Mid Croc** | **1036** | **9.3** | **96.2** | **101.0** | **102.8** | **104.4** | **139.4** | **100.3** | **49%** | **51%** | **0%** | | | **5.28** |

**0.00 – No forestry or forestry less than 0.5km² or less then 1% of catchment area**

VS – Verification study (DWAF, 2006)

HCR – Hydrology of the Crocodile River (DWA, 1985)

## Table F-2 Crocodile River quinary catchments: (cont)

| Catchment | | Growth in forestry area (km²) | | | | | | | Species Distribution | | | SFR parameters & SFR | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Quinary | Area (km²) | HCR 1950 | HCR 1964 | HCR 1972 | HCR 1982 | 1991 | CSIR 1995 | VS 2004 | Pine | Euca lypt | Wattle | MAR red (%) | Low fl red (%) | SFR MCM |
| X22D-1 | 41 | 2.3 | 29.0 | 30.1 | 30.1 | 31.6 | 36.3 | 32.3 | 90% | 10% | 0% | 27.92 | 26.63 | 2.56 |
| X22D-2 | 97 | 6.2 | 78.6 | 81.4 | 81.5 | 85.7 | 86.2 | 87.4 | 91% | 9% | 0% | 27.92 | 26.63 | 6.95 |
| X22D-3 | 136 | 8.6 | 109.0 | 112.9 | 112.9 | 118.9 | 120.7 | 121.2 | 84% | 16% | 0% | 27.92 | 26.63 | 7.52 |
| X22E-1 | 16 | 13.3 | 13.7 | 14.1 | 14.1 | 14.1 | 11.6 | 14.2 | 27% | 73% | 0% | 30.13 | 31.07 | 1.61 |
| X22E-2 | 48 | 37.7 | 38.8 | 39.9 | 39.9 | 39.9 | 35.0 | 40.3 | 76% | 24% | 0% | 30.13 | 31.07 | 3.63 |
| X22E-3 | 89 | 37.0 | 41.0 | 43.0 | 46.2 | 58.9 | 64.3 | 55.9 | 60% | 40% | 0% | 30.13 | 31.07 | 3.95 |
| X22F-1 | 106 | 0.0 | 33.2 | 44.6 | 46.0 | 48.6 | 34.6 | 37.8 | 24% | 76% | 0% | 39.28 | 66.79 | 1.57 |
| X22F-2 | 107 | 1.9 | 24.1 | 25.0 | 25.0 | 26.3 | 34.8 | 26.9 | 63% | 37% | 0% | 39.28 | 66.79 | 1.15 |
| **Nelspruit** | **640** | **107.0** | **367.4** | **391.0** | **395.7** | **424.0** | **423.6** | **415.9** | **73%** | **27%** | **0%** | | | **28.94** |
| X22G-1 | 77 | 51.0 | 56.3 | 56.3 | 56.3 | 57.3 | 63.4 | 62.8 | 60% | 40% | 0% | 31.89 | 37.05 | 5.00 |
| X22G-2 | 30 | 3.0 | 18.3 | 28.0 | 28.0 | 27.0 | 25.1 | 27.8 | 18% | 82% | 0% | 31.89 | 37.05 | 1.83 |
| X22H-1 | 66 | 8.0 | 45.6 | 45.6 | 45.6 | 45.6 | 21.2 | 44.3 | 13% | 87% | 0% | 38.88 | 78.89 | 2.12 |
| X22H-2 | 90 | 0.0 | 20.5 | 20.5 | 20.5 | 20.5 | 28.9 | 21.2 | 16% | 84% | 0% | 38.88 | 78.89 | 0.81 |
| X22H-3 | 44 | 0.0 | 0.6 | 0.7 | 0.7 | 0.7 | 14.1 | 0.0 | 100% | 0% | 0% | 38.88 | 78.89 | 0.00 |
| **White R** | **308** | **62.0** | **141.3** | **151.1** | **151.1** | **151.1** | **152.7** | **156.1** | **33%** | **67%** | **0%** | | | **9.76** |
| X23A-1 | 52 | 1.7 | 17.7 | 20.5 | 21.8 | 30.6 | 25.0 | 40.2 | 39% | 62% | 0% | 35.09 | 44.75 | 4.67 |
| X23A-2 | 75 | 2.3 | 24.2 | 28.1 | 29.9 | 41.8 | 36.3 | 55.0 | 45% | 55% | 0% | 35.09 | 44.75 | 5.25 |
| X23B-1 | 34 | 10.5 | 13.9 | 14.6 | 28.8 | 31.0 | 4.7 | 27.8 | 48% | 52% | 0% | 48.41 | 58.49 | 1.28 |
| X23B-2 | 97 | 1.6 | 2.2 | 2.3 | 4.5 | 4.9 | 13.6 | 4.4 | 45% | 55% | 0% | 48.41 | 58.49 | 0.17 |
| X23B-3 | 98 | 1.1 | 1.4 | 1.5 | 2.9 | 3.1 | 13.7 | 2.8 | 33% | 67% | 0% | 48.41 | 58.49 | 0.11 |
| **NoordK** | **356** | **17.2** | **59.4** | **67.0** | **87.9** | **111.4** | **93.3** | **130.1** | **43%** | **57%** | **0%** | | | **11.48** |
| X23C-1 | 81 | 0.0 | 30.8 | 49.4 | 60.5 | 61.7 | 60.3 | 71.9 | 59% | 41% | 0% | 34.86 | 35.09 | 8.17 |
| X23D-1 | 98 | 0.0 | 43.2 | 62.7 | 65.4 | 59.5 | 44.0 | 67.8 | 22% | 78% | 0% | 53.21 | 90.19 | 9.06 |
| X23D-2 | 83 | 0.0 | 0.0 | 0.0 | 0.0 | 8.0 | 37.3 | 19.2 | 32% | 68% | 0% | 53.21 | 90.19 | 1.59 |
| X23F-2 | 167 | 0.3 | 0.4 | 0.5 | 0.9 | 1.0 | 8.9 | 0.9 | 81% | 19% | 0% | 48.09 | 70.07 | 0.03 |
| **SuidK** | **430** | **0.3** | **74.4** | **112.6** | **126.8** | **130.2** | **150.5** | **159.8** | **40%** | **60%** | **0%** | | | **18.90** |
| X23E-1 | 87 | 43.0 | 54.6 | 57.2 | 63.1 | 63.1 | 61.1 | 65.6 | 92% | 8% | 0% | 37.21 | 32.59 | 4.64 |
| X23E-2 | 94 | 37.0 | 47.0 | 49.3 | 54.4 | 54.4 | 65.9 | 56.5 | 41% | 59% | 0% | 37.21 | 32.59 | 3.39 |
| X23F-1 | 143 | 5.5 | 7.3 | 7.7 | 15.2 | 16.3 | 7.6 | 14.6 | 68% | 33% | 0% | 48.09 | 70.07 | 0.59 |
| **Queens** | **323** | **85.5** | **108.9** | **114.2** | **132.7** | **133.9** | **134.6** | **136.7** | **69%** | **31%** | **0%** | | | **8.62** |
| X23G-1 | 76 | | | | | 0.0 | 0.2 | 0.7 | 86% | 14% | 0% | 36.51 | 31.33 | 0.03 |
| X23G-2 | 149 | | | | | 0.0 | 0.4 | 0.0 | 85% | 15% | 0% | 36.51 | 31.33 | 0.00 |
| X23H-1 | 81 | | | | | 0.0 | 3.4 | 0.0 | | | | 43.01 | 83.53 | 0.00 |
| X23H-2 | 110 | 9.6 | 10.5 | 13.4 | 13.4 | 13.4 | 4.6 | 15.3 | 54% | 46% | 0% | 43.01 | 83.53 | 0.00 |
| X23H-3 | 30 | 0.4 | 0.5 | 0.6 | 0.6 | 0.6 | 1.2 | 0.7 | 50% | 50% | 0% | 43.01 | 83.53 | 0.69 |
| X23H-4 | 11 | | | | | 0.0 | 0.5 | 0.0 | | | | 43.01 | 83.53 | 0.04 |
| X23H-5 | 74 | | | | | 0.0 | 3.1 | 0.0 | 75% | 25% | 0% | 43.01 | 83.53 | 0.00 |
| **Kaap** | **531** | **10.0** | **11.0** | **14.0** | **14.0** | **14.0** | **13.3** | **16.7** | **55%** | **45%** | **0%** | | | **0.76** |
| X24A-1 | 89 | 0.0 | 0.3 | 0.7 | 1.0 | 1.3 | 0.2 | 0.7 | 19% | 81% | 0% | 48.26 | 87.61 | 0.00 |
| X24A-2 | 159 | | | | | 0.0 | 0.4 | 0.0 | | | | 48.26 | 87.61 | 0.00 |
| X24B-1 | 35 | | | | | 0.0 | 0.6 | 0.0 | | | | 50.73 | 82.47 | 0.00 |
| X24B-2 | 117 | 0.0 | 2.4 | 5.2 | 8.4 | 10.6 | 2.0 | 5.9 | 40% | 60% | 0% | 50.73 | 82.47 | 0.20 |
| X24B-3 | 182 | | | | | 0.0 | 3.1 | 0.0 | | | | 50.73 | 82.47 | 0.00 |
| X24C-1 | 259 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.0 | 0.1 | 39% | 61% | 0% | 42.62 | 51.34 | 0.00 |
| X24C-2 | 27 | 0.0 | 0.1 | 0.1 | 0.2 | 0.3 | 0.0 | 0.1 | 100% | 0% | 0% | 42.62 | 51.34 | 0.00 |
| X24D-1 | 25 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.3 | 0.0 | 38% | 62% | 0% | 36.46 | 71.49 | 0.00 |
| X24D-2 | 277 | 0.0 | 1.9 | 4.2 | 6.7 | 8.5 | 3.5 | 4.8 | 28% | 72% | 0% | 36.46 | 71.49 | 0.15 |
| **Lower Croc** | **(3349)** | **0.0** | **4.8** | **10.3** | **16.6** | **20.9** | **10.1** | **11.7** | **34%** | **66%** | **0%** | | | **0.40** |
| **Total** | **10445** | **375.0** | **1252.6** | **1492.1** | **1692.1** | **1996.5** | **1810.6** | **1943.3** | **67%** | **33%** | **0%** | | | **157.50** |

**0.00 – No forestry or forestry less than 0.5km² or less then 1% of catchment area**

VS – Verification study (DWAF, 2006)

HCR – Hydrology of the Crocodile River (DWA, 1985)

## Table F-3 Sabie River quinary catchments: Growth in forestry area from 1920, current (2004) distribution, SFR parameters and estimated streamflow reduction

| Catchment | | Growth in forestry in quinary catchments (km²) | | | | | | | | Species Distribution | | | Reduction in runoff | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Quinary | Area (km²) | 1921 | SRC 1954 | SRC 1965 | SRC 1972 | SRC 1985 | VS 1996 | VS 1998 | VS 2004 | Pine | Euca lypt | Wattle | MAR red (%) | Low fl red (%) | SFR MCM |
| X31A-1 | 174 | 0.0 | 74.0 | 84.0 | 87.0 | 89.0 | 95.1 | 100.9 | 112.4 | 89.4% | 10.6% | 0.0% | 29.50 | 37.26 | 16.39 |
| X31A-2 | 56 | 0.0 | 27.0 | 27.0 | 34.0 | 35.0 | 36.9 | 37.9 | 41.3 | 95.9% | 4.1% | 0.0% | 29.50 | 37.26 | 4.03 |
| X31B-1 | 198 | 0.0 | 52.6 | 92.5 | 96.9 | 100.7 | 113.9 | 128.7 | 142.1 | 72.6% | 27.4% | 0.0% | 23.43 | 21.20 | 13.37 |
| X31C-1 | 54 | 0.0 | 19.0 | 19.0 | 26.0 | 26.0 | 27.5 | 28.7 | 30.5 | 81.5% | 18.5% | 0.0% | 27.85 | 45.63 | 5.06 |
| X31C-2 | 100 | 0.0 | 25.0 | 51.0 | 61.0 | 61.0 | 59.8 | 68.5 | 71.6 | 42.8% | 57.2% | 0.0% | 27.85 | 45.63 | 8.16 |
| X31D-2 | 100 | 0.0 | 24.0 | 42.1 | 65.0 | 45.9 | 53.0 | 45.1 | 46.5 | 38.2% | 61.8% | 0.0% | 37.38 | 41.93 | 4.05 |
| X31D-3 | 90 | 0.0 | 1.0 | 1.0 | 8.0 | 8.0 | 5.9 | 9.4 | 8.7 | 52.9% | 47.1% | 0.0% | 37.38 | 41.93 | 0.71 |
| **Upper Sab** | **771** | **0.0** | **222.5** | **316.6** | **377.9** | **365.6** | **392.1** | **419.1** | **453.1** | **70.9%** | **29.1%** | **0.0%** | | | **51.77** |
| X31E-1 | 98 | 0.0 | 46.0 | 48.0 | 59.0 | 59.0 | 61.3 | 69.6 | 73.2 | 69.4% | 30.6% | 0.0% | 25.91 | 41.84 | 7.92 |
| X31E-2 | 80 | 0.0 | 14.0 | 29.0 | 33.0 | 38.0 | 46.1 | 51.6 | 55.5 | 33.8% | 66.2% | 0.0% | 25.91 | 41.84 | 6.17 |
| X31E-3 | 36 | | 0.0 | 1.0 | 6.0 | 16.0 | 6.6 | 8.6 | 7.4 | 32.6% | 67.4% | 0.0% | 25.91 | 41.84 | 0.53 |
| X31F-1 | 93 | 0.0 | 46.0 | 51.0 | 51.0 | 51.0 | 62.3 | 67.6 | 74.3 | 51.5% | 48.5% | 0.0% | 22.17 | 33.45 | 7.75 |
| X31G-1 | 116 | 0.0 | 21.9 | 28.7 | 44.4 | 49.8 | 42.3 | 52.4 | 53.4 | 23.7% | 76.3% | 0.0% | 22.17 | 51.95 | 4.57 |
| X31G-2 | 10 | 0.0 | 2.2 | 2.9 | 4.4 | 5.0 | 2.6 | 3.2 | 3.1 | 29.7% | 70.3% | 0.0% | 22.17 | 51.95 | 0.30 |
| X31G-3 | 42 | 0.0 | 0.0 | 0.0 | 16.2 | 18.2 | 1.5 | 1.8 | 2.3 | 25.5% | 74.5% | 0.0% | 35.60 | 51.95 | 0.17 |
| **Marite** | **474** | **0.0** | **130.1** | **160.5** | **214.0** | **237.0** | **222.8** | **254.8** | **269.2** | **46.2%** | **53.8%** | **0.0%** | | | **27.41** |
| X31H-1 | 45 | 0.0 | 30.0 | 35.0 | 35.0 | 35.0 | 36.8 | 40.1 | 42.0 | 54.7% | 45.3% | 0.0% | 27.11 | 33.20 | 4.37 |
| X31H-2 | 16 | 0.0 | 6.0 | 6.0 | 6.0 | 9.2 | 5.9 | 7.3 | 7.0 | 25.3% | 74.7% | 0.0% | 27.11 | 33.20 | 0.47 |
| X31J-1 | 154 | 0.0 | 1.0 | 15.0 | 20.0 | 20.0 | 18.4 | 22.9 | 25.0 | 35.5% | 64.5% | 0.0% | 35.71 | 29.14 | 1.80 |
| **White W** | **215** | **0.0** | **37.0** | **56.0** | **61.0** | **64.2** | **61.1** | **70.3** | **74.0** | **45.4%** | **54.6%** | **0.0%** | | | **6.64** |
| X31K-1 | 80 | | | | | | | 0.0 | 0.4 | 33.3% | 66.7% | 0.0% | 39.13 | 47.17 | 0.00 |
| X31K-2 | 100 | | | | | | | | 0.0 | 0.0% | 0.0% | 0.0% | 39.13 | 47.17 | 0.00 |
| X31K-3 | 51 | | | | | | | | 0.0 | 0.0% | 0.0% | 0.0% | 39.13 | 47.17 | 0.00 |
| X31K-4 | 260 | | | | | | | | 0.0 | 0.0% | 0.0% | 0.0% | 39.13 | 47.17 | 0.00 |
| X31L-1 | 67 | | | | | 0.0 | 0.1 | 0.5 | 0.6 | 79.7% | 20.3% | 0.0% | 33.92 | 33.75 | 0.01 |
| X31L-2 | 70 | | | | | | | | 0.0 | 62.2% | 37.8% | 0.0% | 33.92 | 33.75 | 0.00 |
| X31L-3 | 158 | | | | | | | | 0.0 | 0.0% | 0.0% | 0.0% | 33.92 | 33.75 | 0.00 |
| **X31 all** | **1500** | **0.0** | **0.0** | **0.0** | **0.0** | **0.0** | **0.1** | **0.5** | **1.0** | **62.7%** | **37.3%** | **0.0%** | | | **0.01** |
| X32A-1 | 38 | 0.0 | 18.0 | 18.0 | 28.0 | 28.0 | 3.0 | 6.5 | 5.6 | 77.7% | 22.3% | 0.0% | 21.29 | 16.72 | 0.47 |
| X32A-2 | 72 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 4.4 | 6.3 | 8.1 | 78.2% | 21.8% | 0.0% | 21.29 | 16.72 | 0.44 |
| X32B-1 | 54 | 0.0 | 5.0 | 5.0 | 8.0 | 8.0 | 4.0 | 6.8 | 8.7 | 68.5% | 31.5% | 0.0% | 29.95 | 34.71 | 0.56 |
| X32C-1 | 16 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.8 | 1.1 | 67.0% | 33.0% | 0.0% | 29.84 | 41.86 | 0.03 |
| X32C-2 | 13 | | | | | | | | 0.0 | 100.0% | 0.0% | 0.0% | 29.84 | 41.86 | 0.00 |
| X32D-1 | 62 | 0.0 | 15.0 | 23.0 | 29.0 | 29.0 | 11.3 | 20.6 | 16.8 | 72.4% | 27.6% | 0.0% | 20.97 | 23.00 | 1.52 |
| X32D-2 | 36 | | | | | 0.0 | 0.0 | 0.0 | 0.1 | 20.9% | 79.1% | 0.0% | 20.97 | 23.00 | 0.00 |
| X32E-1 | 28 | 0.0 | 0.0 | 0.4 | 3.9 | 3.9 | 9.2 | 12.0 | 15.2 | 84.6% | 15.4% | 0.0% | 23.37 | 18.41 | 0.87 |
| X32E-2 | 51 | 0.0 | 0.0 | 0.6 | 7.1 | 7.1 | 0.0 | 0.1 | 0.3 | 17.5% | 82.5% | 0.0% | 23.37 | 18.41 | 0.00 |
| X32F-1 | 65 | | | | | | | | 0.0 | 0.0% | 0.0% | 0.0% | 35.36 | 67.52 | 0.00 |
| **X32 all** | **1907** | **0.0** | **38.0** | **47.0** | **76.0** | **76.0** | **32.3** | **53.1** | **55.9** | **76.0%** | **24.0%** | **0.0%** | | | **3.89** |
| **X33 all** | **1448** | | | | | | | | **0.0** | | | | | | **0.00** |
| **Total** | **6315** | **0.0** | **427.6** | **580.2** | **728.9** | **742.8** | **708.4** | **797.8** | **853.2** | **61.2%** | **38.8%** | **0.0%** | | | **89.72** |

**0.00 – No forestry or forestry less than 0.5km² or less then 1% of catchment area**

VS – Verification study (DWAF, 2006)

SRC – Sabie River catchment Study (DWAF, 1990)

# Appendix G

## Inter-basin transfers records

**Table G-1 Transfers from Nooitgedacht Dam (million $m^3$ / month) to strategic users (Power Stations) in the Olifants WMA**

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1961** | 0.08 | 0.10 | 0.08 | 0.21 | 0.19 | 0.30 | 0.33 | 0.41 | 0.44 | 0.41 | 0.40 | 0.46 | **3.40** |
| **1962** | 0.40 | 0.24 | 0.25 | 0.28 | 0.31 | 0.30 | 0.22 | 0.34 | 0.47 | 0.60 | 0.54 | 0.63 | **4.57** |
| **1963** | 0.48 | 0.58 | 0.60 | 0.62 | 0.70 | 0.72 | 0.89 | 0.71 | 0.90 | 0.63 | 0.45 | 0.94 | **8.22** |
| **1964** | 1.02 | 1.18 | 0.99 | 1.18 | 1.15 | 1.49 | 1.42 | 1.51 | 1.30 | 1.52 | 1.60 | 1.39 | **15.76** |
| **1965** | 1.49 | 1.45 | 1.50 | 1.52 | 1.29 | 1.62 | 1.58 | 1.53 | 1.62 | 1.83 | 1.90 | 1.87 | **19.19** |
| **1966** | 2.12 | 1.89 | 1.90 | 1.79 | 1.57 | 1.84 | 1.73 | 1.74 | 1.64 | 1.85 | 1.68 | 1.77 | **21.52** |
| **1967** | 1.94 | 1.88 | 2.04 | 1.85 | 1.55 | 1.60 | 1.47 | 1.61 | 1.54 | 1.95 | 1.79 | 1.79 | **21.01** |
| **1968** | 2.01 | 2.11 | 2.14 | 2.21 | 1.73 | 1.97 | 1.84 | 1.98 | 2.07 | 2.21 | 1.96 | 1.74 | **23.96** |
| **1969** | 1.91 | 1.85 | 1.88 | 2.11 | 1.83 | 2.34 | 2.05 | 2.10 | 2.57 | 2.22 | 2.64 | 2.40 | **25.90** |
| **1970** | 2.81 | 2.57 | 2.78 | 1.99 | 1.98 | 2.50 | 2.26 | 2.19 | 2.22 | 2.91 | 3.00 | 3.38 | **30.60** |
| **1971** | 3.95 | 3.33 | 3.10 | 3.11 | 2.97 | 2.95 | 3.14 | 3.02 | 3.15 | 3.94 | 4.10 | 3.79 | **40.56** |
| **1972** | 4.15 | 3.29 | 2.92 | 3.13 | 1.73 | 1.41 | 0.00 | 0.73 | 0.04 | 1.27 | 2.49 | 3.04 | **24.19** |
| **1973** | 1.43 | 3.49 | 5.23 | 5.42 | 5.14 | 5.49 | 5.28 | 5.11 | 4.96 | 5.79 | 6.46 | 6.92 | **60.73** |
| **1974** | 3.99 | 5.59 | 4.30 | 7.45 | 6.38 | 7.44 | 5.25 | 6.25 | 5.87 | 6.32 | 6.85 | 6.41 | **72.08** |
| **1975** | 2.71 | 3.44 | 4.44 | 6.03 | 6.27 | 6.66 | 6.03 | 6.56 | 6.23 | 7.02 | 7.08 | 7.26 | **69.72** |
| **1976** | 7.02 | 6.29 | 7.00 | 5.98 | 2.60 | 2.92 | 1.85 | 2.13 | 2.16 | 1.58 | 2.28 | 6.34 | **48.15** |
| **1977** | 4.06 | 8.86 | 1.34 | 2.88 | 11.09 | 10.08 | 2.40 | 10.17 | 4.92 | 4.13 | 2.73 | 1.86 | **64.51** |
| **1978** | 2.79 | 4.42 | 2.56 | 2.79 | 3.46 | 3.72 | 1.08 | 0.96 | 0.59 | 1.15 | 1.02 | 1.49 | **26.02** |
| **1979** | 1.62 | 1.03 | 2.09 | 2.47 | 1.86 | 2.91 | 2.76 | 3.59 | 2.04 | 1.97 | 1.26 | 1.89 | **25.47** |
| **1980** | 3.24 | 2.87 | 3.51 | 3.90 | 1.99 | 7.47 | 8.29 | 4.14 | 2.83 | 2.81 | 3.28 | 1.55 | **45.86** |
| **1981** | 5.14 | 4.08 | 5.00 | 6.36 | 3.91 | 3.48 | 4.04 | 4.65 | 4.71 | 4.47 | 1.74 | 1.99 | **49.56** |
| **1982** | 0.40 | 0.67 | 0.57 | 0.44 | 1.03 | 2.61 | 2.30 | 2.05 | 0.83 | 0.09 | 0.11 | 0.44 | **11.52** |
| **1983** | 0.66 | 1.25 | 3.50 | 8.80 | 9.10 | 5.73 | 5.57 | 3.26 | 4.17 | 3.61 | 2.86 | 1.76 | **50.28** |
| **1984** | 2.47 | 2.42 | 2.23 | 4.81 | 3.09 | 3.23 | 3.53 | 3.79 | 3.54 | 1.45 | 2.87 | 2.76 | **36.19** |
| **1985** | 3.06 | 3.25 | 1.77 | 3.22 | 2.95 | 2.95 | 2.82 | 3.14 | 3.16 | 2.89 | 2.32 | 1.63 | **33.14** |
| **1986** | 1.10 | 0.59 | 1.15 | 2.24 | 2.39 | 2.95 | 3.58 | 3.65 | 3.56 | 1.83 | 2.02 | 2.29 | **27.36** |
| **1987** | 1.99 | 8.06 | 10.10 | 10.81 | 4.71 | 2.70 | 2.18 | 2.01 | 1.77 | 2.36 | 3.90 | 2.62 | **53.21** |
| **1988** | 2.78 | 2.37 | 2.68 | 2.78 | 3.06 | 2.30 | 2.10 | 2.03 | 1.89 | 1.85 | 1.85 | 2.44 | **28.14** |
| **1989** | 2.53 | 1.60 | 6.84 | 9.77 | 8.93 | 10.32 | 6.63 | 1.22 | 1.10 | 1.68 | 1.32 | 2.39 | **54.33** |
| **1990** | 3.00 | 4.12 | 3.64 | 4.06 | 7.59 | 7.95 | 9.77 | 4.21 | 2.36 | 2.20 | 2.73 | 1.28 | **52.91** |
| **1991** | 3.68 | 2.80 | 1.66 | 1.21 | 0.92 | 0.37 | 0.23 | 0.41 | 2.60 | 1.67 | 2.98 | 1.52 | **20.05** |
| **1992** | 3.35 | 2.76 | 6.80 | 5.33 | 2.80 | 1.18 | 0.61 | 0.63 | 0.34 | 0.49 | 0.42 | 0.40 | **25.12** |
| **1993** | 0.78 | 1.05 | 1.09 | 1.24 | 6.83 | 0.96 | 0.77 | 0.87 | 0.95 | 1.90 | 1.38 | 2.20 | **20.03** |
| **1994** | 4.12 | 2.62 | 1.26 | 1.24 | 0.82 | 0.97 | 0.58 | 1.76 | 0.65 | 0.64 | 0.69 | 0.73 | **16.08** |
| **1995** | 0.43 | 0.17 | 0.93 | 5.26 | 5.77 | 6.32 | 6.64 | 8.00 | 7.77 | 7.86 | 6.58 | 4.11 | **59.85** |
| **1996** | 3.04 | 1.61 | 4.55 | 6.69 | 5.15 | 1.33 | 0.88 | 1.87 | 2.66 | 1.48 | 1.35 | 2.47 | **33.06** |
| **1997** | 1.42 | 4.43 | 6.38 | 4.08 | 1.73 | 2.47 | 2.52 | 2.71 | 3.00 | 1.67 | 1.53 | 1.39 | **33.33** |
| **1998** | 1.59 | 1.40 | 5.08 | 7.12 | 6.80 | 8.70 | 4.87 | 2.86 | 2.05 | 2.33 | 2.71 | 2.53 | **48.02** |
| **1999** | 3.68 | 9.02 | 5.77 | 5.31 | 8.64 | 7.82 | 6.17 | 10.50 | 11.04 | 11.19 | 9.26 | 8.42 | **96.82** |
| **2000** | 4.12 | 6.52 | 8.33 | 9.27 | 8.67 | 2.75 | 1.85 | 5.06 | 5.59 | 5.79 | 5.81 | 7.51 | **71.27** |
| **2001** | 6.79 | 6.06 | 1.35 | 1.99 | 2.13 | 2.81 | 4.13 | 2.45 | 2.97 | 2.44 | 2.16 | 2.13 | **37.41** |
| **2002** | 2.85 | 2.85 | 2.79 | 2.72 | 2.50 | 3.29 | 3.29 | 3.35 | 2.79 | 2.87 | 3.00 | 3.23 | **35.53** |
| **2003** | 3.34 | 2.45 | 3.47 | 3.12 | 1.81 | 1.46 | 2.44 | 2.96 | 3.05 | 2.56 | 0.00 | 0.00 | **26.67** |
| **2004** | **0.00** | **0.00** | **0.00** | **1.91** | **2.37** | **3.30** | **3.33** | **2.40** | **2.74** | **2.29** | **3.07** | **6.67** | **28.08** |
| **Average** | **2.59** | **2.99** | **3.20** | **3.83** | **3.65** | **3.50** | **2.96** | **3.03** | **2.79** | **2.73** | **2.63** | **2.63** | **36.54** |
| **Min** | **0.08** | **0.10** | **0.08** | **0.21** | **0.19** | **0.30** | **0.00** | **0.34** | **0.04** | **0.09** | **0.00** | **0.00** | **3.40** |
| **Max** | **7.02** | **9.02** | **10.10** | **10.81** | **11.09** | **10.32** | **9.77** | **10.50** | **11.04** | **11.19** | **9.26** | **8.42** | **96.82** |

**Data sources:**

DWAF: Hydrological monitoring site; X1R001 dam balance

Data patched

**Table G-2 Transfers from Gemsbokhoek (million $m^3$ / month) to strategic users (Power Stations) in the Olifants WMA**

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1972 | 0.00 | 0.00 | 0.00 | 0.00 | 0.34 | 0.00 | 0.00 | 0.00 | 0.00 | 0.52 | 0.00 | 0.00 | **0.86** |
| 1973 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **0.04** |
| 1974 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.10 | 0.91 | **1.01** |
| 1975 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.01 | 0.00 | 0.00 | 0.01 | 0.01 | 0.02 | **0.07** |
| 1976 | 0.00 | 0.01 | 0.02 | 0.00 | 0.29 | 1.71 | 1.32 | 1.79 | 1.62 | 0.99 | 0.16 | 0.07 | **7.98** |
| 1977 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.52 | 1.43 | 0.01 | 0.01 | 0.02 | 0.01 | **2.03** |
| 1978 | 0.01 | 0.00 | 0.02 | 0.01 | 0.32 | 0.30 | 0.58 | 0.33 | 0.41 | 0.68 | 0.58 | 0.29 | **3.53** |
| 1979 | 0.23 | 0.13 | 0.16 | 0.03 | 1.24 | 1.77 | 0.72 | 0.78 | 1.48 | 1.42 | 0.85 | 0.02 | **8.83** |
| 1980 | 0.02 | 0.01 | 0.00 | 0.00 | 0.05 | 0.01 | 0.00 | 0.93 | 0.86 | 1.40 | 1.31 | 1.09 | **5.68** |
| 1981 | 0.00 | 0.17 | 0.25 | 0.00 | 0.74 | 0.88 | 0.49 | 0.40 | 0.00 | 0.86 | 1.24 | 0.31 | **5.34** |
| 1982 | 0.06 | 0.79 | 0.00 | 0.00 | 0.32 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **1.17** |
| 1983 | 0.21 | 0.24 | 0.00 | 0.00 | 0.00 | 1.58 | 0.16 | 0.22 | 1.75 | 2.26 | 2.08 | 1.14 | **9.64** |
| 1984 | 0.05 | 0.04 | 0.15 | 0.16 | 0.15 | 0.29 | 0.27 | 0.20 | 0.13 | 0.16 | 0.35 | 0.06 | **2.01** |
| 1985 | 0.13 | 0.10 | 0.40 | 0.43 | 0.40 | 0.75 | 0.70 | 0.53 | 0.35 | 0.43 | 0.91 | 0.15 | **5.28** |
| 1986 | 0.06 | 0.04 | 0.18 | 0.19 | 0.18 | 0.33 | 0.31 | 0.23 | 0.15 | 0.19 | 0.40 | 0.07 | **2.33** |
| 1987 | 0.43 | 0.31 | 1.31 | 1.40 | 1.31 | 2.46 | 2.29 | 1.74 | 1.13 | 1.40 | 2.96 | 0.50 | **17.24** |
| 1988 | 0.37 | 0.27 | 1.14 | 1.22 | 1.14 | 2.14 | 2.00 | 1.52 | 0.99 | 1.22 | 2.58 | 0.43 | **15.02** |
| 1989 | 0.12 | 0.09 | 0.36 | 0.39 | 0.36 | 0.68 | 0.63 | 0.48 | 0.31 | 0.39 | 0.82 | 0.14 | **4.77** |
| 1990 | 0.16 | 0.12 | 0.49 | 0.53 | 0.49 | 0.93 | 0.87 | 0.66 | 0.43 | 0.53 | 1.12 | 2.12 | **8.45** |
| 1991 | 0.96 | 0.12 | 1.72 | 1.18 | 0.67 | 0.13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **4.78** |
| 1992 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.44 | 1.53 | 0.78 | 0.55 | 0.29 | 0.25 | 0.15 | **4.99** |
| 1993 | 0.02 | 0.46 | 0.35 | 0.91 | 0.00 | 1.56 | 1.04 | 1.27 | 1.03 | 1.09 | 5.96 | 0.53 | **14.22** |
| 1994 | 0.02 | 0.09 | 1.05 | 1.27 | 2.27 | 2.39 | 2.71 | 1.77 | 0.76 | 1.48 | 0.52 | 0.27 | **14.60** |
| 1995 | 0.85 | 0.85 | 2.14 | 0.15 | 0.20 | 0.37 | 0.31 | 0.29 | 0.23 | 0.29 | 0.42 | 0.16 | **6.26** |
| 1996 | 0.05 | 0.06 | 0.15 | 0.45 | 0.61 | 1.16 | 0.95 | 0.88 | 0.70 | 0.90 | 1.32 | 0.49 | **7.72** |
| 1997 | 0.17 | 0.18 | 0.45 | 0.54 | 0.70 | 1.40 | 1.15 | 1.10 | 0.83 | 1.10 | 1.60 | 0.58 | **9.80** |
| 1998 | 0.20 | 0.21 | 0.53 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.85 | 0.92 | 0.67 | 0.56 | **3.94** |
| 1999 | 0.42 | 0.47 | 0.02 | 0.13 | 0.18 | 0.30 | 0.27 | 0.25 | 0.21 | 0.26 | 0.32 | 0.14 | **2.97** |
| 2000 | 0.98 | 0.00 | 0.00 | 0.00 | 0.07 | 1.54 | 1.67 | 1.17 | 1.02 | 1.15 | 1.00 | 0.00 | **8.60** |
| 2001 | 0.65 | 1.26 | 2.67 | 1.80 | 2.15 | 2.51 | 0.83 | 0.95 | 0.89 | 1.03 | 0.92 | 0.11 | **15.77** |
| 2002 | 0.03 | 0.09 | 1.59 | 1.25 | 0.14 | 0.06 | 0.05 | 0.01 | 0.01 | 0.00 | 0.01 | 0.02 | **3.26** |
| 2003 | 0.03 | 0.01 | 0.03 | 0.07 | 0.12 | 0.16 | 0.72 | 0.04 | 0.01 | 0.01 | 0.02 | 0.03 | **1.25** |
| **2004** | **0.04** | **0.05** | **0.07** | **0.14** | **0.17** | **0.32** | **0.26** | **0.24** | **0.20** | **0.25** | **0.34** | **0.12** | **2.20** |
| **Average** | **0.19** | **0.19** | **0.46** | **0.37** | **0.44** | **0.82** | **0.68** | **0.61** | **0.51** | **0.64** | **0.87** | **0.32** | **6.11** |
| **Min** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.04** |
| **Max** | **0.98** | **1.26** | **2.67** | **1.80** | **2.27** | **2.51** | **2.71** | **1.79** | **1.75** | **2.26** | **5.96** | **2.12** | **17.24** |

**Data sources:**

DWAF: Hydrological monitoring site X1H035

Data patched

Eskom data; A van der Merwe; Aug 2006

**Table G-3 Transfers from Vygeboom Dam (million $m^3$ / month) to strategic users (Power Stations) in the Olifants WMA**

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1972 | 0.00 | 0.31 | 0.65 | 0.71 | 1.27 | 2.29 | 3.46 | 3.93 | 3.87 | 2.88 | 2.50 | 1.45 | **23.32** |
| 1973 | 2.98 | 1.73 | 0.00 | 0.00 | 0.03 | 0.15 | 0.00 | 0.00 | 0.00 | 0.00 | 0.06 | 0.59 | **5.54** |
| 1974 | 3.70 | 1.94 | 2.35 | 0.00 | 0.01 | 0.01 | 0.00 | 0.01 | 0.03 | 0.05 | 0.01 | 0.21 | **8.32** |
| 1975 | 3.33 | 3.31 | 1.69 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.04 | 0.00 | 0.00 | 0.01 | **8.39** |
| 1976 | 0.14 | 0.47 | 0.12 | 1.12 | 3.80 | 3.05 | 2.33 | 2.88 | 2.89 | 4.61 | 5.26 | 5.04 | **31.71** |
| 1977 | 3.50 | 5.12 | 5.29 | 4.47 | 3.92 | 4.49 | 3.35 | 3.33 | 4.87 | 2.42 | 4.75 | 4.58 | **50.09** |
| 1978 | 4.21 | 2.26 | 4.11 | 4.48 | 2.70 | 4.30 | 5.56 | 5.64 | 6.15 | 5.58 | 5.74 | 5.54 | **56.27** |
| 1979 | 5.34 | 6.30 | 5.16 | 4.24 | 4.30 | 3.13 | 2.79 | 2.85 | 3.07 | 3.72 | 4.66 | 5.54 | **51.10** |
| 1980 | 5.28 | 4.78 | 4.52 | 4.46 | 4.95 | 0.93 | 0.25 | 3.88 | 4.66 | 5.49 | 5.10 | 5.88 | **50.18** |
| 1981 | 4.08 | 4.18 | 3.68 | 3.44 | 3.87 | 4.20 | 3.85 | 4.05 | 4.40 | 3.60 | 4.02 | 4.70 | **48.07** |
| 1982 | 6.57 | 5.44 | 6.70 | 6.72 | 5.55 | 6.87 | 5.82 | 5.43 | 4.18 | 4.03 | 4.51 | 4.61 | **66.43** |
| 1983 | 5.63 | 4.36 | 2.29 | 0.00 | 0.19 | 2.82 | 2.43 | 4.41 | 3.12 | 3.27 | 5.01 | 5.61 | **39.14** |
| 1984 | 5.57 | 6.39 | 7.03 | 4.74 | 4.70 | 3.17 | 3.58 | 3.99 | 4.05 | 6.18 | 6.15 | 6.38 | **61.93** |
| 1985 | 3.81 | 4.53 | 5.82 | 4.09 | 3.44 | 5.04 | 5.19 | 5.92 | 6.10 | 6.67 | 6.79 | 6.38 | **63.78** |
| 1986 | 6.71 | 6.06 | 5.43 | 6.51 | 5.06 | 6.74 | 6.10 | 6.52 | 5.42 | 5.21 | 5.75 | 5.55 | **71.06** |
| 1987 | 4.50 | 1.46 | 0.00 | 0.00 | 3.94 | 5.11 | 5.55 | 4.22 | 4.81 | 4.29 | 3.77 | 4.73 | **42.38** |
| 1988 | 4.91 | 4.56 | 3.43 | 5.43 | 4.76 | 5.16 | 4.38 | 5.26 | 5.01 | 4.60 | 5.36 | 5.45 | **58.31** |
| 1989 | 6.00 | 4.39 | 1.50 | 0.00 | 0.00 | 2.33 | 4.88 | 2.61 | 2.11 | 1.59 | 3.06 | 4.43 | **32.90** |
| 1990 | 5.08 | 4.49 | 4.30 | 3.07 | 0.08 | 0.00 | 0.00 | 5.46 | 3.55 | 4.71 | 3.60 | 3.85 | **38.19** |
| 1991 | 4.14 | 4.62 | 4.56 | 5.48 | 5.10 | 6.58 | 6.58 | 7.10 | 4.45 | 4.66 | 5.06 | 5.59 | **63.92** |
| 1992 | 4.16 | 4.55 | 0.32 | 2.59 | 1.25 | 1.89 | 3.11 | 4.21 | 5.62 | 6.27 | 6.81 | 6.18 | **46.96** |
| 1993 | 5.52 | 4.82 | 5.54 | 4.72 | 0.76 | 5.69 | 4.87 | 4.97 | 5.92 | 5.30 | 5.47 | 5.13 | **58.71** |
| 1994 | 3.54 | 4.82 | 5.69 | 4.72 | 3.67 | 4.66 | 4.49 | 3.78 | 5.73 | 5.11 | 2.60 | 4.27 | **53.08** |
| 1995 | 5.22 | 6.85 | 4.73 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.31 | 5.51 | 3.46 | **26.08** |
| 1996 | 6.55 | 5.48 | 1.54 | 1.54 | 2.89 | 6.23 | 5.45 | 5.14 | 4.44 | 5.91 | 6.31 | 5.79 | **57.27** |
| 1997 | 5.29 | 2.81 | 0.47 | 3.37 | 4.46 | 5.84 | 5.07 | 5.77 | 5.63 | 6.27 | 6.33 | 5.97 | **57.28** |
| 1998 | 5.45 | 5.74 | 1.94 | 0.35 | 0.80 | 0.66 | 3.65 | 4.94 | 5.73 | 5.90 | 6.12 | 6.01 | **47.29** |
| 1999 | 4.82 | 0.61 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **5.43** |
| 2000 | 0.00 | 2.12 | 0.00 | 0.00 | 0.73 | 5.77 | 5.18 | 3.02 | 2.71 | 2.69 | 2.92 | 1.41 | **26.55** |
| 2001 | 2.96 | 1.68 | 4.67 | 6.25 | 4.41 | 4.76 | 4.73 | 6.48 | 6.46 | 6.47 | 6.75 | 7.09 | **62.71** |
| 2002 | 7.47 | 7.00 | 5.26 | 6.46 | 6.47 | 6.93 | 6.63 | 6.96 | 6.70 | 7.29 | 7.29 | 6.96 | **81.42** |
| 2003 | 7.20 | 6.26 | 6.85 | 6.89 | 6.53 | 6.88 | 6.18 | 7.09 | 6.41 | 7.46 | 7.07 | 6.92 | **81.74** |
| **2004** | **6.99** | **6.59** | **6.68** | **6.23** | **5.52** | **6.05** | **5.93** | **6.22** | **5.56** | **5.93** | **6.20** | **6.55** | **74.45** |
| **Average** | **4.49** | **4.12** | **3.40** | **3.09** | **2.88** | **3.69** | **3.68** | **4.12** | **4.05** | **4.20** | **4.56** | **4.60** | **46.97** |
| **Min** | **0.00** | **0.31** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **5.43** |
| **Max** | **7.47** | **7.00** | **7.03** | **6.89** | **6.53** | **6.93** | **6.63** | **7.10** | **6.70** | **7.46** | **7.29** | **7.09** | **81.74** |

**Data sources:**

DWAF: Hydrological monitoring site; X1R003 dam balance

**Table G-4 Transfers from Komati River (million $m^3$ / month) at Mhlume weir in Swaziland to irrigators and domestic users in the Mbuluzi (W60) catchments**

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1981 | 7.84 | 9.52 | 10.25 | 10.39 | 14.22 | 15.07 | 10.14 | 8.76 | 6.40 | 5.99 | 6.40 | 6.82 | **111.80** |
| 1982 | 8.62 | 8.31 | 6.35 | 11.05 | 7.51 | 7.21 | 6.29 | 4.78 | 4.83 | 3.88 | 2.18 | 3.17 | **74.18** |
| 1983 | 3.69 | 9.46 | 13.37 | 15.92 | 7.54 | 13.55 | 8.78 | 9.87 | 5.51 | 1.05 | 6.93 | 4.69 | **100.37** |
| 1984 | 10.03 | 4.72 | 13.17 | 18.20 | 10.15 | 14.89 | 11.92 | 7.08 | 4.63 | 6.16 | 11.42 | 11.71 | **124.08** |
| 1985 | 12.36 | 11.54 | 17.32 | 12.08 | 11.49 | 12.65 | 13.26 | 8.29 | 11.41 | 9.01 | 8.74 | 7.40 | **135.54** |
| 1986 | 11.57 | 8.37 | 12.32 | 18.59 | 18.79 | 17.79 | 12.88 | 14.36 | 9.42 | 7.32 | 8.41 | 9.06 | **148.90** |
| 1987 | 2.39 | 14.69 | 11.58 | 19.78 | 17.05 | 14.77 | 14.08 | 11.03 | 8.24 | 5.20 | 9.18 | 5.75 | **133.73** |
| 1988 | 4.19 | 13.70 | 10.89 | 14.29 | 10.56 | 14.32 | 14.75 | 11.21 | 3.24 | 7.28 | 9.58 | 9.95 | **123.97** |
| 1989 | 10.48 | 10.52 | 7.47 | 13.82 | 9.78 | 18.98 | 12.26 | 10.60 | 11.05 | 8.55 | 10.72 | 9.69 | **133.93** |
| 1990 | 9.96 | 11.29 | 14.50 | 12.53 | 9.14 | 13.51 | 16.24 | 8.02 | 4.67 | 7.27 | 11.01 | 11.40 | **129.56** |
| 1991 | 11.96 | 14.35 | 12.75 | 16.46 | 13.55 | 11.95 | 8.84 | 5.82 | 5.90 | 6.09 | 6.17 | 4.98 | **118.82** |
| 1992 | 7.98 | 8.40 | 12.28 | 12.27 | 14.67 | 19.58 | 15.50 | 11.46 | 7.63 | 7.72 | 8.01 | 5.94 | **131.43** |
| 1993 | 11.63 | 9.81 | 14.26 | 14.86 | 16.99 | 18.13 | 14.66 | 9.41 | 7.06 | 6.99 | 6.60 | 4.72 | **135.10** |
| 1994 | 7.60 | 13.64 | 12.33 | 15.00 | 15.19 | 9.08 | 11.39 | 12.64 | 7.44 | 5.93 | 5.31 | 4.69 | **120.25** |
| 1995 | 4.98 | 10.66 | 17.65 | 18.54 | 11.30 | 12.23 | 13.11 | 11.45 | 5.23 | 9.46 | 9.73 | 12.29 | **136.62** |
| 1996 | 8.99 | 9.37 | 10.56 | 11.55 | 13.21 | 13.02 | 12.87 | 10.56 | 2.53 | 12.14 | 9.90 | 7.46 | **122.18** |
| 1997 | 8.40 | 10.25 | 5.58 | 10.37 | 12.60 | 13.41 | 15.33 | 6.63 | 9.40 | 10.62 | 8.99 | 8.53 | **120.10** |
| 1998 | 3.87 | 5.03 | 1.22 | 8.52 | 4.68 | 11.53 | 14.18 | 9.74 | 7.20 | 9.67 | 9.39 | 10.27 | **95.30** |
| 1999 | 8.73 | 12.64 | 6.01 | 4.87 | 3.84 | 0.64 | 0.62 | 0.64 | 0.62 | 0.64 | 0.64 | 0.62 | **40.52** |
| 2000 | 0.64 | 0.62 | 0.64 | 8.52 | 4.68 | 11.46 | 14.18 | 9.74 | 7.20 | 9.67 | 9.39 | 10.27 | **87.02** |
| 2001 | 8.73 | 2.07 | 10.25 | 18.98 | 13.13 | 20.48 | 18.19 | 16.16 | 8.30 | 11.31 | 11.07 | 10.57 | **149.23** |
| 2002 | 11.99 | 12.58 | 15.07 | 18.56 | 18.60 | 15.94 | 11.44 | 8.94 | 3.41 | 8.07 | 7.64 | 4.73 | **136.98** |
| 2003 | 3.66 | 0.00 | 0.00 | 10.72 | 13.17 | 16.15 | 14.07 | 9.80 | 8.08 | 7.19 | 7.26 | 7.31 | **97.43** |
| **2004** | **4.47** | **7.24** | **15.58** | **15.11** | **13.83** | **17.84** | **14.75** | **10.82** | **3.52** | **7.01** | **5.80** | **5.83** | **121.80** |
| **Average:** | **7.70** | **9.12** | **10.48** | **13.79** | **11.90** | **13.93** | **12.49** | **9.49** | **6.37** | **7.26** | **7.94** | **7.41** | **117.87** |
| **Min** | **0.64** | **0.00** | **0.00** | **4.87** | **3.84** | **0.64** | **0.62** | **0.64** | **0.62** | **0.64** | **0.64** | **0.62** | **40.52** |
| **Max** | **12.36** | **14.69** | **17.65** | **19.78** | **18.79** | **20.48** | **18.19** | **16.16** | **11.41** | **12.14** | **11.42** | **12.29** | **149.23** |

**Data sources:**

Hydrological monitoring site; GS26

P Scott of Mhlume Water; 2006

Data patched

**Table G-5 Transfers from Usutu WMA (Jericho Dam) via Camden p/s (UK Link) to the upper Boesmanspruit (million m$^3$ / month) to augment inflows to Nooitgedacht Dam**

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1992 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.80 | 1.44 | 2.01 | 4.14 | 4.36 | 4.21 | **17.96** |
| 1993 | 1.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **1.05** |
| 1994 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **0.00** |
| 1995 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **0.00** |
| 1996 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **0.00** |
| 1997 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **0.00** |
| 1998 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **0.00** |
| 1999 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **0.00** |
| 2000 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **0.00** |
| 2001 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **0.00** |
| 2002 | 0.00 | 0.00 | 1.11 | 0.00 | 0.00 | 0.00 | 0.00 | 1.27 | 4.11 | 4.10 | 11.33 | 3.22 | **25.14** |
| 2003 | 3.23 | 2.60 | 3.61 | 4.12 | 4.30 | 1.61 | 2.50 | 3.43 | 1.64 | 5.37 | 2.83 | 1.54 | **36.79** |
| **2004** | **0.73** | **1.04** | **1.11** | **4.32** | **1.89** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **9.08** |
| **Average:** | **0.39** | **0.28** | **0.45** | **0.65** | **0.48** | **0.12** | **0.33** | **0.47** | **0.60** | **1.05** | **1.42** | **0.69** | **6.92** |
| **Min** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** |
| **Max** | **3.23** | **2.60** | **3.61** | **4.32** | **4.30** | **1.61** | **2.50** | **3.43** | **4.11** | **5.37** | **11.33** | **4.21** | **36.79** |

VRSAU report
Eskom data; A van der Merwe; Aug 2006

**Table G-6 Returns of excess water Arnot Power Station (million $m^3$ / month) in the Olifants WMA to Nooitgedacht Dam**

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1974 | 0.00 | 0.01 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **0.02** |
| 1975 | 0.01 | 0.02 | 0.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **0.12** |
| 1976 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.08 | 0.10 | 0.15 | 0.14 | 0.46 | 0.36 | 0.58 | **1.89** |
| 1977 | 0.40 | 0.42 | 0.20 | 0.19 | 0.25 | 0.52 | 0.15 | 0.14 | 0.03 | 0.07 | 0.07 | 0.09 | **2.52** |
| 1978 | 0.10 | 0.12 | 0.15 | 0.08 | 0.04 | 0.26 | 0.45 | 0.87 | 1.34 | 1.01 | 0.88 | 0.77 | **6.06** |
| 1979 | 0.82 | 0.95 | 0.53 | 0.77 | 0.69 | 0.26 | 0.01 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | **4.08** |
| 1980 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.12 | 0.01 | 0.05 | 0.10 | **0.30** |
| 1981 | 0.09 | 0.07 | 0.07 | 0.05 | 0.00 | 0.04 | 0.00 | 0.00 | 0.18 | 0.03 | 0.22 | 0.23 | **0.98** |
| 1982 | 0.89 | 0.88 | 0.83 | 0.86 | 0.31 | 0.03 | 0.06 | 0.04 | 0.75 | 1.36 | 1.25 | 0.13 | **7.40** |
| 1983 | 0.19 | 0.18 | 0.36 | 0.00 | 0.00 | 0.02 | 0.02 | 0.03 | 0.00 | 0.14 | 0.08 | 0.21 | **1.23** |
| 1984 | 0.05 | 0.00 | 0.06 | 0.00 | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 | 0.56 | 0.02 | 0.07 | **0.80** |
| 1985 | 0.00 | 0.00 | 0.06 | 0.05 | 0.00 | 0.15 | 0.03 | 0.01 | 0.07 | 0.03 | 0.14 | 0.18 | **0.71** |
| 1986 | 0.54 | 0.40 | 0.56 | 0.13 | 0.02 | 0.03 | 0.07 | 0.00 | 0.14 | 0.31 | 0.24 | 0.07 | **2.50** |
| 1987 | 0.07 | 0.00 | 0.00 | 0.00 | 0.05 | 0.09 | 0.17 | 0.29 | 0.00 | 0.00 | 0.00 | 0.01 | **0.67** |
| 1988 | 0.00 | 0.00 | 0.06 | 0.09 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **0.20** |
| 1989 | 0.18 | 0.15 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **0.33** |
| 1990 | 0.00 | 0.01 | 0.16 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **0.22** |
| 1991 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | **0.04** |
| 1992 | 0.00 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.91 | 0.80 | **1.75** |
| 1993 | 0.30 | 0.25 | 0.11 | 0.18 | 0.02 | 0.63 | 0.71 | 0.40 | 0.60 | 0.40 | 0.79 | 0.10 | **4.48** |
| 1994 | 0.01 | 0.14 | 0.77 | 0.27 | 0.43 | 0.70 | 1.80 | 1.17 | 1.40 | 0.56 | 0.89 | 0.34 | **8.47** |
| 1995 | 0.13 | 0.29 | 0.43 | 0.00 | 0.19 | 0.01 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | **1.06** |
| 1996 | 1.72 | 0.34 | 0.32 | 0.00 | 0.01 | 0.71 | 0.59 | 0.34 | 0.19 | 0.29 | 0.04 | 0.45 | **4.99** |
| 1997 | 0.47 | 0.33 | 0.00 | 0.51 | 0.37 | 1.15 | 0.11 | 1.08 | 0.03 | 0.74 | 0.55 | 0.42 | **5.74** |
| 1998 | 0.71 | 0.71 | 0.23 | 0.00 | 0.00 | 0.36 | 1.32 | 1.66 | 0.92 | 0.76 | 0.76 | 0.54 | **7.96** |
| 1999 | 1.79 | 1.93 | 1.09 | 0.88 | 1.14 | 0.65 | 0.61 | 1.70 | 2.11 | 2.02 | 1.42 | 1.76 | **17.10** |
| 2000 | 1.63 | 0.62 | 0.21 | 1.43 | 0.00 | 0.39 | 0.47 | 0.35 | 0.00 | 0.02 | 0.01 | 0.00 | **5.11** |
| 2001 | 0.00 | 0.00 | 1.03 | 0.64 | 0.62 | 0.12 | 0.06 | 0.43 | 0.21 | 0.27 | 0.18 | 0.22 | **3.77** |
| 2002 | 0.96 | 0.31 | 0.26 | 0.75 | 0.79 | 0.77 | 0.54 | 0.02 | 0.10 | 0.01 | 0.00 | 0.12 | **4.62** |
| 2003 | 0.06 | 0.38 | 0.20 | 0.25 | 0.60 | 1.28 | 0.53 | 0.36 | 0.10 | 0.18 | 0.11 | 0.00 | **4.05** |
| **2004** | **0.00** | **0.00** | **0.05** | **0.24** | **0.03** | **0.01** | **0.30** | **0.04** | **0.01** | **0.02** | **0.01** | **0.00** | **0.71** |
| **Average** | **0.36** | **0.28** | **0.25** | **0.24** | **0.18** | **0.27** | **0.26** | **0.30** | **0.27** | **0.30** | **0.29** | **0.23** | 3.22 |
| **Minimum** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | 0.02 |
| **Maximum** | **1.79** | **1.93** | **1.09** | **1.43** | **1.14** | **1.28** | **1.80** | **1.70** | **2.11** | **2.02** | **1.42** | **1.76** | 17.10 |

**Data sources:**

DWAF: Hydrological monitoring site; X1H038 (part of X1R001 dam balance)

Data patched

Data missing

**Table G-7 Transfers from Shiyalongubu Dam (million $m^3$ / month) in the Upper Lomati (X14) to Louws Creek in the Kaap (X23) for the Louws Creek IB**

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1939 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1940 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1941 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1942 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1943 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1944 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1945 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1946 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1947 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1948 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1949 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1950 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1951 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1952 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1953 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1954 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1955 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1956 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1957 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1958 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1959 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1960 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1961 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1962 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1963 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1964 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1965 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1966 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1967 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1968 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1969 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1970 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1971 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1972 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1973 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1974 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1975 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1976 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1977 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1978 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1979 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1980 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1981 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1982 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1983 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1984 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1985 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1986 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1987 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1988 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1989 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1990 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1991 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1992 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1993 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1994 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1995 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1996 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1997 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1998 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 1999 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 2000 | 0.22 | 0.35 | 0.44 | 0.44 | 0.44 | 0.35 | 0.35 | 0.35 | 0.22 | 0.22 | 0.22 | 0.22 | **3.82** |
| 2001 | 0.40 | 0.32 | 0.28 | 0.23 | 0.46 | 0.58 | 0.56 | 0.48 | 0.42 | 0.58 | 0.58 | 0.46 | **5.33** |
| 2002 | 0.58 | 0.42 | 0.54 | 0.51 | 0.52 | 0.57 | 0.41 | 0.17 | 0.13 | 0.12 | 0.10 | 0.11 | **4.17** |
| 2003 | 0.10 | 0.09 | 0.12 | 0.14 | 0.13 | 0.58 | 0.43 | 0.40 | 0.16 | 0.26 | 0.27 | 0.41 | **3.09** |
| **2004** | **0.50** | **0.40** | **0.22** | **0.21** | **0.31** | **0.27** | **0.64** | **0.58** | **0.37** | **0.37** | **0.33** | **0.41** | **4.61** |
| **Average** | **0.23** | **0.35** | **0.43** | **0.43** | **0.43** | **0.36** | **0.36** | **0.35** | **0.22** | **0.23** | **0.23** | **0.23** | **3.85** |
| **Minimum** | **0.10** | **0.09** | **0.12** | **0.14** | **0.13** | **0.27** | **0.35** | **0.17** | **0.13** | **0.12** | **0.10** | **0.11** | **3.09** |
| **Maximum** | **0.58** | **0.42** | **0.54** | **0.51** | **0.52** | **0.58** | **0.64** | **0.58** | **0.42** | **0.58** | **0.58** | **0.46** | **5.33** |

**Data sources:**
Hydrology of the Crocodile River (DWAF, 1985)
Water Bailiff for Louws Creek IB

## Table G-8 Diversions from Gladdespruit (million $m^3$ / month) to Vygeboom Dam

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1973 | 5.83 | 5.23 | 7.26 | 8.55 | 1.14 | 0.00 | 0.00 | 1.20 | 4.84 | 4.40 | 3.50 | 2.94 | **44.89** |
| 1974 | 2.76 | 1.32 | 2.66 | 3.68 | 4.94 | 5.09 | 4.77 | 4.10 | 3.03 | 1.92 | 2.10 | 1.77 | **38.14** |
| 1975 | 1.90 | 2.20 | 3.51 | 5.34 | 2.67 | 4.82 | 4.83 | 5.36 | 4.90 | 4.37 | 3.49 | 3.13 | **46.52** |
| 1976 | 2.90 | 3.02 | 3.28 | 2.84 | 4.38 | 4.57 | 4.03 | 3.09 | 2.57 | 2.17 | 1.86 | 2.00 | **36.71** |
| 1977 | 2.33 | 2.88 | 3.47 | 4.70 | 3.80 | 5.10 | 5.56 | 4.25 | 3.33 | 3.18 | 2.43 | 2.12 | **43.15** |
| 1978 | 2.33 | 2.63 | 2.94 | 2.90 | 3.26 | 3.32 | 2.45 | 1.84 | 1.60 | 1.64 | 1.71 | 1.60 | **28.22** |
| 1979 | 1.64 | 2.63 | 3.23 | 3.59 | 3.74 | 3.55 | 3.31 | 2.65 | 2.21 | 2.07 | 1.93 | 1.74 | **32.29** |
| 1980 | 1.55 | 2.55 | 3.85 | 3.84 | 3.49 | 3.70 | 4.40 | 3.70 | 2.92 | 2.69 | 2.38 | 2.54 | **37.61** |
| 1981 | 2.25 | 3.05 | 4.00 | 7.17 | 4.34 | 3.75 | 2.98 | 2.30 | 1.87 | 1.77 | 1.58 | 1.35 | **36.41** |
| 1982 | 1.60 | 1.81 | 1.80 | 2.86 | 1.61 | 1.57 | 1.56 | 1.45 | 1.81 | 1.51 | 1.18 | 0.99 | **19.75** |
| 1983 | 1.00 | 3.10 | 3.45 | 4.40 | 3.10 | 3.90 | 4.71 | 2.95 | 2.19 | 2.48 | 1.85 | 1.74 | **34.87** |
| 1984 | 2.21 | 2.95 | 4.42 | 4.00 | 6.28 | 5.10 | 2.80 | 2.26 | 1.90 | 1.67 | 1.50 | 1.40 | **36.49** |
| 1985 | 2.30 | 3.00 | 4.50 | 6.54 | 6.83 | 4.91 | 3.61 | 2.50 | 2.19 | 1.86 | 1.60 | 1.31 | **41.15** |
| 1986 | 1.50 | 1.50 | 2.60 | 4.46 | 3.15 | 3.64 | 1.90 | 1.87 | 1.49 | 1.30 | 1.36 | 1.70 | **26.47** |
| 1987 | 4.13 | 3.59 | 1.74 | 1.70 | 1.54 | 2.33 | 2.62 | 1.90 | 1.65 | 1.58 | 1.25 | 1.40 | **25.43** |
| 1988 | 0.59 | 1.17 | 2.47 | 3.39 | 3.25 | 3.57 | 2.84 | 2.22 | 2.20 | 1.59 | 1.33 | 1.02 | **25.64** |
| 1989 | 1.62 | 3.70 | 4.50 | 3.45 | 3.65 | 4.50 | 2.72 | 2.10 | 1.40 | 1.25 | 1.20 | 0.88 | **30.97** |
| 1990 | 1.30 | 1.41 | 3.44 | 4.56 | 4.46 | 2.60 | 2.30 | 2.29 | 1.79 | 1.54 | 1.27 | 1.13 | **28.09** |
| 1991 | 1.06 | 1.61 | 1.77 | 2.23 | 1.58 | 0.85 | 0.63 | 0.44 | 0.44 | 0.40 | 0.49 | 0.27 | **11.77** |
| 1992 | 0.33 | 0.43 | 0.73 | 0.21 | 1.52 | 3.45 | 1.04 | 0.73 | 0.48 | 0.44 | 0.39 | 0.12 | **9.87** |
| 1993 | 0.77 | 0.64 | 1.48 | 0.54 | 0.82 | 0.40 | 0.85 | 0.44 | 0.40 | 0.40 | 0.50 | 0.35 | **7.59** |
| 1994 | 0.84 | 1.29 | 1.72 | 2.93 | 1.81 | 1.62 | 2.08 | 1.99 | 1.05 | 0.79 | 0.54 | 0.34 | **17.00** |
| 1995 | 0.38 | 0.84 | 1.76 | 4.20 | 4.20 | 4.01 | 2.15 | 1.85 | 1.68 | 1.77 | 1.62 | 1.12 | **25.58** |
| 1996 | 0.56 | 1.58 | 1.90 | 2.80 | 1.19 | 3.19 | 3.37 | 1.89 | 1.93 | 1.46 | 1.26 | 0.42 | **21.55** |
| 1997 | 1.88 | 2.19 | 2.25 | 2.55 | 2.37 | 2.79 | 1.70 | 1.19 | 0.70 | 0.52 | 0.80 | 0.88 | **19.82** |
| 1998 | 1.37 | 1.93 | 2.90 | 2.85 | 2.33 | 1.39 | 0.79 | 0.61 | 0.60 | 0.93 | 0.93 | 0.71 | **17.34** |
| 1999 | 0.31 | 0.79 | 2.91 | 5.62 | 4.08 | 5.64 | 6.02 | 4.37 | 2.74 | 2.30 | 1.62 | 1.38 | **37.78** |
| 2000 | 0.25 | 2.77 | 4.20 | 2.52 | 2.28 | 2.47 | 1.86 | 1.81 | 1.29 | 1.07 | 1.09 | 1.02 | **22.63** |
| 2001 | 1.46 | 3.99 | 4.48 | 2.99 | 2.82 | 2.72 | 1.87 | 1.18 | 1.06 | 1.05 | 1.08 | 1.15 | **25.85** |
| 2002 | 1.45 | 1.62 | 2.58 | 3.23 | 2.05 | 1.34 | 1.12 | 1.00 | 1.02 | 0.97 | 0.84 | 0.50 | **17.72** |
| 2003 | 0.63 | 0.83 | 0.88 | 2.57 | 2.93 | 4.42 | 3.68 | 1.90 | 1.33 | 1.25 | 1.04 | 0.81 | **22.27** |
| **2004** | **0.73** | **2.13** | **2.77** | **4.74** | **2.58** | **2.65** | **2.58** | **1.86** | **1.35** | **1.15** | **0.95** | **0.68** | **24.17** |
| **Average** | **1.62** | **2.20** | **2.98** | **3.69** | **3.07** | **3.22** | **2.72** | **2.17** | **1.87** | **1.67** | **1.46** | **1.27** | **27.93** |
| **Minimum** | **0.25** | **0.43** | **0.73** | **0.21** | **0.82** | **0.00** | **0.00** | **0.44** | **0.40** | **0.40** | **0.39** | **0.12** | **7.59** |
| **Maximum** | **5.83** | **5.23** | **7.26** | **8.55** | **6.83** | **5.64** | **6.02** | **5.36** | **4.90** | **4.40** | **3.50** | **3.13** | **46.52** |

**Data sources:**
DWAF: Hydrological monitoring site; X1H019 and X1H027
VRSAU study (DWAF, 1997)

**Table G-9 Diversions from Popanyane River (million $m^3$ / month) to Gladdespruit to augment inflows to Vygeboom Dam**

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1974 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.13 | 0.30 | 0.29 | **0.76** |
| 1975 | 0.41 | 0.50 | 0.57 | 0.52 | 0.78 | 0.56 | 0.55 | 0.75 | 0.53 | 0.48 | 0.43 | 0.26 | **6.34** |
| 1976 | 0.51 | 0.92 | 0.63 | 0.54 | 0.59 | 0.36 | 0.41 | 0.26 | 0.22 | 0.21 | 0.18 | 0.11 | **4.94** |
| 1977 | 0.20 | 0.35 | 0.39 | 1.09 | 1.06 | 1.07 | 0.47 | 0.36 | 0.31 | 0.28 | 0.30 | 0.35 | **6.23** |
| 1978 | 0.68 | 0.69 | 0.48 | 0.32 | 0.37 | 0.26 | 0.22 | 0.17 | 0.15 | 0.17 | 0.22 | 0.22 | **3.95** |
| 1979 | 0.56 | 1.09 | 0.88 | 1.15 | 0.94 | 0.89 | 0.42 | 0.30 | 0.37 | 0.39 | 0.43 | 0.31 | **7.73** |
| 1980 | 0.47 | 1.09 | 1.25 | 0.75 | 0.77 | 0.74 | 0.40 | 0.34 | 0.23 | 0.23 | 0.19 | 0.25 | **6.71** |
| 1981 | 0.25 | 0.46 | 0.62 | 1.11 | 0.38 | 0.31 | 0.27 | 0.22 | 0.16 | 0.19 | 0.17 | 0.15 | **4.29** |
| 1982 | 0.17 | 0.27 | 0.20 | 0.20 | 0.10 | 0.17 | 0.27 | 0.18 | 0.14 | 0.15 | 0.15 | 0.14 | **2.14** |
| 1983 | 0.10 | 0.61 | 0.82 | 1.01 | 1.09 | 0.89 | 0.27 | 0.19 | 0.18 | 0.27 | 0.19 | 0.18 | **5.80** |
| 1984 | 0.40 | 0.40 | 0.31 | 0.26 | 0.69 | 0.47 | 0.14 | 0.09 | 0.21 | 0.18 | 0.14 | 0.16 | **3.45** |
| 1985 | 0.24 | 0.26 | 0.26 | 0.24 | 0.34 | 0.36 | 0.57 | 0.18 | 0.17 | 0.15 | 0.14 | 0.13 | **3.04** |
| 1986 | 0.14 | 0.13 | 0.40 | 0.37 | 0.19 | 0.41 | 0.34 | 0.18 | 0.14 | 0.13 | 0.17 | 0.34 | **2.94** |
| 1987 | 0.75 | 0.52 | 0.66 | 0.33 | 0.28 | 0.40 | 0.23 | 0.16 | 0.12 | 0.17 | 0.16 | 0.19 | **3.97** |
| 1988 | 0.60 | 0.23 | 0.48 | 0.37 | 0.66 | 0.67 | 0.28 | 0.27 | 0.34 | 0.26 | 0.22 | 0.15 | **4.53** |
| 1989 | 0.25 | 0.63 | 0.84 | 0.39 | 0.31 | 0.28 | 0.20 | 0.19 | 0.19 | 0.09 | 0.15 | 0.12 | **3.64** |
| 1990 | 0.17 | 0.23 | 0.52 | 0.90 | 0.59 | 0.58 | 0.33 | 0.28 | 0.24 | 0.23 | 0.19 | 0.18 | **4.44** |
| 1991 | 0.13 | 0.20 | 0.14 | 0.16 | 0.19 | 0.19 | 0.11 | 0.07 | 0.10 | 0.11 | 0.12 | 0.11 | **1.63** |
| 1992 | 0.13 | 0.20 | 0.62 | 0.32 | 0.61 | 0.34 | 0.13 | 0.39 | 0.29 | 0.30 | 0.37 | 0.25 | **3.95** |
| 1993 | 0.28 | 0.32 | 0.36 | 0.08 | 0.23 | 0.23 | 0.11 | 0.08 | 0.07 | 0.06 | 0.09 | 0.07 | **1.98** |
| 1994 | 0.07 | 0.15 | 0.12 | 0.00 | 0.00 | 0.06 | 0.14 | 0.15 | 0.08 | 0.07 | 0.08 | 0.05 | **0.97** |
| 1995 | 0.07 | 0.13 | 0.40 | 0.36 | 0.54 | 0.90 | 0.75 | 0.75 | 0.51 | 0.41 | 0.29 | 0.19 | **5.30** |
| 1996 | 0.33 | 0.19 | 0.43 | 0.35 | 0.53 | 0.79 | 0.62 | 0.83 | 0.92 | 0.88 | 0.68 | 0.38 | **6.93** |
| 1997 | 0.90 | 0.75 | 0.72 | 0.80 | 0.68 | 0.61 | 0.49 | 0.34 | 0.02 | 0.04 | 0.14 | 0.13 | **5.62** |
| 1998 | 0.17 | 0.14 | 0.15 | 0.08 | 0.07 | 0.06 | 0.10 | 0.10 | 0.09 | 0.02 | 0.01 | 0.01 | **1.00** |
| 1999 | 0.01 | 0.01 | 0.41 | 0.95 | 1.36 | 1.19 | 0.97 | 0.71 | 0.45 | 0.31 | 0.00 | 0.00 | **6.37** |
| 2000 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.12 | **0.12** |
| 2001 | 0.25 | 0.77 | 0.64 | 0.23 | 0.44 | 0.21 | 0.13 | 0.06 | 0.05 | 0.06 | 0.11 | 0.23 | **3.18** |
| 2002 | 0.28 | 0.21 | 0.30 | 0.36 | 0.23 | 0.16 | 0.21 | 0.17 | 0.19 | 0.18 | 0.16 | 0.12 | **2.57** |
| 2003 | 0.14 | 0.21 | 0.16 | 0.41 | 0.28 | 0.32 | 0.36 | 0.17 | 0.15 | 0.17 | 0.16 | 0.13 | **2.66** |
| **2004** | **0.10** | **0.19** | **0.18** | **0.17** | **0.18** | **0.20** | **0.17** | **0.12** | **0.10** | **0.10** | **0.10** | **0.08** | **1.69** |
| **Average** | **0.28** | **0.39** | **0.46** | **0.46** | **0.48** | **0.45** | **0.32** | **0.26** | **0.22** | **0.21** | **0.20** | **0.18** | **3.91** |
| **Minimum** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.12** |
| **Maximum** | **0.90** | **1.09** | **1.25** | **1.15** | **1.36** | **1.19** | **0.97** | **0.83** | **0.92** | **0.88** | **0.68** | **0.38** | **7.73** |

**Data sources:**
DWAF: Hydrological monitoring sites; X1H020 and X1H029
VRSAU study (DWAF, 1997)

**Table G-10 Diversions from Kruisfonteinspruit (million m$^3$ / month) in the upper Sand to Blinkwaterspruit in the Upper White River for irrigators**

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1981 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.12 | 0.11 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | **0.27** |
| 1982 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **0.00** |
| 1983 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.20 | 0.08 | 0.01 | 0.08 | 0.00 | 0.04 | **0.42** |
| 1984 | 0.00 | 0.14 | 0.19 | 0.24 | 0.72 | 0.68 | 0.13 | 0.11 | 0.07 | 0.02 | 0.00 | 0.00 | **2.31** |
| 1985 | 0.00 | 0.01 | 0.20 | 0.40 | 0.55 | 0.25 | 0.38 | 0.31 | 0.11 | 0.02 | 0.00 | 0.00 | **2.23** |
| 1986 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **0.00** |
| 1987 | 0.00 | 0.00 | 0.00 | 0.00 | 0.12 | 0.73 | 0.48 | 0.20 | 0.01 | 0.12 | 0.08 | 0.10 | **1.83** |
| 1988 | 0.26 | 0.30 | 0.57 | 0.48 | 0.60 | 0.85 | 0.45 | 0.29 | 0.28 | 0.21 | 0.10 | 0.09 | **4.49** |
| 1989 | 0.03 | 0.28 | 0.48 | 0.60 | 0.63 | 0.66 | 0.68 | 0.48 | 0.29 | 0.19 | 0.16 | 0.11 | **4.57** |
| 1990 | 0.13 | 0.11 | 0.33 | 0.66 | 0.67 | 0.66 | 0.51 | 0.33 | 0.23 | 0.14 | 0.09 | 0.07 | **3.93** |
| 1991 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **0.03** |
| 1992 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **0.00** |
| 1993 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **0.00** |
| 1994 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **0.00** |
| 1995 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **0.01** |
| 1996 | 0.00 | 0.00 | 0.07 | 0.50 | 0.56 | 0.70 | 0.72 | 0.59 | 0.33 | 0.27 | 0.21 | 0.27 | **4.23** |
| 1997 | 0.28 | 0.31 | 0.46 | 0.78 | 0.72 | 0.71 | 0.46 | 0.25 | 0.15 | 0.12 | 0.09 | 0.06 | **4.37** |
| 1998 | 0.27 | 0.34 | 0.73 | 0.74 | 0.83 | 0.76 | 0.49 | 0.40 | 0.25 | 0.19 | 0.14 | 0.09 | **5.24** |
| 1999 | 0.07 | 0.14 | 0.33 | 0.81 | 0.90 | 0.95 | 0.91 | 0.81 | 0.62 | 0.43 | 0.27 | 0.24 | **6.47** |
| 2000 | 0.21 | 0.36 | 0.60 | 0.58 | 0.57 | 0.80 | 0.79 | 0.57 | 0.35 | 0.30 | 0.21 | 0.14 | **5.47** |
| 2001 | 0.18 | 0.64 | 0.82 | 0.67 | 0.66 | 0.66 | 0.67 | 0.42 | 0.32 | 0.18 | 0.15 | 0.09 | **5.46** |
| 2002 | 0.12 | 0.22 | 0.15 | 0.17 | 0.09 | 0.07 | 0.04 | 0.04 | 0.03 | 0.03 | 0.03 | 0.03 | **1.02** |
| 2003 | 0.03 | 0.05 | 0.05 | 0.05 | 0.05 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **0.24** |
| **2004** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.01** |
| **Average** | **0.07** | **0.12** | **0.21** | **0.28** | **0.32** | **0.36** | **0.29** | **0.20** | **0.13** | **0.10** | **0.06** | **0.06** | **2.19** |
| **Min** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** |
| **Max** | **0.28** | **0.64** | **0.82** | **0.81** | **0.90** | **0.95** | **0.91** | **0.81** | **0.62** | **0.43** | **0.27** | **0.27** | **6.47** |

**Data sources:**
DWAF: Hydrological monitoring site; X2H064
Data missing / incomplete

**Table G-11 Transfers from the Sabie canal (million $m^3$ / month) in the Sabie River to the Nsikazi North WSS in the Upper Nsikazi catchments**

| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1997 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | **6.48** |
| 1998 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | **6.48** |
| 1999 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | **6.48** |
| 2000 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | **6.48** |
| 2001 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | **6.48** |
| 2002 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | **6.48** |
| 2003 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | **6.48** |
| **2004** | **0.54** | **0.54** | **0.54** | **0.54** | **0.54** | **0.54** | **0.54** | **0.54** | **0.54** | **0.54** | **0.54** | **0.54** | **6.48** |
| **Average** | **0.54** | **0.54** | **0.54** | **0.54** | **0.54** | **0.54** | **0.54** | **0.54** | **0.54** | **0.54** | **0.54** | **0.54** | **6.48** |
| **Min** | **0.54** | **0.54** | **0.54** | **0.54** | **0.54** | **0.54** | **0.54** | **0.54** | **0.54** | **0.54** | **0.54** | **0.54** | **6.48** |
| **Max** | **0.54** | **0.54** | **0.54** | **0.54** | **0.54** | **0.54** | **0.54** | **0.54** | **0.54** | **0.54** | **0.54** | **0.54** | **6.48** |

DEPARTMENT OF WATER AFFAIRS & FORESTRY

# INKOMATI WATER AVAILABILITY ASSESSMENT

## WATER REQUIREMENTS

## Assessment of Alien Vegetation

**Volume 2**

Report No. PWMA 05/X22/00/0908

June 2009

Water for Africa
Environmental, Engineering & Management Consultants (Pty) Ltd
Reg. No. 2005/001583/07

CPH2O

SRK Consulting
Engineers and Scientists

| | |
|---|---|
| **PROJECT NAME:** | INKOMATI WATER AVAILABILITY ASSESSMENT |
| **REPORT TITLE:** | Water Requirements: Volume 2: Assessment of Alien vegetation |
| **AUTHORS:** | S Hardy |
| | BB Wolff-Piggott |
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Submitted by Water for Africa in association with SRK and $CPH_2O$

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**SJL Mallory** (Date)

Project Leader

**DEPARTMENT OF WATER AFFAIRS AND FORESTRY**

Directorate of Water resource Planning Systems

Approved for Department of Water Affairs and Forestry by:

22/10/2009

N J van Wyk (Date)

Chief Engineer: Water Resource Planning (East)

09/10/2009

J A van Rooyen (Date)

Director: Water Resource Planning

# SCHEDULE OF REPORTS

| | | |
|---|---|---|
| | PWMA 05/X22/00/0808 | Main Report |
| This Report ☞ | PWMA 05/X22/00/0908 | Water Requirements Volume 1<br>Water Requirements Volume 2: Assessment of Alien Vegetation |
| | PWMA 05/X22/00/1008 | Ecological Water Requirements |
| | PWMA 05/X22/00/1108 | Water Quality |
| | PWMA 05/X22/00/1208 | Infrastructure and Operating Rules Volume 1<br>Infrastructure and Operating Rules Volume 2: Appendices |
| | PWMA 05/X22/00/1308 | Rainfall Volume !: Report<br>Rainfall Volume 2: Appendices |
| | PWMA 05/X22/00/1408 | Hydrology of Komati River Volume 1<br>Hydrology of Komati River Volume 2: Appendices |
| | PWMA 05/X22/00/1508 | Hydrology of Crocodile River Volume 1<br>Hydrology of Crocodile River Volume 2 Appendices |
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# Annexure 1

**Condensed area cover in hectares per species per sub-quaternary.**

**1.1 Non-riparian**

**1.2 Riparian**

# Annexure 2

**Sub-quaternaries not visited or insufficiently sampled were assessed using other methods.**

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**Figure 1:**

**Maps showing the distribution and densities per species.**

**Non-riparian**

- ***Acacia mearnsii***
- ***Eucalyptus sp*.**
- ***Pinus sp.***
- ***Melia azaderach***
- ***Jacaranda mimosifolia***
- ***Chromolaena odorata***
- ***Lantana camara***
- ***Solanum mauritianum***

**Riparian**

- ***Acacia mearnsii***
- ***Eucalyptus sp*.**
- ***Pinus sp.***
- ***Melia azaderach***
- ***Jacaranda mimosifolia***
- ***Chromolaena odorata***
- ***Lantana camara***
- ***Solanum mauritianum***

**Figure 2:**

**Survey sites recording no alien plants**

**Sub-quaternaries in which Survey sites did not record alien plants**

- **Non-riparian**
- **Riparian**

# 1. Executive Summary:

An alien plant field survey was conducted over a period of two and a half months from December 2007 to mid February 2008 within the Inkomati catchment area.
A total of 204 sub-quaternaries were assessed, with an average of four sites per quaternary, differentiating between riparian and non riparian zones. Sample sites varied in size from 9 hectares (300 x 300 m), and sometimes larger, to a relatively smaller area of 0.25 hectares (50m x 50m). A total of 33 alien plants; including trees, shrubs and one grass were documented. All species noted were given a density value for each sub-quaternary. This value is measured in hectares per sub-quaternary and is expressed as a percentage within both the non-riparian and riparian zones of each sub-quaternary. The entire Inkomati catchment area under study has 11 tertiaries harbouring the 204 sub-quaternaries. The distribution and densities of alien plants within the Inkomati catchment area are described per quaternary.

# 2.0 Introduction

## 2.1 Objective:

To identify the current spatial distribution of alien vegetation in the Inkomati Water Availability study area, distinguishing the riparian and non-riparian zones within each of the sub-quaternaries. The alien plants are to be placed into the following categories required by the WRSM 2000 model:

- Tall tree
- Medium tree
- Tall shrub

## 2.2 Deliverables:

The deliverables are to be provided in the following form:

- Digital data in a shape file format, classified into tall trees, medium trees and tall shrubs. Each area must be classified as riparian or non-riparian. For each study catchment, the percentage and age of each of the three vegetation types must be estimated, as well as the percentage in the riparian zone.

## 2.3 Limitations and assumptions:

- Limited time and broad scale of study.
- Due to the extensive nature of the area to be assessed, it was not possible to survey the entire sub-quaternary. It was also not possible to survey within all land types within each sub-quaternary.
- Determining age of vegetation. Versveld *et al* (1998) state that no information on, or estimates of, the mean age of invading alien vegetation could be found

in the Summer rainfall region. Information gathered during their mapping and observations indicated that most invasions occur in riparian habitats and the trees are typically mature. They therefore decided that a mean age of 20 years is to be used for invading vegetation in the summer rainfall region.

# 3.0 Methodology

## 3.1 GIS support tool

A digital image (Spot 5 thematic map) of the entire Inkomati catchment provided the baseline from which the field operator could work from. Super-imposed over this layer, was a basic woody vegetative structural cover, sorted into various categories according to canopy density and height. This layer provided the boundary within which to select and sample sites. The total number of sub-quaternaries within the Inkomati catchment was reduced from 225 to 204, omitting those occurring in the Kruger National Park. In addition to the woody vegetative structural cover layer, a layer demarcating all riparian zones was used to guide sample site selection.

## 3.2 Field appraisal

The field work involved a rapid appraisal from the vehicle at appropriate points along the road. Where possible, a sample was taken over a broad area from a clear vantage point. In many cases, sites were sampled within the confines of a riparian zone, with views limited to 50 meters.

Alien plant species occurring were given the following biomass classes derived by Le Maitre *et al* (1996) ( in Versveld *et al* 1998):

- Tall tree (3)
- Medium tree (2)

- Tall shrub (1)

and allotted an estimate of the following densities, Versveld *et al* (1998);

**Table: 1 Density values used as a guideline for field survey**

| **Density class** | **Canopy cover** | **Mid-value** | **Canopy diameters apart** |
|---|---|---|---|
| Rare | <1% | 0.5% | >10 |
| Occasional | 1 – 5% | 2.5% | 3 – 10 + |
| Scattered | 6 – 25% | 15% | 1 – 3 |
| Medium | 26 – 75% | 50% | 0.3 – 1 |
| Dense | >75% | 87.5% | <0.1 |

## 3.3 Data sheet information:

On average 4 samples were taken per sub-quaternary; two within a riparian zone and two outside of the riparian zone. At each site the following additional information was recorded:

- Riparian or non-riparian
- Site number
- Latitude and longitude
- Altitude
- Broad classification of vegetation type; eg. Thicket, grassland, forest etc. and
- photographic record

## 3.4 Additional survey methods

### 3.4.1 Gaps (See annexure 2)

Sub-quaternaries not visited or insufficiently sampled were assessed in the following manner:

- Local knowledge. Data was provided by a few local individuals who had knowledge of the alien plant distribution in a few of the sub-quaternaries.

- Field worker knowledge. From observations made and information gathered during field work data gathered from surrounding areas were extrapolated into neighbouring sub-quaternaries.

### 3.4.2 GIS

- The GIS woody layer can be used to determine percentage cover for some of the sub-quaternaries with extensive areas of wattle and gum "jungles", such as tertiary X11.
- The woody vector layer was 'ground-truthed' during the field survey and assisted in determining the "jungles" on the satellite image.

# 4.0 Results

All 204 tertiaries were assessed. A small percentage (<5%) has only riparian or non riparian data. In many of the afforested areas all non-riparian zones are planted to commercial trees which resulted in a number of sub-quaternaries sampled by other means in the non- riparian zones (annexure 2). All sites sampled within forestry plantations were located in open areas between compartments and do not include any commercially planted areas.

## 4.1 Inflated densities

The majority of sites selected in the Highveld included wattle and/ or gum "jungles". "Jungles" were assigned a density level of 5 (or greater than 75%), This resulted in inflated field observation values when using the density level system (Table 1). In addition, there were a few sites within quaternary X13 where excessively high levels of *Acacia mearnsii* and *Chromolaena odorata* were recorded. Most of the sites surveyed ("jungles" in the Highveld not included) which were allocated value of 4 and 5 represented a small portion of the 300m by 300m sample site. Based on these high recordings, all density values of 5 (>75%) and 4 (26-75%) were scaled down to 3 (6 – 25%). This was done throughout the entire study area.

## 4.2 Alien plant species recorded

A total of 33 alien plant species were recorded. A few more were observed in the field but were not considered that important for this project because of their low frequency levels and perceived low impact on the water availability within a quaternary. See Annexure 1.

The following table represents the dominant 12 species selected according to their level of frequency and density levels within the Inkomati catchment:

**Table 2 Dominant alien species**

| Alien Plant species | Local name | Biomass class |
|---|---|---|
| *Acacia mearnsii* | Wattle | Tall tree (3) |
| *Pinus sp.* | Pine | Tall tree (3) |
| *Eucalyptus sp.* | Gum | Tall tree (3) |
| *Populus sp.* | Poplar | Tall tree (3) |
| *Melia azaderach* | Seringa | Medium tree (2) |
| *Jacaranda mimosifolia* | Jacaranda | Medium tree (2) |
| *Chromolaena odorata* | Triffid weed | Tall shrub (1) |
| *Lantana camara* | Lantana | Tall shrub (1) |
| *Solanum mauritianum* | Bugweed | Tall shrub (1) |
| *Datura sp.* | | Tall shrub (1) |
| *Ricinus communis* | Castor Oil plant | Tall shrub (1) |
| *Senna sp.* | | Tall shrub (1) |

## 4.3 Distribution and extent of alien plant invasions

In order to quantify the data collected (in percentages) and express it in terms of hectares per sub-quaternary, the following methodology was adopted based on a stream flow reduction model Le Maitre *et al* (1996) and Van Wilgen *et al* (1997) in Versveld *et al* (1998).

The canopy cover in areas with less than 100% had to be adjusted to equate to a canopy cover of 100%. This was done by reducing the size of the invaded area to its equivalent, had there been 100% cover. For example, an area of 100 ha with a 50% alien-invader cover, equates to an area of 50 ha with a 100% cover. The reduced area (50ha) is described as the 'condensed' area (Versveld *et al*, 1998).

**Example:**

Site 1 has four (4) alien plants with 3, 10, 10 and 15% cover respectively. The equivalent density classes are 2 (1 – 5%) and 3 (6 – 25%). The corresponding mid points are 2.5% and 15% cover and thus the equivalent areas are 2.5 and 15 ha if the cover for each species is "condensed" to 100%. The total condensed cover for all species in site 1 (2.5% + 15% + 15% + 15%) is equal to 47.5%. Using this value with other data in the same sub-quaternary an average cover percentage is determined. The average cover percentage is then multiplied by the total hectares in that particular sub-quaternary to determine the total hectare of alien plant cover in hectares.

Each of the 33 species is recorded in hectares per sub-quaternary. The sub-quaternaries, in turn, are represented per tertiary. There are 11 tertiaries within the entire Inkomati catchment. The results are dealt with per tertiary and detailed in a spreadsheet (Annexure I) and distribution maps (Figure 1).

## 4.4 Assessing the nature and extent of invasions

From the data collected and synthesized into "condensed" hectares (Annexure I) the following results are revealed per quaternary differentiated between the non-riparian and riparian zones.

### 4.4.1 Non-riparian

#### 4.4.1.1 Tertiary X11

The total condensed cover by alien vegetation in quaternary X11 is 62 755 ha, representing 17.8% of the catchment. More than half (63%) of the invaded area is occupied by *Acacia mearnsii* followed by *Eucalyptus* sp. (25.4%). The sub-quaternaries with the highest levels of invasion are X11A-1, X11B-2, X11C-1, X11D-1 and X11F-1, dominated by *Acacia mearnsii*. *Eucalyptus sp.* dominates sub-quaternary X11B-1.

#### 4.4.1.2 Tertiary X12

The total condensed cover by alien vegetation in quaternary X12 is 26 657 ha, representing 10.4% of the catchment. *Acacia mearnsii* is dominant, representing more than 65.7% of alien plant invaders. *Eucalyptus* sp. contributes towards 23.3% and *Pinus* sp. 7%. The sub-quaternaries with the highest levels of invasion are X12B-1 and X12E-1. These sub-quaternaries are dominated by *Acacia mearnsii*.

#### 4.4.1.3 Tertiary X13

The total condensed cover by alien vegetation in quaternary X13 is 31 579 ha, representing 8.7% of the catchment. Thirty four percent of the entire condensed area is invaded by *Lantana camara* followed by *Chromalaena odorata* (31%) and *Acacia mearnsii* (20.9%). The most densely populated sub-quaternaries include X13A-1 and X13C-1 (*Acacia mearnsii*), X13E-1 (mainly *Chromolaena odorata* and *Lantana camara*), X13G-2 (dominated by *Chromolaena odorata* and *Lantana camara*) and X13H-2 (mainly *Lantana camara*).

#### 4.4.1.4 Tertiary X14

The total condensed cover by alien vegetation in quaternary X14 is 17 679 ha, representing 12% of the catchment. *Chromolaena odorata* contributes towards the largest portion of all alien plants at 29.5%, followed by *Eucalyptus sp*. (21%) and *Pinus sp*. (16.1%). Other species include *Lantana camara* (11.2%), *Psidium* *guajava* (6%) and *Solanum mauritianum* (4.5%). The most densely populated sub-quaternaries include X14C-1 (mainly *Eucalyptus sp*. and *Pinus sp*.) and X14E-1 (mainly *Chromalaena odorata*).

#### 4.4.1.5 Tertiary X21

The total condensed cover by alien vegetation in quaternary X21 is 40 797 ha, representing 13.2% of the catchment. *Acacia mearnsii* contributes towards 50.8% of the invaded area, followed by *Eucalyptus sp*. (21%) and *Pinus sp*. (16.1%). The sub-quaternaries registering the highest levels of alien invasive plants include X21B-2, X21B-3, X21F-1 and X21G-2 all dominated by *Acacia mearnsii*. Sub-quaternary X21A-1 is dominated by *Acacia mearnsii* and *Eucalyptus sp*. and X21A-2 includes *Acacia mearnsii*, *Eucalyptus sp*. and *Pinus sp.*

#### 4.4.1.6 Tertiary X22

The total condensed cover by alien vegetation in quaternary X22 is 21 121 ha, representing 8.9% of the catchment. *Eucalyptus sp*. represents 25% of the total invaded area followed by *Pinus sp.* 23%, *Lantana camara*. 21% and *Solanum mauritianum* (20.2%). Sub-quaternary X22C-2 has the highest level of invasive plants (mainly *Eucalyptus sp*. and *Pinus sp*.) followed by X22E-3 dominated by *Lantana camara* and *Solanum mauritianum*.

#### 4.4.1.7 Tertiary X23

The total condensed cover by alien vegetation in quaternary X23 is 10 356 ha, representing 6.3% of the catchment. More than half (57%) of the invaded area is inhabited by *Lantana camara* followed by *Eucalyptus sp*. (24.5%). *Melia azaderach* and *Jacaranda mimosifolia* occur but at comparatively reduced levels of 7.6% and 4.8% respectively. The sub-quaternaries with the highest levels of alien plant percentages include X23F-2, dominated by *Lantana camara* and X23B-3 dominated by *Eucalyptus sp*.

#### 4.4.1.8 Tertiary X24

The total condensed cover by alien vegetation in quaternary X24 is 1 172 ha, representing 0.96% of the catchment. *Lantana camara* dominates the alien plant condensed area with 74%. *Chromolaena odorata* and *Eucalyptus sp*. each contribute 8% towards the alien plant condensed area. Sub-quaternary X24H-2 records the highest levels of alien plant invasion (mainly *Lantana camara*).

#### 4.4.1.9 Tertiary X31

The total condensed cover by alien vegetation in quaternary X31 is 20 985 ha, representing 9.8% of the catchment. *Pinus sp*. dominate with 41% followed by *Lantana camara* (22.5%), and Eucalyptus sp. (18.9%). *Solanum mauritianum* and *Rubus* sp. are represented at much lower levels of 8.2% and 5.9% respectively. The highest densities of alien plants occur in sub-quaternary X31G-1 (mainly *Lantana camara*, *Eucalyptus sp*. and *Pinus sp*.) and 31E-2 (*Eucalyptus sp., Solanum mauritianum* and *Rubus sp*).

#### 4.4.1.10 Tertiary X32

The total condensed cover by alien vegetation in quaternary X32 is 2 290 ha, representing 1.9% of the catchment. *Lantana camara* records the highest levels of 33.6% followed by *Solanum mauritianum* (31.8%) of the total condensed alien plant cover and *Rubus sp*. (18.8%). The most densely populated sub-quaternary is X32E-1 inhabiting the aforementioned three species.

#### 4.4.1.11 Sub-quaternary 40C-1

This is the only sub-quaternary represented in quaternary X40 in the Inkomati catchment area outside of the Kruger National park. The total area is 3 665 ha. No alien plants were recorded in the non-riparian sites surveyed.

## 4.4.2 Riparian

### 4.4.2.1 Tertiary X11

The total condensed cover for quaternary X11 is 14.6%. This is 3.2% less cover compared to the non-riparian area. Almost half (46.7%) of the condensed area is occupied by *Acacia mearnsii* followed by *Populus sp*. (39.4%). The highest density levels occur in sub-quaternary X11A-1, dominated by *Acacia mearnsii* followed by X11B-1 (mainly *Acacia mearnsii* and *Populus sp*.). *Acacia mearnsii* is also well represented in X11F-1.

### 4.4.2.2 Tertiary X12

The total condensed cover for quaternary X12 is 7.7%. This is 2.7% less cover compared to that of the non-riparian area. *Acacia mearnsii* dominates with 39%. *Lantana camara* follows with 20.4%, *Pinus sp*. (12.8%) and *Rubus sp*. (9.6%). The highest densities occur in sub-quaternaries 12B-1 (mainly *Acacia mearnsii* and *Pinus sp*), X12F-1 (*Acacia mearnsii*) and 12K-1 (mainly *Lantana camara*).

### 4.4.2.3 Tertiary X13

The total condensed cover for quaternary X13 is 13.4%. This is 4.7% more cover compared to that of the non-riparian area. *Chromolaena odorata* covers almost half (39.5%) of the area inhabited by alien plants. *Solanum mauritianum* follows with 15.1%, *Lantana camara* 10.1% and *Acacia mearnsii* has 7.4% cover. The sub-quaternary with the highest percentage cover is X13G-2 (dominated by *Chromolaena odorata*). X13C-1 follows closely and is dominated by *Acacia mearnsii*. X13K-1 also has a high population of alien plants dominated by *Chromolaena odorata* and *Melia azaderach*.

### 4.4.2.4 Tertiary X14

The total condensed cover for quaternary X14 is 16.1%. This represents a 4.1% additional cover compared to that of the non-riparian area. *Chromolaena odorata* dominates with 39.5% of the total alien cover. *Eucalyptus sp. Pinus sp*. and

*Solanum mauritianum* follow with 13.3%, 12.1% and 12.3% respectively. *Rubus sp.* represents 10.1% of the alien plant cover. The highest density levels occur in sub-quaternaries X14H-1 dominated by *Chromolaena odorata* followed by X14B-2 dominated by *Rubus sp*. and *Solanum mauritianum* and X14F-1 (mainly *Chromolaena odorata* and *Eucalyptus sp*.).

#### 4.4.2.5 Tertiary X21

The total condensed cover for quaternary X21 is 13.7%. This represents a 0.46% more cover than that of the non-riparian area. *Acacia mearnsii* represents almost half (46.8%) of the alien plant cover in this quaternary. *Solanum mauritianum* and *Rubus sp*. follow with 12.1% and 12.3% respectively. *Populus sp*. contributes towards 6.5% of the alien plant cover. Sub-quaternary X21F-2 has the highest density of aliens dominated largely by *Acacia mearnsii*. X21F-1 follows and is also dominated by Acacia mearnsii. X21K-2 records high levels of alien plants (mainly *Eucalyptus sp*. and *Melia azaderach*).

#### 4.4.2.6 Tertiary X22

The total condensed cover for quaternary X22 is 16.1%. This represents a 7.2% additional cover compared to that of the non-riparian area. *Eucalyptus sp*. and *Solanum mauritianum* record the highest readings of 26.8% each. This is closely followed by *Lantana camara* (21%). The highest levels of alien plant invasion occur in sub-quaternary X22C-3. *Lantana camara* and *Solanum mauritianum* dominate this sub-quaternary. X22F-2 follows and is also dominated by *Solanum mauritianum* and *Lantana camara*.

#### 4.4.2.7 Tertiary X23

The total condensed cover for quaternary X23 is 12%. This represents a 5.7% additional cover compared to that of the non-riparian area. *Melia azaderach* records the highest density levels (27.9%) of all alien plants in this quaternary. This is followed by *Eucalyptus sp*. (23.6%). *Lantana camara*, *Ricinus communis* and *Solanum mauritianum* record levels of 15.7%, 12.2% and 8% respectively. The sub-quaternary with the highest levels of alien plant invasion by a substantial margin is X23G-2 where *lantana camara*, *Ricinus communis* and *Melia azaderach* occur in similar densities. X23B-3 follows and is primarily invaded by *Eucalyptus sp*.

#### 4.4.2.8 Tertiary X24

The total condensed cover for quaternary X24 is 3.3%. This represents a 2.4% additional cover compared to that of the non-riparian area. *Lantana camara* shows the highest density (43.2%) with *Senna* sp. (18.3%) and *Chromolaena odorata* (11.6%) recording the next highest levels. Sub-quaternary X24A-2 has the highest levels of alien plant invasion dominated mainly by *Lantana camara.*

#### 4.4.2.9 Tertiary X31

The total condensed cover for quaternary X31 is 6.5%. This represents a 3.3% less cover compared to that of the non-riparian area. Almost half (49.5%) of the condensed area is occupied by *Eucalyptus sp*. *Pinus sp*. has a condensed cover of 24% and *Solanum mauritianum* 8%. *Lantana camara* (5.8%) and *Rubus sp*. (4.6%) occur in smaller quantities. Sub-quaternary X31D-2 has the highest density of alien plants dominated mainly by *Eucalyptus sp*. and *Pinus sp*. X31J-1 is the next highest with *Eucalyptus sp*. dominating.

#### 4.4.2.10 Tertiary X32

The total condensed cover for quaternary X32 is 8.9%. This represents a 7.1% additional cover compared to that of the non-riparian area. *Datura* sp. has a condensed cover of more than half (51.8%) of the alien plant cover in this quaternary. *Ricinus communis* follows with 23.9%. *Lantana camara* (10.4%) and *Eucalyptus* sp. (5.6%) record significant levels. Sub-quaternary X32G-2 has the highest level of alien plant cover dominated by *Datura* sp. and *Ricinus communis*. X32H-2 follows and again *Datura* sp. is the dominant specie.

#### 4.4.2.11 Sub-quaternary X40C-1

The total condensed cover for sub-quaternary X40C-1 is 0.5%. This represents a 0.5% additional cover compared to that of the non-riparian area. The only specie contributing to this is *Datura sp*.

## 4.5 Comparing the alien plant densities of Non-riparian zones with Riparian zones

### 4.5.1 Per Tertiary

Of the 11 tertiaries only tertiaries X11 (-3.17%), X12 (-2.69%) and X31 (-3.33%) reflected lower levels of alien plant percentage cover in the riparian zones compared with that in the non-riparian zones. The remaining tertiaries all recorded greater densities of alien plant invasions in the riparian zones.

### 4.5.2 Per species

**Tall tree (3)**

*Acacia mearnsii* occurrs in higher densities in the non-riparian zones compared with that in the riparian zones throughout the entire Inkomati catchment.

Overall, *Eucalyptus sp*. is more dominant in the non-riparian zones (16.7%) compared to the riparian zones (11.7%). There are, however, a number of tertiaries where *Eucalyptus sp*. dominates the riparian zones viz; X22, X23, X31 and X32.

*Pinus sp*. occurs in higher densities in the non-riparian zones (9%) compared with the riparian zones (5%). Only quaternary X12 reflects a higher density of *Pinus sp*. in the riparian zones (12.8%) with the non-riparian zones (7%).

*Populus sp*. is mainly recorded in the riparian zones with high densities in tertiaries X11 (39.4%) and X21 (6.5%).

**Medium tree (2)**

*Jacaranda mimosifolia* occurs in high densities (4.8%) in quaternary X23 in the non-riparian zones. *Melia azaderach* occurs in high densities in the same quaternary but records higher levels in the riparian zone (27.9%) compared with the non-riparian zone (7.6%).

**Tall shrub (1)**

*Chromolaena odorata* occurs in higher densities in all riparian zones (8.2%) of all tertiaries it occurs in, compared with the non-riparian zones (6.2%).

*Solanum mauritianum* dominates the riparian zones in tertiaries X13 (15.1%), X14 (12.3%), X21 (12.1%) and X22 (26.8%). In contrast, the densities are higher in the non-riparian zones of quaternary X32 (31.8%).

There is a significant population of *Datura sp*. occurring in quaternary X32. This species occurs in higher density levels in the riparian zones (51.8%) compared with the non-riparian zones (<1%).

*Lantana camara* is well distributed throughout the Inkomati catchment. It occurs in higher densities in the non-riparian zones (23.1%) compared with the riparian zones (11.5%).

*Psidium guajava* is most dominant in quaternary X14 where it occurs in higher densities in the non riparian-zones (6%) compared with less than 1% in the riparian zones.

*Ricinus communis* occurs in high densities in the riparian zones of tertiaries X23 (12.2%) and X32 (23.9%).

*Rubus sp*. recorded marginally higher densities in the riparian zones (3.4%) compared with the non-riprian zones (2.6%) throughout the entire Inkomati catchment. Higher densities occur in the non-riparian zones of quaternary X32 (18.8%) compared to the riparian zones (<1%).

*Senna sp*. dominates the riparian zones in quaternary X24 (18.3%).

### 4.6 Comparing past surveys

Deall (2002) carried out a similar survey in the Inkomati catchment in Swaziland. He recorded very high levels of *Acacia mearnsii* (26%) and *Chromolaena* (54%) compared with other species in that quaternary. These density levels are similar to that recorded in this survey, where *Chromolaena odorata* has a 45% density and *Acacia mearnsii* 20.9%. There is, however, a significant difference between the densities of *Lantana camara* from Deall (2002) who records 6.9% compared with a reading from this survey of 22.4%.

Goodall *et al* (1994) in their study on the distribution of *Chromolaena odorata* in Swaziland recorded a fairly widespread distribution in that country. They did, however, state that the infestation levels were higher in the north. Northern Swaziland falls into the Inkomati catchment where this current survey records very high levels of *Chromlaena odorata*.

When comparing the invasion levels of alien plants per quaternary with the data collated by Versveld *et al* (1996), (table 3) similar density levels occur for most tertiaries. Tertiaries that do not show similarities include X11, X12, X13 and X14. The invasive levels recorded by Versveld *et al* (1998) in tertiaries X11 (1.53%) and X12 (1.06%) were very low; it is likely that the Acacia, Eucalypt and Poplar "jungles" were not included in the study.

Quaternary X13 has a much reduced density level (0.02%) recorded by Versveld *et al* (1998) compared to this current survey (8.7%) and Deall *et al* (2002), 6%. This discrepancy could be attributed to the different approach used; mainly field interpretation by Hardy and Deall as opposed to the desktop exercise compiled by

Versveld et al (1996). Similarly Quaternary X14 is also given a low density level by Versveld et al (1996) (2.3%) compared with 10.5% in this current study.

The remaining tertiaries X21 to X40 reflect similar levels of invasive alien plants between this current report and Versveld *et al* (1998). See Table 3.

**Table 3 Comparison of results**

| **Quaternary** | **Hardy Riparian %** | **Hardy Non-Riparian %** | **Versveld et al (1996) %** |
|---|---|---|---|
| X11 | 14.62 | **17.79** | **1.53** |
| X12 | 7.72 | **10.41** | **1.06** |
| X13 | 13.4 | **8.72** | **0.02** |
| X14 | 16.06 | **11.95** | **2.30** |
| X21 | 13.66 | **13.2** | **11.87** |
| X22 | 16.1 | **8.9** | **7.82** |
| X23 | 12.01 | **6.31** | **7.48** |
| X24 | 3.32 | **0.96** | **0.83** |
| X31 | 6.46 | **9.79** | **15.05** |
| X32 | 8.94 | **1.90** | **3.16** |
| X40 | 0.50 | **0.00** | **0.05** |

## 4.7 Sites recording no aliens

A total of 946 sites were sampled throughout the entire study area. Within this total, no aliens were recorded in 14 **riparian** sites and 53 **non-riparian** sites. This represents 2% and 5% respectively of all sites sampled (Figure 2).

The distribution of no aliens in the **riparian** sites is limited to the northern tertiaries X31 and X32, sub-quaternaries X21C-1 and X21C-2 north east of Dullstroom, X11E-2 north of Carolina and a few sub-quaternaries in the Badplaas area.

In contrast to this the distribution of sites reflecting no alien plants in **non-riparian** zones covers a similar area but incorporates many more sub-quaternaries. In addition to these areas no alien were recorded in the non-riparian sites east of

Nelspruit to Komatipoort. A number of sites in three sub-quaternaries in Swaziland, X13B-1, X13G-1 and X13H-1 recoded no aliens in the non-riparian sites.

# 5.0 Discussion

This study shows that *Acacia mearnsii* is the most dominant alien plant in the Inkomati catchment in both the riparian and non-riparian zones. *Eucalyptus* is the second most dominant in both the aforementioned zones. Although less dominant in the riparian zone, *Lantana camara* is well established throughout the Inkomati catchment. *Pinus* is dominant in the non-riparian zones but is not represented in significant levels in the riparian zones. Both *Solanum mauritianum* and *Chromolaena odorata* show a marked increase in dominance in the riparian zones.

The high density cover of *Chromolaena odorata* reported by both Deall (2002) and Goodall *et al* (1994) was also illustrated by this study. Although not widespread, where it does occur, it forms dense stands. This species is well established in the Inkomati catchments in Swaziland and immediately north of Swaziland. It is also well established along the pass over Kaalrug mountains and in the foothills of the Drakensberg near Acornhoek.

Topographical features such as krantzes are often covered in dense thickets of alien plants. The main species in these habitats include *Pinus* sp., *Eucalyptus* sp. and *Acacia mearnsii*. Road edges are often more densely covered with alien plants compared to the adjacent landscape. Disturbances such as old mine dumps are densely populated with alien plants. The mines around Barberton have high levels of *Lantana camara*, (Tony Ferrar *pers comm*.).

An emerging invasive species in the Mpumalanga Highveld and Lowveld is the pompom weed, *Campuloclinium macrcephalum*. This is an annual species that has a high dispersal capacity and consequent rapid rate of spread. Information on this species has been collected by a resident of Barberton and has been made available to the Department of Water Affairs and Forestry. This species poses a great threat to habitat diversity and ecosystem integrity.

The field survey, together with the woody vegetation vector layer played an important role in determining the extent of densely vegetated *Acacia mearnsii* and Eucalyptus sp. "jungles" predominantly in quaternary X11. In contrast, the results of Versveld et al (1998) reveal a very small alien plant cover in both X11 and X12 tertiaries. However, this current survey predominantly identified the "jungles" of mainly wattle and gum in quaternary X11. It is assumed that these jungles would not have been incorporated into their study.

# 7.0 References:

Deall G 2002. Alien Invader Status: Komati and Mbulusi Catchments Swaziland. Report for the Ministry of Water Resources, Swaziland.

Goodall J.M, Zimmerman H.G, & Zeller D. 1994. The distribution of *Chromolaena odorata* in Swaziland and implications for further spread. PPRI, Pietermaritzburg.

Versveld D.B, Le Maitre D.C, & Chapman R.A. 1998. Alien Invading Plants and Water Resources in South Africa: A Preliminary Assessment. CSIR Division of Water, Environment and Forest Technology, Stellenbosch. Water Research Commission Report No TT 99/98.

**NOTE: Updating of Alien Vegetation Estimates (February 2009)**

Some of the areas of alien vegetation derived from the original survey were queried by the hydrology team once streamflow reduction figures had been calculated. It was apparent that generalizing the sample results to the catchment had lead to an overestimate of the alien vegetation figures in these areas. The extrapolation methodology was adjusted for these catchments, and a new set of alien vegetation figures were generated by the core project team and used in the hydrological assessment.

Subsequently selected catchments (X11A-1, X21A-1, X21A-2 and X21B-3) above the Nooitgedacht and Kwena dams were resurveyed by Steven Hardy in February 2009, using a larger sample site. Alien vegetation extents for these catchments were reassessed and found to match classified SPOT satellite imagery (analysed by Geoterraimage, 2008) more closely.

The revised methodology, reassessed total condensed areas and follow-up survey results are presented in an addendum to the report. The results are discussed in relation to the classified SPOT image.

A number of recommendations for any further study of alien vegetation in this area were identified:

- All catchments above the Nooitgedacht and Kwena dams that were reassessed should be resurveyed using the follow-up survey methodology (site size 1-3km$^2$).
- Resurvey of the remaining reassessed catchments should be strongly considered, using the follow-up methodology.
- The resurveyed results should be assessed against the classified satellite image, and should be adjusted if necessary to improve the confidence of the alien vegetation assessment.

**ADDENDUM: Updating of Alien Vegetation Estimates (February 2009)**

## I Revision of Alien Vegetation Estimates

The alien vegetation estimates were revised for certain catchments after obtaining feedback from the hydrological modelling team. Review of the field photographs for selected sites confirmed that the densities reported from the study were well-founded. Analysis of the classified SPOT image obtained from GeoTerraImage (2008) suggested that the extrapolation from the sites inspected to the catchment scale had exaggerated the alien vegetation infestation in some cases e.g. catchment X11A-1 was reported to have an alien infestation in excess of 15%, where only 6.1% total woody vegetation was identified on the image. A rapid visual scan of several catchments using publically available aerial imagery confirmed this conclusion.

A number of classes were identified in the GTI analysis:

- Plantation.
- Plantation / tall tree mix.
- Plantation / orchard mix.
- Medium tree.
- Medium tree / plantation mix.
- Tall shrub.
- Tall shrub mix (plantation).
- Cloud obscured.
- Non-woody.

It was not possible to directly assess alien vegetation using the image, but it proved to be a useful cross-check. The Geoterraimage (GTI) analysis indicated an overall total woody vegetation cover of 21.1% for the study area, and included commercial afforestation. It should be borne in mind that this analysis did not attempt to assess vegetation density, and for this reason would provide a higher (uncondensed) woody cover estimate relative to the field survey. On the other hand the field survey could have picked up light shrub infestation in areas where the image analysis could not detect this, and the analysis would have underestimated in these areas.

*Revision of Methodology*

The methodology documented in the Hardy report used five density classes, as given below:

Table 1: Original Density Classes

| Density class | Canopy cover | Mid-value | Canopy diameters apart |
|---|---|---|---|
| Rare | <1% | 0.5% | >10 |
| Occasional | 1 – 5% | 2.5% | 3 – 10 + |
| Scattered | 6 – 25% | 15% | 1 – 3 |
| Medium | 26 – 75% | 50% | 0.3 – 1 |
| Dense | >75% | 87.5% | <0.1 |

When extrapolating to the catchment from the surveyed sites, density values of 4 (26-75%) and 5 (>75%) were scaled down to 3 (6-25%) in order not to overestimate the infestation with alien vegetation. This approach had to be revised in a number of catchments where it was found to generate unreasonable values.

The approach adopted by the team for these catchments was to rescale the density classes down a level. An additional density class 0 with mid-value 0.25% was used to hold readings that had previously been allocated to the 0.5% mid-value.

Table 2: Revised Density Classes

| Density class | Canopy cover | Mid-value | Prior Class |
|---|---|---|---|
| Additional | n/a | 0.25% | 0.5% |
| Rare | <1% | 0.5% | 2.5% |
| Occasional | 1 – 5% | 2.5% | 15% + |

*Summary of Results*

Table 3 below compares the revised catchment estimates of total condensed area of alien vegetation with the Versfeld Report, and the original estimates. The total revised estimate is substantially lower than the original in most catchments, although it is of the same order as the Versfeld estimate.

Table 3: Comparison of Revised Alien Vegetation Estimate with the Versfeld Report

| Quaternary | Hardy Report (2008) | Revised (2009) | Versfeld |
|---|---|---|---|
| X11 | 17.55% | 3.15% | 1.53% |
| X12 | 10.23% | 2.51% | 1.03% |
| X13 | 9.10% | 1.85% | 0.01% |
| X14 | 12.31% | 2.92% | 1.43% |
| X21 | 13.23% | 2.93% | 11.88% |
| X22 | 9.34% | 5.52% | 7.81% |
| X23 | 6.69% | 4.41% | 7.48% |
| X24 | 1.17% | 1.12% | 1.03% |
| X31 | 9.55% | 3.43% | 14.00% |
| X32 | 2.51% | 2.20% | 3.89% |
| X40 (partial) | 0.05% | 0.05% | 0.14% |
| *Total* | *9.40%* | *2.81%* | *5.10%* |

## II Follow-up Survey

A follow-up survey of alien vegetation was carried out for selected catchments (X11A-1, X21A-1, X21A-2 and X21B-3) above the Nooitgedacht and Kwena dams. This followed a similar methodology to the original survey, and used the same density classes as in Table 1, but each site covered a relatively broad area (1-3km$^2$). In addition, at least five sites were surveyed in each catchment. Surveys were carried out at 24 distinct sites in Catchment X11A-1, as it is over three times larger than any of the other catchments.

Total condensed areas of alien vegetation were calculated from the follow-up survey, and are presented as percentages below in Table 4

Table 4: Alien Vegetation Estimate from Follow-Up Survey

| Catchment | Area (km2) | TCA (%) |
|---|---|---|
| X11A-1 | 671.9 | 4.82% |
| X21A-1 | 124.9 | 8.45% |
| X21B-2 | 115.8 | 7.51% |
| X21B-3 | 185.8 | 1.68% |
| Average | - | 4.99% |

The average alien vegetation infestation from the follow-up survey of 4.99% for these catchments is more in line with the GTI assessment of woody vegetation of 6.2% (given minimal forestry here), confirming that the follow-up methodology is providing more representative results.

The Total Condensed Area of alien vegetation before and after the revision is given in Tables 5 to 9 below.

Table 5: Percentage of Alien Vegetation in Catchments X11 and X12

| Quinary | Original % TCA | Revised % TCA |
|---|---|---|
| X11A-1 | 18.1% | 3.4% |
| X11B-1 | 19.1% | 3.4% |
| X11B-2 | 16.4% | 2.8% |
| X11C-1 | 16.1% | 2.8% |
| X11D-1 | 17.6% | 3.0% |
| X11D-2 | 2.4% | 5.0% |
| X11D-3 | 1.6% | 7.1% |
| X11E-1 | 15.4% | 2.7% |
| X11E-2 | 0.0% | 0.0% |
| X11F-1 | 15.1% | 2.5% |
| X11G-1 | 14.7% | 2.6% |
| X11H-1 | 17.3% | 3.0% |
| X11J-1 | 3.0% | 3.0% |
| X11K-1 | 0.4% | 0.4% |
| X11K-2 | 0.0% | 0.0% |
| X11K-3 | 2.2% | 2.2% |
| X11K-4 | 0.4% | 0.4% |
| X12A-1 | 0.5% | 0.5% |
| X12B-1 | 21.0% | 3.7% |
| X12C-1 | 0.0% | 0.0% |
| X12C-2 | 14.1% | 2.4% |
| X12D-1 | 15.1% | 2.5% |
| X12-D2 | 0.7% | 0.7% |
| X12E-1 | 14.3% | 2.4% |
| X12F-1 | 0.8% | 0.8% |
| X12F-2 | 0.0% | 0.0% |
| X12F-3 | 0.0% | 0.0% |
| X12G-1 | 14.9% | 14.9% |
| X12G-2 | 0.6% | 0.6% |
| X12G-3 | 0.3% | 0.3% |
| X12H-1 | 0.0% | 0.0% |
| X12H-2 | 0.1% | 0.1% |
| X12H-3 | 0.2% | 0.2% |
| X12J-1 | 1.3% | 1.3% |
| X12J-2 | 17.4% | 17.4% |
| X12J-3 | 14.5% | 14.5% |
| X12K-1 | 15.1% | 2.5% |
| X12K-2 | 0.4% | 0.4% |
| Total | 11.0% | 2.9% |

Table 6: Percentage of Alien Vegetation in Catchments X13 and X14

| Quinary | Original % TCA | Revised % TCA |
|---|---|---|
| X13A-1 | 16.2% | 2.9% |
| X13B-1 | 0.1% | 0.1% |
| X13B-2 | 0.2% | 0.2% |
| X13C-1 | 16.0% | 3.0% |
| X13D-1 | 2.2% | 2.2% |
| X13E-1 | 17.6% | 3.0% |
| X13F-1 | 0.5% | 0.5% |
| X13F-2 | 3.1% | 3.1% |
| X13G-1 | 0.1% | 0.1% |
| X13G-2 | 38.4% | 6.7% |
| X13G-3 | 3.3% | 3.3% |
| X13H-1 | 1.4% | 1.4% |
| X13H-2 | 16.4% | 2.8% |
| X13J-1 | 2.5% | 2.5% |
| X13J-2 | 1.6% | 1.6% |
| X13J-3 | 0.0% | 0.0% |
| X13J-4 | 0.0% | 0.0% |
| X13K-1 | 2.7% | 2.7% |
| X13K-2 | 1.3% | 1.3% |
| X13L-1 | 1.0% | 1.0% |
| X13L-2 | 0.8% | 0.8% |
| X14A-1 | 3.6% | 3.6% |
| X14B-1 | 0.2% | 0.2% |
| X14B-2 | 1.9% | 1.9% |
| X14C-1 | 41.0% | 7.4% |
| X14D-1 | 32.6% | 6.1% |
| X14D-2 | 15.9% | 2.8% |
| X14E-1 | 17.3% | 4.1% |
| X14F-1 | 11.8% | 2.5% |
| X14G-1 | 1.8% | 1.8% |
| X14G-2 | 0.0% | 0.0% |
| X14G-3 | 0.5% | 0.5% |
| X14H-1 | 1.6% | 1.6% |
| Total | 8.0% | 2.2% |

Table 7: Percentage of Alien Vegetation in Catchments X21 and X22

| Quinary | Original % TCA | Revised % TCA |
|---|---|---|
| X21A-1 | 27.7% | 4.6% |
| X21A-2 | 43.5% | 7.2% |
| X21B-1 | 16.5% | 3.3% |
| X21B-2 | 15.2% | 2.5% |
| X21B-3 | 16.0% | 3.2% |
| X21C-1 | 14.4% | 2.6% |
| X21C-2 | 13.3% | 13.3% |
| X21C-3 | 2.3% | 2.3% |
| X21D-1 | 1.3% | 1.3% |
| X21D-2 | 1.5% | 1.5% |
| X21E-1 | 2.4% | 2.4% |
| X21E-2 | 0.7% | 0.7% |
| X21F-1 | 15.4% | 2.6% |
| X21F-2 | 1.7% | 1.7% |
| X21G-1 | 15.1% | 3.2% |
| X21G-2 | 15.6% | 2.8% |
| X21H-1 | 3.0% | 3.0% |
| X21H-2 | 0.1% | 0.1% |
| X21J-1 | 1.0% | 1.0% |
| X21J-2 | 2.7% | 2.7% |
| X21K-1 | 16.4% | 3.4% |
| X21K-2 | 23.7% | 4.4% |
| X21K-3 | 1.3% | 1.3% |
| X22A-1 | 2.5% | 2.5% |
| X22A-2 | 3.6% | 3.6% |
| X22B-1 | 5.5% | 5.5% |
| X22B-2 | 1.3% | 1.3% |
| X22C-1 | 11.1% | 11.1% |
| X22C-2 | 29.6% | 5.0% |
| X22C-3 | 4.4% | 4.4% |
| X22D-1 | 0.1% | 0.1% |
| X22D-2 | 14.4% | 14.4% |
| X22D-3 | 5.1% | 5.1% |
| X22E-1 | 15.2% | 15.2% |
| X22E-2 | 4.3% | 5.1% |
| X22E-3 | 36.3% | 36.3% |
| X22F-1 | 4.9% | 4.9% |
| X22F-2 | 3.1% | 3.1% |
| X22G-1 | 9.2% | 9.2% |
| X22G-2 | 3.7% | 3.7% |
| X22H-1 | 1.4% | 1.4% |
| X22H-2 | 1.6% | 1.6% |
| X22H-3 | 2.0% | 2.0% |
| X22J-1 | 19.0% | 3.4% |
| X22J-2 | 4.4% | 4.4% |
| X22K-1 | 2.3% | 2.3% |
| X22K-2 | 3.4% | 3.4% |
| X22K-3 | 0.2% | 0.2% |
| Total | 9.5% | 4.0% |

Table 8: Percentage of Alien Vegetation in Catchments X23 and X24

| Quinary | Original % TCA | Revised % TCA |
|---|---|---|
| X23A-1 | 0.6% | 0.6% |
| X23A-2 | 1.3% | 1.3% |
| X23B-1 | 0.4% | 0.4% |
| X23B-2 | 16.5% | 3.4% |
| X23B-3 | 20.8% | 3.9% |
| X23C-1 | 0.4% | 0.4% |
| X23C-2 | 0.1% | 0.1% |
| X23D-1 | 5.2% | 5.2% |
| X23D-2 | 3.4% | 3.4% |
| X23E-1 | 0.2% | 0.2% |
| X23E-2 | 0.2% | 0.2% |
| X23F-1 | 7.8% | 2.3% |
| X23F-2 | 17.8% | 17.8% |
| X23G-1 | 1.1% | 1.1% |
| X23G-2 | 3.0% | 3.0% |
| X23H-1 | 14.9% | 14.9% |
| X23H-2 | 0.2% | 0.2% |
| X23H-3 | 14.3% | 14.3% |
| X23H-4 | 0.8% | 0.8% |
| X23H-5 | 0.0% | 0.0% |
| X24A-1 | 1.1% | 1.1% |
| X24A-2 | 3.9% | 3.9% |
| X24B-1 | 3.2% | 3.2% |
| X24B-2 | 0.5% | 0.5% |
| X24B-3 | 0.5% | 0.5% |
| X24C-1 | 0.7% | 0.7% |
| X24C-2 | 0.6% | 0.6% |
| X24D-1 | 0.0% | 0.0% |
| X24D-2 | 1.2% | 1.2% |
| X24E-1 | 0.5% | 0.5% |
| X24E-2 | 0.0% | 0.0% |
| X24F-1 | 0.0% | 0.0% |
| X24H-1 | 0.3% | 0.3% |
| X24H-2 | 12.9% | 12.9% |
| Total | 3.2% | 2.4% |

Table 9: Percentage of Alien Vegetation in Catchments X31 and X32

| Quinary | Original % TCA | Revised % TCA |
|---|---|---|
| X31A-1 | 14.9% | 2.7% |
| X31A-2 | 15.1% | 15.1% |
| X31B-1 | 3.5% | 3.5% |
| X31C-1 | 0.1% | 0.1% |
| X31C-2 | 4.1% | 4.1% |
| X31D-1 | 15.0% | 15.0% |
| X31D-2 | 4.9% | 4.9% |
| X31D-3 | 4.2% | 4.2% |
| X31E-1 | 14.7% | 2.7% |
| X31E-2 | 47.8% | 8.2% |
| X31E-3 | 0.0% | 0.0% |
| X31F-1 | 6.7% | 6.7% |
| X31G-1 | 42.3% | 7.1% |
| X31G-2 | 17.5% | 17.5% |
| X31G-3 | 13.9% | 13.9% |
| X31H-1 | 15.8% | 15.8% |
| X31H-2 | 0.4% | 0.4% |
| X31J-1 | 9.9% | 2.5% |
| X31K-1 | 13.9% | 13.9% |
| X31K-2 | 0.5% | 0.5% |
| X31K-3 | 1.3% | 1.3% |
| X31K-4 | 0.0% | 0.0% |
| X31L-1 | 0.0% | 0.0% |
| X31L-2 | 0.2% | 0.2% |
| X31L-3 | 0.0% | 0.0% |
| X31M-1 | 0.5% | 0.5% |
| X31M-2 | 0.0% | 0.0% |
| X32A-1 | 7.6% | 7.6% |
| X32A-2 | 1.0% | 1.0% |
| X32B-1 | 3.3% | 3.3% |
| X32C-1 | 0.1% | 0.1% |
| X32C-2 | 0.1% | 0.1% |
| X32C-3 | 0.1% | 0.1% |
| X32C-4 | 1.0% | 1.0% |
| X32C-5 | 0.0% | 0.0% |
| X32C-6 | 1.9% | 1.9% |
| X32C-7 | 0.0% | 0.0% |
| X32D-1 | 5.7% | 5.7% |
| X32D-2 | 3.5% | 3.5% |
| X32E-1 | 43.5% | 43.5% |
| X32E-2 | 0.1% | 0.1% |
| X32F-1 | 0.0% | 0.0% |
| X32F-2 | 0.0% | 0.0% |
| X32F-3 | 0.0% | 0.0% |
| X32F-4 | 0.0% | 0.0% |
| X32G-1 | 0.2% | 0.2% |
| X32G-2 | 2.4% | 2.4% |
| X32G-3 | 1.2% | 1.2% |
| X32H-1 | 1.2% | 1.2% |
| X32H-2 | 1.4% | 1.4% |
| X40C-1 | 0.1% | 0.1% |
| Total | 4.7% | 2.4% |

# ANNEXURE 1.1

## Condensed cover per species per sub-quaternary

## NON-RIPARIAN

| X11 - Non-riparian: Tall tree | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ID | *Acacia sp.* | *Acacia mearnsii* | *Acacia melanoxylon* | *Casuarina sp.* | *Cedrela toona* | *Eucalyptus sp.* | *Pinus sp.* | *Populus sp.* | *Spathoda sp.* | *Tipianu sp.* |
| X11A-1 | 0.0 | 10078.3 | 0.0 | 0.0 | 0.0 | 1679.7 | 0.0 | 0.0 | 0.0 | 0.0 |
| X11B-1 | 180.3 | 901.3 | 0.0 | 0.0 | 0.0 | 5408.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| X11B-2 | 0.0 | 3543.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X11C-1 | 0.0 | 4783.4 | 0.0 | 0.0 | 0.0 | 797.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| X11D-1 | 0.0 | 3852.4 | 0.0 | 0.0 | 0.0 | 642.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| X11D-2 | 0.0 | 1433.1 | 0.0 | 0.0 | 0.0 | 0.0 | 47.8 | 0.0 | 0.0 | 0.0 |
| X11D-3 | 0.0 | 3575.1 | 0.0 | 0.0 | 0.0 | 3575.1 | 0.0 | 3575.1 | 0.0 | 0.0 |
| X11E-1 | 0.0 | 77.7 | 0.0 | 0.0 | 0.0 | 2331.5 | 0.0 | 0.0 | 0.0 | 0.0 |
| X11E-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X11F-1 | 0.0 | 2738.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X11G-1 | 0.0 | 3956.4 | 0.0 | 0.0 | 0.0 | 131.9 | 0.0 | 0.0 | 0.0 | 0.0 |
| X11H-1 | 0.0 | 3980.5 | 0.0 | 0.0 | 0.0 | 663.4 | 0.0 | 0.0 | 0.0 | 0.0 |
| X11J-1 | 0.0 | 93.1 | 0.0 | 0.0 | 0.0 | 0.0 | 465.6 | 0.0 | 0.0 | 0.0 |
| X11K-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X11K-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X11K-3 | 0.0 | 713.2 | 0.0 | 0.0 | 0.0 | 713.2 | 713.2 | 0.0 | 0.0 | 0.0 |
| X11K-4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Tot. condensed | 180.3 | 39726.1 | 0.0 | 0.0 | 0.0 | 15942.2 | 1226.6 | 3575.1 | 0.0 | 0.0 |
| % of condensed | 0.3 | 63.3 | 0.0 | 0.0 | 0.0 | 25.4 | 2.0 | 5.7 | 0.0 | 0.0 |
| % of quaternary | 0.1 | 11.3 | 0.0 | 0.0 | 0.0 | 4.5 | 0.3 | 1.0 | 0.0 | 0.0 |
| % of Inkomati | 0.01 | 1.74 | 0.00 | 0.00 | 0.00 | 0.70 | 0.05 | 0.16 | 0.00 | 0.00 |

| X11 - Non-riparian: Medium tree | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ID | *Grevillea robusta* | *Jacaranda mimosifolia* | *Melia azaderach* | *Morus alba* | *Privet* | *Quercus robur* | *Salix sp.* | *Sesbania sp.* |
| X11A-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 335.9 | 0.0 |
| X11B-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X11B-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X11C-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X11D-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X11D-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X11D-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X11E-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X11E-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X11F-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X11G-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X11H-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X11J-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X11K-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X11K-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X11K-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X11K-4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Tot. condensed | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 335.9 | 0.0 |
| % of condensed | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 |
| % of quaternary | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 |
| % of Inkomati | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 |

## X11 - Non-riparian: Tall shrub

| ID | *Agave sp.* | *Arundo donax* | *Caesalpinea decapetala* | *Chromelaena odorata* | *Cotoneaster sp.* | *Datura sp.* | *Lantana camara* | *Psidium guajava* | *Pueraria lobata* | *Ricinus communis* | *Rubus sp.* | *Senna didymobotrya* | *Senna sp.* | *Solanum maritianum* | *Solanum sp.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| X11A-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 335.9 |
| X11B-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X11B-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X11C-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X11D-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X11D-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1433.1 |
| X11D-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X11E-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X11E-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X11F-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X11G-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X11H-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X11J-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X11K-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X11K-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X11K-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X11K-4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Tot. condensed | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1769.1 |
| % of condensed | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.8 |
| % of quaternary | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 |
| % of Inkomati | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 |

| X11 - Total condensed cover per sub-quaternary: Non-riparian | | | | | |
|---|---|---|---|---|---|
| ID | Total condensed area | % of Total condensed area | % of total area | | HA |
| X11A-1 | 12429.9 | 18.5 | 0.54 | | 67188.381 |
| X11B-1 | 6489.7 | 18.0 | 0.28 | | 36053.970 |
| X11B-2 | 3543.4 | 15.0 | 0.15 | | 23622.801 |
| X11C-1 | 5580.6 | 17.5 | 0.24 | | 31889.047 |
| X11D-1 | 4494.5 | 17.5 | 0.20 | | 25682.845 |
| X11D-2 | 2914.0 | 30.5 | 0.13 | | 9554.112 |
| X11D-3 | 10725.3 | 45.0 | 0.47 | | 23833.975 |
| X11E-1 | 2409.2 | 15.5 | 0.11 | | 15543.080 |
| X11E-2 | 0.0 | 0.0 | 0.00 | | 8594.418 |
| X11F-1 | 2738.1 | 15.0 | 0.12 | | 18253.836 |
| X11G-1 | 4088.3 | 15.5 | 0.18 | | 26376.163 |
| X11H-1 | 4643.9 | 17.5 | 0.20 | | 26536.744 |
| X11J-1 | 558.7 | 3.0 | 0.02 | | 18623.990 |
| X11K-1 | 0.0 | 0.0 | 0.00 | | 6517.672 |
| X11K-2 | 0.0 | 0.0 | 0.00 | | 5774.422 |
| X11K-3 | 2139.7 | 45.0 | 0.09 | | 4754.843 |
| X11K-4 | 0.0 | 0.0 | 0.00 | | 4029.472 |
| Tot. condensed ha | 62755.2 | 17.79 | 2.74 | Tot. ha for X11 | 352829.771 |
| Total condensed area as a; | | | | | |
| % of quaternary X11 | 17.79 | | | | |
| % of Inkomati | 2.74 | | | | |

| X12 - Non-riparian: Tall tree | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ID | *Acacia sp.* | *Acacia mearnsii* | *Acacia melanoxylon* | *Casuarina sp.* | *Cedrela toona* | *Eucalyptus sp.* | *Pinus sp.* | *Populus sp.* | *Spathoda sp.* | *Tipianu sp.* |
| X12A-1 | 0.0 | 3665.4 | 0.0 | 0.0 | 0.0 | 3665.4 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12B-1 | 0.0 | 2321.6 | 0.0 | 0.0 | 0.0 | 386.9 | 386.9 | 0.0 | 0.0 | 0.0 |
| X12C-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12C-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2151.8 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12D-1 | 0.0 | 2083.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12-D2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12E-1 | 0.0 | 4990.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12F-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12F-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12F-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12G-1 | 0.0 | 0.0 | 40.7 | 0.0 | 0.0 | 0.0 | 1221.1 | 0.0 | 0.0 | 0.0 |
| X12G-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12G-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12H-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12H-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12H-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12J-1 | 0.0 | 87.7 | 0.0 | 0.0 | 0.0 | 0.0 | 87.7 | 0.0 | 0.0 | 0.0 |
| X12J-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 169.2 | 0.0 | 0.0 | 0.0 |
| X12J-3 | 0.0 | 789.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12K-1 | 0.0 | 3579.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12K-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Tot. condensed | 0.0 | 17516.8 | 40.7 | 0.0 | 0.0 | 6204.0 | 1864.9 | 0.0 | 0.0 | 0.0 |
| % of condensed | 0.0 | 65.7 | 0.2 | 0.0 | 0.0 | 23.3 | 7.0 | 0.0 | 0.0 | 0.0 |
| % of quaternary | 0.0 | 6.8 | 0.0 | 0.0 | 0.0 | 2.4 | 0.7 | 0.0 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.77 | 0.00 | 0.00 | 0.00 | 0.27 | 0.08 | 0.00 | 0.00 | 0.00 |

| X12 - Non-riparian: Medium tree | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ID | *Grevillea robusta* | *Jacaranda mimosifolia* | *Melia azaderach* | *Morus alba* | *Privet* | *Quercus robur* | *Salix sp.* | *Sesbania sp.* |
| X12A-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12B-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12C-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12C-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12D-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12-D2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12E-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12F-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12F-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12F-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12G-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12G-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12G-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12H-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12H-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12H-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12J-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12J-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12J-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12K-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12K-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Tot. condensed | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of condensed | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of quaternary | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

## X12 - Non-riparian: Tall shrub

| ID | *Agave sp.* | *Arundo donax* | *Caesalpinea decapetala* | *Chromelaena odorata* | *Cotoneaster sp.* | *Datura sp.* | *Lantana camara* | *Psidium guajava* | *Pueraria lobata* | *Ricinus communis* | *Rubus sp.* | *Senna didymobotrya* | *Senna sp.* | *Solanum maritianum* | *Solanum sp.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| X12A-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12B-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12C-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12C-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12D-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12-D2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12E-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12F-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12F-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12F-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12G-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12G-2 | 15.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12G-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12H-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12H-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12H-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12J-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12J-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1015.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12J-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12K-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X12K-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Tot. condensed | 15.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1015.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of condensed | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3.8 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of quaternary | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 |

| X12 - Total condensed cover per sub-quaternary: Non-riparian | | | | | |
|---|---|---|---|---|---|
| ID | Total condensed area | % of Total condensed area | % of total area | | HA |
| X12A-1 | 7330.7 | 30.0 | 0.32 | | 24435.687 |
| X12B-1 | 3095.4 | 20.0 | 0.14 | | 15477.229 |
| X12C-1 | 0.0 | 0.0 | 0.00 | | 4246.951 |
| X12C-2 | 2151.8 | 15.0 | 0.09 | | 14345.010 |
| X12D-1 | 2083.1 | 15.0 | 0.09 | | 13887.551 |
| X12-D2 | 0.0 | 0.0 | 0.00 | | 8406.806 |
| X12E-1 | 4990.2 | 15.0 | 0.22 | | 33268.015 |
| X12F-1 | 0.0 | 0.0 | 0.00 | | 9465.948 |
| X12F-2 | 0.0 | 0.0 | 0.00 | | 6391.499 |
| X12F-3 | 0.0 | 0.0 | 0.00 | | 15404.865 |
| X12G-1 | 1261.8 | 15.5 | 0.06 | | 8140.664 |
| X12G-2 | 15.7 | 0.5 | 0.00 | | 3148.973 |
| X12G-3 | 0.0 | 0.0 | 0.00 | | 12584.357 |
| X12H-1 | 0.0 | 0.0 | 0.00 | | 7033.653 |
| X12H-2 | 0.0 | 0.0 | 0.00 | | 13924.799 |
| X12H-3 | 0.0 | 0.0 | 0.00 | | 7613.605 |
| X12J-1 | 175.4 | 1.0 | 0.01 | | 17541.559 |
| X12J-2 | 1184.4 | 17.5 | 0.05 | | 6767.918 |
| X12J-3 | 789.7 | 15.0 | 0.03 | | 5264.857 |
| X12K-1 | 3579.1 | 15.0 | 0.16 | | 23860.688 |
| X12K-2 | 0.0 | 0.0 | 0.00 | | 4755.863 |
| Tot. condensed ha | 26657.42 | 10.41 | 1.16 | Tot. ha for X12 | 255966.5 |
| Total condensed area as a; | | | | | |
| % of quaternary X12 | 10.41 | | | | |
| % of Inkomati | 1.16 | | | | |

| X13 - Non-riparian: Tall tree | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ID | *Acacia sp.* | *Acacia mearnsii* | *Acacia melanoxylon* | *Casuarina sp.* | *Cedrela toona* | *Eucalyptus sp.* | *Pinus sp.* | *Populus sp.* | *Spathoda sp.* | *Tipianu sp.* |
| X13A-1 | 0.0 | 3672.0 | 0.0 | 0.0 | 0.0 | 0.0 | 122.4 | 0.0 | 0.0 | 0.0 |
| X13B-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13B-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13C-1 | 0.0 | 2928.5 | 0.0 | 0.0 | 0.0 | 97.6 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13D-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13E-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13F-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13F-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13G-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13G-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 531.7 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13G-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13H-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13H-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13J-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13J-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13J-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13J-4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13K-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13K-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13L-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13L-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Tot. condensed | 0.0 | 6600.5 | 0.0 | 0.0 | 0.0 | 629.3 | 122.4 | 0.0 | 0.0 | 0.0 |
| % of condensed | 0.0 | 20.9 | 0.0 | 0.0 | 0.0 | 2.0 | 0.4 | 0.0 | 0.0 | 0.0 |
| % of quaternary | 0.0 | 1.8 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.29 | 0.00 | 0.00 | 0.00 | 0.03 | 0.01 | 0.00 | 0.00 | 0.00 |

| X13 - Non-riparian: Medium tree | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ID | *Grevillea robusta* | *Jacaranda mimosifolia* | *Melia azaderach* | *Morus alba* | *Privet* | *Quercus robur* | *Salix sp.* | *Sesbania sp.* |
| X13A-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13B-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13B-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13C-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13D-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13E-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13F-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13F-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13G-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13G-2 | 0.0 | 531.7 | 531.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13G-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13H-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13H-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13J-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13J-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13J-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13J-4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13K-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13K-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13L-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13L-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Tot. condensed | 0.0 | 531.7 | 531.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of condensed | 0.0 | 1.7 | 1.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of quaternary | 0.0 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.02 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

## X13 - Non-riparian: Tall shrub

| ID | *Agave sp.* | *Arundo donax* | *Caesalpinea decapetala* | *Chromelaena odorata* | *Cotoneaster sp.* | *Datura sp.* | *Lantana camara* | *Psidium guajava* | *Pueraria lobata* | *Ricinus communis* | *Rubus sp.* | *Senna didymobotrya* | *Senna sp.* | *Solanum maritianum* | *Solanum sp.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| X13A-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13B-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13B-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13C-1 | 0.0 | 0.0 | 0.0 | 97.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13D-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 90.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 90.3 |
| X13E-1 | 0.0 | 0.0 | 0.0 | 3173.3 | 0.0 | 0.0 | 528.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13F-1 | 0.0 | 0.0 | 0.0 | 3078.9 | 0.0 | 0.0 | 3078.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13F-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 5.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 5.9 | 0.0 | 29.3 |
| X13G-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13G-2 | 0.0 | 0.0 | 0.0 | 3190.3 | 0.0 | 0.0 | 3190.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 531.7 | 0.0 |
| X13G-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 769.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 769.7 | 0.0 | 0.0 |
| X13H-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13H-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3091.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 515.2 |
| X13J-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 175.6 |
| X13J-2 | 80.6 | 0.0 | 0.0 | 80.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 80.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13J-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13J-4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13K-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13K-2 | 0.0 | 0.0 | 0.0 | 183.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 183.0 | 0.0 | 0.0 | 0.0 |
| X13L-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 109.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X13L-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 33.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Tot. condensed | 80.6 | 0.0 | 0.0 | 9803.7 | 0.0 | 5.9 | 10802.3 | 90.3 | 0.0 | 80.6 | 0.0 | 183.0 | 775.6 | 531.7 | 810.5 |
| % of condensed | 0.3 | 0.0 | 0.0 | 31.0 | 0.0 | 0.0 | 34.2 | 0.3 | 0.0 | 0.3 | 0.0 | 0.6 | 2.5 | 1.7 | 2.6 |
| % of quaternary | 0.0 | 0.0 | 0.0 | 2.7 | 0.0 | 0.0 | 3.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.2 | 0.1 | 0.2 |
| % of Inkomati | 0.00 | 0.00 | 0.00 | 0.43 | 0.00 | 0.00 | 0.47 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.03 | 0.02 | 0.04 |

| X13 - Total condensed cover per sub-quaternary: Non-riparian | | | | | |
|---|---|---|---|---|---|
| ID | Total condensed area | % of Total condensed area | % of total area | | HA |
| X13A-1 | 3794.4 | 15.5 | 0.17 | | 24479.897 |
| X13B-1 | 0.0 | 0.0 | 0.00 | | 14861.280 |
| X13B-2 | 0.0 | 0.0 | 0.00 | | 8811.524 |
| X13C-1 | 3123.7 | 16.0 | 0.14 | | 19523.113 |
| X13D-1 | 180.7 | 1.0 | 0.01 | | 18065.778 |
| X13E-1 | 3702.2 | 17.5 | 0.16 | | 21155.552 |
| X13F-1 | 6157.8 | 30.0 | 0.27 | | 20525.889 |
| X13F-2 | 41.1 | 3.5 | 0.00 | | 1172.886 |
| X13G-1 | 0.0 | 0.0 | 0.00 | | 7069.950 |
| X13G-2 | 8507.5 | 40.0 | 0.37 | | 21268.667 |
| X13G-3 | 1539.5 | 30.0 | 0.07 | | 5131.663 |
| X13H-1 | 0.0 | 0.0 | 0.00 | | 9948.122 |
| X13H-2 | 3606.5 | 17.5 | 0.16 | | 20608.708 |
| X13J-1 | 175.6 | 2.5 | 0.01 | | 7024.405 |
| X13J-2 | 241.7 | 1.5 | 0.01 | | 16114.867 |
| X13J-3 | 0.0 | 0.0 | 0.00 | | 52251.429 |
| X13J-4 | 0.0 | 0.0 | 0.00 | | 3540.534 |
| X13K-1 | 0.0 | 0.0 | 0.00 | | 25477.966 |
| X13K-2 | 366.0 | 1.0 | 0.02 | | 36595.893 |
| X13L-1 | 109.3 | 0.5 | 0.00 | | 21852.724 |
| X13L-2 | 33.9 | 0.5 | 0.00 | | 6788.994 |
| Tot. condensed ha | 31579.77 | 8.72 | 1.38 | Tot. ha for X13 | 362269.8 |
| Total condensed area as a; | | | | | |
| % of quaternary X13 | 8.72 | | | | |
| % of Inkomati | 1.38 | | | | |

| X14 - Non-riparian: Tall tree | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ID | *Acacia sp.* | *Acacia mearnsii* | *Acacia melanoxylon* | *Casuarina sp.* | *Cedrela toona* | *Eucalyptus sp.* | *Pinus sp.* | *Populus sp.* | *Spathoda sp.* | *Tipianu sp.* |
| X14A-1 | 0.0 | 70.4 | 0.0 | 0.0 | 0.0 | 0.0 | 352.0 | 0.0 | 0.0 | 0.0 |
| X14B-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X14B-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X14C-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2485.9 | 2485.9 | 0.0 | 0.0 | 0.0 |
| X14D-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 941.8 | 0.0 | 0.0 | 0.0 | 0.0 |
| X14D-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X14E-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X14F-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 293.7 | 0.0 | 0.0 | 0.0 | 0.0 |
| X14G-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X14G-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X14G-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X14H-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Tot. condensed | 0.0 | 70.4 | 0.0 | 0.0 | 0.0 | 3721.4 | 2838.0 | 0.0 | 0.0 | 0.0 |
| % of condensed | 0.0 | 0.4 | 0.0 | 0.0 | 0.0 | 21.0 | 16.1 | 0.0 | 0.0 | 0.0 |
| % of quaternary | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.5 | 1.9 | 0.0 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.16 | 0.12 | 0.00 | 0.00 | 0.00 |

| X14 - Non-riparian: Medium tree | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ID | *Grevillea robusta* | *Jacaranda mimosifolia* | *Melia azaderach* | *Morus alba* | *Privet* | *Quercus robur* | *Salix sp.* | *Sesbania sp.* |
| X14A-1 | 0.0 | 70.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X14B-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X14B-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X14C-1 | 414.3 | 414.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X14D-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X14D-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X14E-1 | 0.0 | 88.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X14F-1 | 0.0 | 0.0 | 293.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X14G-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X14G-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X14G-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X14H-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Tot. condensed | 414.3 | 573.4 | 293.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of condensed | 2.3 | 3.2 | 1.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of quaternary | 0.3 | 0.4 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of Inkomati | 0.02 | 0.03 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

## X14 - Non-riparian: Tall shrub

| ID | *Agave sp.* | *Arundo donax* | *Caesalpinea decapetala* | *Chromelaena odorata* | *Cotoneaster sp.* | *Datura sp.* | *Lantana camara* | *Psidium guajava* | *Pueraria lobata* | *Ricinus communis* | *Rubus sp.* | *Senna didymobotrya* | *Senna sp.* | *Solanum maritianum* | *Solanum sp.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| :14A-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| :14B-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| :14B-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| :14C-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 414.3 | 82.9 | 0.0 | 414.3 | 0.0 | 0.0 | 0.0 | 414.3 | 0.0 |
| :14D-1 | 0.0 | 0.0 | 157.0 | 157.0 | 0.0 | 0.0 | 0.0 | 941.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| :14D-2 | 0.0 | 0.0 | 0.0 | 987.2 | 0.0 | 0.0 | 0.0 | 32.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| :14E-1 | 0.0 | 0.0 | 0.0 | 2659.9 | 0.0 | 88.7 | 443.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 88.7 | 0.0 |
| :14F-1 | 0.0 | 0.0 | 0.0 | 293.7 | 0.0 | 58.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 293.7 | 0.0 |
| :14G-1 | 0.0 | 0.0 | 0.0 | 1114.7 | 0.0 | 0.0 | 1114.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| :14G-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| :14G-3 | 10.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| :14H-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ot. condensed | 10.2 | 0.0 | 157.0 | 5212.5 | 0.0 | 147.4 | 1972.4 | 1057.5 | 0.0 | 414.3 | 0.0 | 0.0 | 0.0 | 796.7 | 0.0 |
| ; of condensed | 0.1 | 0.0 | 0.9 | 29.5 | 0.0 | 0.8 | 11.2 | 6.0 | 0.0 | 2.3 | 0.0 | 0.0 | 0.0 | 4.5 | 0.0 |
| ; of quaternary | 0.0 | 0.0 | 0.1 | 3.5 | 0.0 | 0.1 | 1.3 | 0.7 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 |
| ; of Inkomati | 0.00 | 0.00 | 0.01 | 0.23 | 0.00 | 0.01 | 0.09 | 0.05 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 |

| X14 - Total condensed cover per sub-quaternary: Non-riparian | | | | | |
|---|---|---|---|---|---|
| ID | Total condensed area | % of Total condensed area | % of total area | | HA |
| X14A-1 | 492.9 | 3.5 | 0.02 | | 14081.582 |
| X14B-1 | 0.0 | 0.0 | 0.00 | | 3732.422 |
| X14B-2 | 0.0 | 0.0 | 0.00 | | 14794.471 |
| X14C-1 | 7126.4 | 43.0 | 0.31 | | 16572.966 |
| X14D-1 | 2197.4 | 35.0 | 0.10 | | 6278.364 |
| X14D-2 | 1020.1 | 15.5 | 0.04 | | 6581.480 |
| X14E-1 | 3369.2 | 19.0 | 0.15 | | 17732.462 |
| X14F-1 | 1233.5 | 10.5 | 0.05 | | 11747.809 |
| X14G-1 | 2229.5 | 30.0 | 0.10 | | 7431.552 |
| X14G-2 | 0.0 | 0.0 | 0.00 | | 10940.591 |
| X14G-3 | 10.2 | 0.5 | 0.00 | | 2046.290 |
| X14H-1 | 0.0 | 0.0 | 0.00 | | 35981.366 |
| Tot. condensed ha | 17679.17 | 11.95 | 0.77 | Tot. ha for X14 | 147921.4 |
| Total condensed area as a; | | | | | |
| % of quaternary X14 | 11.95 | | | | |
| % of Inkomati | 0.77 | | | | |

| X21 - Non-riparian: Tall tree | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ID | *Acacia sp.* | *Acacia mearnsii* | *Acacia melanoxylon* | *Casuarina sp.* | *Cedrela toona* | *Eucalyptus sp.* | *Pinus sp.* | *Populus sp.* | *Spathoda sp.* | *Tipianu sp.* |
| X21A-1 | 0.0 | 1874.1 | 0.0 | 0.0 | 0.0 | 1874.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21A-2 | 0.0 | 2089.4 | 0.0 | 0.0 | 0.0 | 2089.4 | 2089.4 | 0.0 | 0.0 | 0.0 |
| X21B-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 191.6 | 1149.9 | 0.0 | 0.0 | 0.0 |
| X21B-2 | 0.0 | 1736.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21B-3 | 0.0 | 2786.6 | 0.0 | 0.0 | 0.0 | 464.4 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21C-1 | 0.0 | 2435.6 | 0.0 | 0.0 | 0.0 | 0.0 | 81.2 | 0.0 | 0.0 | 0.0 |
| X21C-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1390.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21C-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 139.8 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21D-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21D-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21E-1 | 0.0 | 522.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21E-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21F-1 | 0.0 | 3097.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21F-2 | 0.0 | 2851.9 | 0.0 | 0.0 | 0.0 | 2851.9 | 475.3 | 0.0 | 0.0 | 0.0 |
| X21G-1 | 0.0 | 66.4 | 0.0 | 0.0 | 0.0 | 1993.0 | 66.4 | 0.0 | 0.0 | 0.0 |
| X21G-2 | 0.0 | 3217.2 | 0.0 | 0.0 | 0.0 | 107.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21H-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 73.0 | 365.2 | 0.0 | 0.0 | 0.0 |
| X21H-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21J-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 156.0 | 156.0 | 0.0 | 0.0 | 0.0 |
| X21J-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21K-1 | 0.0 | 55.9 | 0.0 | 0.0 | 0.0 | 1675.6 | 55.9 | 55.9 | 0.0 | 0.0 |
| X21K-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1598.4 | 266.4 | 0.0 | 0.0 | 0.0 |
| X21K-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 13.4 | 0.0 | 0.0 | 0.0 | 0.0 |
| Tot. condensed | 0.0 | 20733.4 | 0.0 | 0.0 | 0.0 | 14618.0 | 4705.6 | 55.9 | 0.0 | 0.0 |
| % of condensed | 0.0 | 50.8 | 0.0 | 0.0 | 0.0 | 35.8 | 11.5 | 0.1 | 0.0 | 0.0 |
| % of quaternary | 0.0 | 6.7 | 0.0 | 0.0 | 0.0 | 4.7 | 1.5 | 0.0 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.91 | 0.00 | 0.00 | 0.00 | 0.64 | 0.21 | 0.00 | 0.00 | 0.00 |

| X21 - Non-riparian: Medium tree | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ID | *Grevillea robusta* | *Jacaranda mimosifolia* | *Melia azaderach* | *Morus alba* | *Privet* | *Quercus robur* | *Salix sp.* | *Sesbania sp.* |
| X21A-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21A-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21B-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21B-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21B-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21C-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21C-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21C-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21D-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21D-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21E-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21E-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21F-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21F-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21G-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21G-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21H-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21H-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21J-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21J-2 | 0.0 | 0.0 | 21.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21K-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21K-2 | 0.0 | 53.3 | 266.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21K-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Tot. condensed | 0.0 | 53.3 | 287.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of condensed | 0.0 | 0.1 | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of quaternary | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

## X21 - Non-riparian: Tall shrub

| ID | *Agave sp.* | *Arundo donax* | *Caesalpinea decapetala* | *Chromelaena odorata* | *Cotoneaster sp.* | *Datura sp.* | *Lantana camara* | *Psidium guajava* | *Pueraria lobata* | *Ricinus communis* | *Rubus sp.* | *Senna didymobotrya* | *Senna sp.* | *Solanum maritianum* | *Solanum sp.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| X21A-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21A-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21B-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21B-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21B-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21C-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21C-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21C-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21D-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21D-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21E-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21E-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21F-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21F-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21G-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21G-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21H-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21H-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21J-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21J-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 21.3 | 0.0 |
| X21K-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 55.9 | 0.0 |
| X21K-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 266.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X21K-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Tot. condensed | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 266.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 77.1 | 0.0 |
| % of condensed | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 |
| % of quaternary | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| X21 - Total condensed cover per sub-quaternary: Non-riparian | | | | | |
|---|---|---|---|---|---|
| ID | Total condensed area | % of Total condensed area | % of total area | | HA |
| X21A-1 | 3748.3 | 30.0 | 0.16 | | 12494.168 |
| X21A-2 | 6268.3 | 45.0 | 0.27 | | 13929.475 |
| X21B-1 | 1341.5 | 17.5 | 0.06 | | 7665.673 |
| X21B-2 | 1736.3 | 15.0 | 0.08 | | 11575.313 |
| X21B-3 | 3251.0 | 17.5 | 0.14 | | 18577.099 |
| X21C-1 | 2516.8 | 15.5 | 0.11 | | 16237.175 |
| X21C-2 | 1390.0 | 15.0 | 0.06 | | 9266.519 |
| X21C-3 | 139.8 | 2.5 | 0.01 | | 5592.871 |
| X21D-1 | 0.0 | 0.0 | 0.00 | | 14787.275 |
| X21D-2 | 0.0 | 0.0 | 0.00 | | 7128.310 |
| X21E-1 | 522.5 | 2.5 | 0.02 | | 20900.520 |
| X21E-2 | 0.0 | 0.0 | 0.00 | | 13611.804 |
| X21F-1 | 3097.6 | 15.0 | 0.14 | | 20650.570 |
| X21F-2 | 6179.1 | 32.5 | 0.27 | | 19012.526 |
| X21G-1 | 2125.8 | 16.0 | 0.09 | | 13286.374 |
| X21G-2 | 3324.4 | 15.5 | 0.15 | | 21447.696 |
| X21H-1 | 438.2 | 3.0 | 0.02 | | 14606.668 |
| X21H-2 | 0.0 | 0.0 | 0.00 | | 8279.533 |
| X21J-1 | 312.0 | 1.0 | 0.01 | | 31204.304 |
| X21J-2 | 42.6 | 1.0 | 0.00 | | 4258.989 |
| X21K-1 | 1899.0 | 17.0 | 0.08 | | 11170.546 |
| X21K-2 | 2450.9 | 23.0 | 0.11 | | 10656.068 |
| X21K-3 | 13.4 | 0.5 | 0.00 | | 2688.006 |
| Tot. condensed ha | 40797.4 | 13.20 | 1.8 | Tot. ha for X21 | 309027.5 |
| Total condensed area as a; | | | | | |
| % of quaternary X21 | 13.20 | | | | |
| % of Inkomati | 1.78 | | | | |

| X22 - Non-riparian: Tall tree | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ID | *Acacia sp.* | *Acacia mearnsii* | *Acacia melanoxylon* | *Casuarina sp.* | *Cedrela toona* | *Eucalyptus sp.* | *Pinus sp.* | *Populus sp.* | *Spathoda sp.* | *Tipianu sp.* |
| X22A-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 520.5 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22A-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 21.5 | 21.5 | 0.0 | 0.0 | 0.0 |
| X22B-1 | 0.0 | 328.0 | 0.0 | 0.0 | 0.0 | 0.0 | 328.0 | 0.0 | 0.0 | 0.0 |
| X22B-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 47.7 | 0.0 | 0.0 | 0.0 |
| X22C-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 115.6 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22C-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22C-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22D-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22D-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1460.2 | 0.0 | 0.0 | 0.0 |
| X22D-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 340.5 | 340.5 | 0.0 | 0.0 | 0.0 |
| X22E-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 241.9 | 0.0 | 0.0 | 0.0 |
| X22E-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 725.1 | 725.1 | 0.0 | 0.0 | 0.0 |
| X22E-3 | 0.0 | 44.3 | 0.0 | 0.0 | 0.0 | 1329.3 | 1329.3 | 0.0 | 0.0 | 0.0 |
| X22F-1 | 0.0 | 52.9 | 0.0 | 0.0 | 0.0 | 52.9 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22F-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1598.1 | 266.3 | 0.0 | 0.0 | 0.0 |
| X22G-1 | 0.0 | 193.1 | 0.0 | 0.0 | 0.0 | 193.1 | 38.6 | 0.0 | 0.0 | 0.0 |
| X22G-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 15.2 | 0.0 | 0.0 | 0.0 |
| X22H-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22H-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22H-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22J-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22J-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22K-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 51.4 | 0.0 | 0.0 | 0.0 |
| X22K-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 391.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22K-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Tot. condensed | 0.0 | 618.3 | 0.0 | 0.0 | 0.0 | 5287.8 | 4865.9 | 0.0 | 0.0 | 0.0 |
| % of condensed | 0.0 | 2.9 | 0.0 | 0.0 | 0.0 | 25.0 | 23.0 | 0.0 | 0.0 | 0.0 |
| % of quaternary | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 2.2 | 2.1 | 0.0 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.23 | 0.21 | 0.00 | 0.00 | 0.00 |

| X22 - Non-riparian: Medium tree | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ID | *Grevillea robusta* | *Jacaranda mimosifolia* | *Melia azaderach* | *Morus alba* | *Privet* | *Quercus robur* | *Salix sp.* | *Sesbania sp.* |
| X22A-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22A-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22B-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22B-2 | 0.0 | 47.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22C-1 | 0.0 | 115.6 | 115.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22C-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22C-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22D-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22D-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22D-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22E-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22E-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22E-3 | 0.0 | 44.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22F-1 | 52.9 | 52.9 | 52.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22F-2 | 0.0 | 53.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22G-1 | 0.0 | 38.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22G-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22H-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22H-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22H-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22J-1 | 0.0 | 261.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22J-2 | 0.0 | 67.7 | 67.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22K-1 | 0.0 | 51.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22K-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22K-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Tot. condensed | 52.9 | 732.7 | 236.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of condensed | 0.3 | 3.5 | 1.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of quaternary | 0.0 | 0.3 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.03 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

## X22 - Non-riparian: Tall shrub

| ID | *Agave sp.* | *Arundo donax* | *Caesalpinea decapetala* | *Chromelaena odorata* | *Cotoneaster sp.* | *Datura sp.* | *Lantana camara* | *Psidium guajava* | *Pueraria lobata* | *Ricinus communis* | *Rubus sp.* | *Senna didymobotrya* | *Senna sp.* | *Solanum maritianum* | *Solanum sp.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| X22A-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22A-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 21.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22B-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 65.6 | 0.0 |
| X22B-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22C-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 115.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22C-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1717.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1717.5 | 0.0 |
| X22C-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 513.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22D-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22D-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22D-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22E-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22E-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22E-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 221.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 221.6 | 44.3 |
| X22F-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 52.9 | 52.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 52.9 | 0.0 |
| X22F-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 266.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1598.1 | 0.0 |
| X22G-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 193.1 | 0.0 |
| X22G-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 15.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 15.2 | 0.0 |
| X22H-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22H-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22H-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22J-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1567.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 261.2 | 0.0 |
| X22J-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 338.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 67.7 | 0.0 |
| X22K-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 51.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X22K-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 78.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 78.2 | 0.0 |
| X22K-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Tot. condensed | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 4445.9 | 566.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 4271.0 | 44.3 |
| % of condensed | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 21.0 | 2.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 20.2 | 0.2 |
| % of quaternary | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.9 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.8 | 0.0 |
| % of Inkomati | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.19 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.19 | 0.00 |

| X22 - Total condensed cover per sub-quaternary: Non-riparian | | | | | |
|---|---|---|---|---|---|
| ID | Total condensed area | % of Total condensed area | % of total area | | HA |
| X22A-1 | 520.5 | 2.5 | 0.02 | | 20818.932 |
| X22A-2 | 64.6 | 1.5 | 0.00 | | 4306.761 |
| X22B-1 | 721.6 | 5.5 | 0.03 | | 13120.840 |
| X22B-2 | 95.5 | 1.0 | 0.00 | | 9545.313 |
| X22C-1 | 462.6 | 10.0 | 0.02 | | 4625.622 |
| X22C-2 | 3435.0 | 30.0 | 0.15 | | 11450.074 |
| X22C-3 | 513.6 | 2.5 | 0.02 | | 20544.909 |
| X22D-1 | 0.0 | 0.0 | 0.00 | | 4097.213 |
| X22D-2 | 1460.2 | 15.0 | 0.06 | | 9734.571 |
| X22D-3 | 681.1 | 5.0 | 0.03 | | 13621.724 |
| X22E-1 | 241.9 | 15.0 | 0.01 | | 1612.565 |
| X22E-2 | 1450.3 | 30.0 | 0.06 | | 4834.186 |
| X22E-3 | 3234.7 | 36.5 | 0.14 | | 8862.096 |
| X22F-1 | 423.4 | 4.0 | 0.02 | | 10585.689 |
| X22F-2 | 3782.1 | 35.5 | 0.17 | | 10653.723 |
| X22G-1 | 656.4 | 8.5 | 0.03 | | 7722.083 |
| X22G-2 | 45.7 | 1.5 | 0.00 | | 3046.646 |
| X22H-1 | 0.0 | 0.0 | 0.00 | | 6618.825 |
| X22H-2 | 0.0 | 0.0 | 0.00 | | 9027.020 |
| X22H-3 | 0.0 | 0.0 | 0.00 | | 4382.487 |
| X22J-1 | 2089.4 | 20.0 | 0.09 | | 10446.863 |
| X22J-2 | 541.7 | 4.0 | 0.02 | | 13541.933 |
| X22K-1 | 154.1 | 1.5 | 0.01 | | 10274.572 |
| X22K-2 | 547.5 | 3.5 | 0.02 | | 15643.629 |
| X22K-3 | 0.0 | 0.0 | 0.00 | | 7575.069 |
| Tot. condensed ha | 21121.7 | 8.92 | 0.9 | Tot. ha for X22 | 236693.3 |
| Total condensed area as a; | | | | | |
| % of quaternary X22 | 8.92 | | | | |
| % of Inkomati | 0.92 | | | | |

| X23 - Non-riparian: Tall tree | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ID | *Acacia sp.* | *Acacia mearnsii* | *Acacia melanoxylon* | *Casuarina sp.* | *Cedrela toona* | *Eucalyptus sp.* | *Pinus sp.* | *Populus sp.* | *Spathoda sp.* | *Tipianu sp.* |
| X23A-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23A-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23B-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23B-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 48.6 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23B-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1468.8 | 49.0 | 0.0 | 0.0 | 0.0 |
| X23C-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23C-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23D-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 246.1 | 49.2 | 0.0 | 0.0 | 0.0 |
| X23D-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 208.6 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23E-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23E-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23F-1 | 0.0 | 71.3 | 0.0 | 0.0 | 0.0 | 71.3 | 71.3 | 0.0 | 0.0 | 0.0 |
| X23F-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23G-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23G-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23H-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 40.7 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23H-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23H-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 450.6 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23H-4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23H-5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Tot. condensed | 0.0 | 71.3 | 0.0 | 0.0 | 0.0 | 2534.8 | 169.5 | 0.0 | 0.0 | 0.0 |
| % of condensed | 0.0 | 0.7 | 0.0 | 0.0 | 0.0 | 24.5 | 1.6 | 0.0 | 0.0 | 0.0 |
| % of quaternary | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.5 | 0.1 | 0.0 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.11 | 0.01 | 0.00 | 0.00 | 0.00 |

| X23 - Non-riparian: Medium tree | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ID | *Grevillea robusta* | *Jacaranda mimosifolia* | *Melia azaderach* | *Morus alba* | *Privet* | *Quercus robur* | *Salix sp.* | *Sesbania sp.* |
| X23A-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23A-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23B-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23B-2 | 0.0 | 0.0 | 48.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23B-3 | 0.0 | 49.0 | 244.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23C-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23C-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23D-1 | 0.0 | 49.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23D-2 | 0.0 | 41.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23E-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23E-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23F-1 | 0.0 | 356.6 | 71.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23F-2 | 0.0 | 0.0 | 417.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23G-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23G-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23H-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23H-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23H-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23H-4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23H-5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Tot. condensed | 0.0 | 496.5 | 782.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of condensed | 0.0 | 4.8 | 7.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of quaternary | 0.0 | 0.3 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.02 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

## X23 - Non-riparian: Tall shrub

| ID | *Agave sp.* | *Arundo donax* | *Caesalpinea decapetala* | *Chromelaena odorata* | *Cotoneaster sp.* | *Datura sp.* | *Lantana camara* | *Psidium guajava* | *Pueraria lobata* | *Ricinus communis* | *Rubus sp.* | *Senna didymobotrya* | *Senna sp.* | *Solanum maritianum* | *Solanum sp.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| X23A-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23A-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23B-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23B-2 | 0.0 | 0.0 | 0.0 | 48.6 | 0.0 | 0.0 | 1459.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 48.6 | 0.0 |
| X23B-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 244.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23C-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23C-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23D-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 49.2 | 49.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 49.2 | 0.0 |
| X23D-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 41.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23E-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23E-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23F-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 356.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 71.3 | 0.0 |
| X23F-2 | 0.0 | 0.0 | 0.0 | 83.5 | 0.0 | 0.0 | 2504.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23G-1 | 0.0 | 0.0 | 0.0 | 37.9 | 0.0 | 0.0 | 37.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23G-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23H-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1219.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23H-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23H-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23H-4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X23H-5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Tot. condensed | 0.0 | 0.0 | 0.0 | 170.1 | 0.0 | 0.0 | 5913.7 | 49.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 169.2 | 0.0 |
| % of condensed | 0.0 | 0.0 | 0.0 | 1.6 | 0.0 | 0.0 | 57.1 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.6 | 0.0 |
| % of quaternary | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 3.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 |
| % of Inkomati | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.26 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 |

| X23 - Total condensed cover per sub-quaternary: Non-riparian | | | | | |
|---|---|---|---|---|---|
| ID | Total condensed area | % of Total condensed area | % of total area | | HA |
| X23A-1 | 0.0 | 0.0 | 0.00 | | 5163.716 |
| X23A-2 | 0.0 | 0.0 | 0.00 | | 7517.645 |
| X23B-1 | 0.0 | 0.0 | 0.00 | | 3392.260 |
| X23B-2 | 1653.9 | 17.0 | 0.07 | | 9728.812 |
| X23B-3 | 2056.4 | 21.0 | 0.09 | | 9792.303 |
| X23C-1 | 0.0 | 0.0 | 0.00 | | 5835.838 |
| X23C-2 | 0.0 | 0.0 | 0.00 | | 2293.166 |
| X23D-1 | 492.1 | 5.0 | 0.02 | | 9842.243 |
| X23D-2 | 292.1 | 3.5 | 0.01 | | 8344.944 |
| X23E-1 | 0.0 | 0.0 | 0.00 | | 8672.304 |
| X23E-2 | 0.0 | 0.0 | 0.00 | | 9367.335 |
| X23F-1 | 1069.7 | 7.5 | 0.05 | | 14262.550 |
| X23F-2 | 3005.3 | 18.0 | 0.13 | | 16696.238 |
| X23G-1 | 75.9 | 1.0 | 0.00 | | 7588.877 |
| X23G-2 | 0.0 | 0.0 | 0.00 | | 14920.855 |
| X23H-1 | 1260.4 | 15.5 | 0.06 | | 8131.307 |
| X23H-2 | 0.0 | 0.0 | 0.00 | | 11017.144 |
| X23H-3 | 450.6 | 15.0 | 0.02 | | 3004.127 |
| X23H-4 | 0.0 | 0.0 | 0.00 | | 1101.730 |
| X23H-5 | 0.0 | 0.0 | 0.00 | | 7352.141 |
| Tot. condensed ha | 10356.3 | 6.31 | 0.5 | Tot. ha for X23 | 164025.5 |
| Total condensed area as a; | | | | | |
| % of quaternary X23 | 6.31 | | | | |
| % of Inkomati | 0.45 | | | | |

| X24 - Non-riparian: Tall tree | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ID | *Acacia sp.* | *Acacia mearnsii* | *Acacia melanoxylon* | *Casuarina sp.* | *Cedrela toona* | *Eucalyptus sp.* | *Pinus sp.* | *Populus sp.* | *Spathoda sp.* | *Tipianu sp.* |
| X24A-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X24A-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X24B-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X24B-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X24B-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X24C-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X24C-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X24D-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X24D-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 94.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| X24E-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X24E-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X24F-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X24H-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X24H-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Tot. condensed | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 94.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of condensed | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 8.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of quaternary | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| X24 - Non-riparian: Medium tree | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ID | *Grevillea robusta* | *Jacaranda mimosifolia* | *Melia azaderach* | *Morus alba* | *Privet* | *Quercus robur* | *Salix sp.* | *Sesbania sp.* |
| X24A-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X24A-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X24B-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X24B-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X24B-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X24C-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X24C-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X24D-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X24D-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X24E-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X24E-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X24F-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X24H-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X24H-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Tot. condensed | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of condensed | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of quaternary | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

## X24 - Non-riparian: Tall shrub

| ID | *Agave sp.* | *Arundo donax* | *Caesalpinea decapetala* | *Chromelaena odorata* | *Cotoneaster sp.* | *Datura sp.* | *Lantana camara* | *Psidium guajava* | *Pueraria lobata* | *Ricinus communis* | *Rubus sp.* | *Senna didymobotrya* | *Senna sp.* | *Solanum maritianum* | *Solanum sp.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| X24A-1 | 42.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 42.9 | 0.0 | 0.0 |
| X24A-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 147.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 29.5 |
| X24B-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 88.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X24B-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 58.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X24B-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 54.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X24C-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 74.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X24C-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X24D-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X24D-2 | 0.0 | 0.0 | 0.0 | 94.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X24E-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 14.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X24E-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X24F-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X24H-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X24H-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 431.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Tot. condensed | 42.9 | 0.0 | 0.0 | 94.1 | 0.0 | 0.0 | 868.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 42.9 | 0.0 | 29.5 |
| % of condensed | 3.7 | 0.0 | 0.0 | 8.0 | 0.0 | 0.0 | 74.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3.7 | 0.0 | 2.5 |
| % of quaternary | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| X24 - Total condensed cover per sub-quaternary: Non-riparian | | | | | |
|---|---|---|---|---|---|
| ID | Total condensed area | % of Total condensed area | % of total area | | HA |
| X24A-1 | 85.8 | 1.0 | 0.00 | | 8581.178 |
| X24A-2 | 177.3 | 3.0 | 0.01 | | 5909.659 |
| X24B-1 | 88.0 | 2.5 | 0.00 | | 3521.371 |
| X24B-2 | 58.7 | 0.5 | 0.00 | | 11735.987 |
| X24B-3 | 54.3 | 0.5 | 0.00 | | 10868.874 |
| X24C-1 | 74.7 | 0.5 | 0.00 | | 14937.090 |
| X24C-2 | 0.0 | 0.0 | 0.00 | | 2682.122 |
| X24D-1 | 0.0 | 0.0 | 0.00 | | 2522.714 |
| X24D-2 | 188.1 | 1.0 | 0.01 | | 18812.896 |
| X24E-1 | 14.0 | 0.5 | 0.00 | | 2809.864 |
| X24E-2 | 0.0 | 0.0 | 0.00 | | 6818.982 |
| X24F-1 | 0.0 | 0.0 | 0.00 | | 18310.679 |
| X24H-1 | 0.0 | 0.0 | 0.00 | | 11450.552 |
| X24H-2 | 431.2 | 15.0 | 0.02 | | 2874.650 |
| Tot. condensed ha | 1172.2 | 0.96 | 0.1 | Tot. ha for X24 | 121836.6 |
| Total condensed area as a; | | | | | |
| % of quaternary X24 | 0.96 | | | | |
| % of Inkomati | 0.05 | | | | |

| X31 - Non-riparian: Tall tree | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ID | *Acacia sp.* | *Acacia mearnsii* | *Acacia melanoxylon* | *Casuarina sp.* | *Cedrela toona* | *Eucalyptus sp.* | *Pinus sp.* | *Populus sp.* | *Spathoda sp.* | *Tipianu sp.* |
| X31A-1 | 0.0 | 85.7 | 0.0 | 0.0 | 0.0 | 0.0 | 2571.8 | 0.0 | 0.0 | 0.0 |
| X31A-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 818.9 | 0.0 | 0.0 | 0.0 |
| X31B-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 492.4 | 0.0 | 0.0 | 0.0 |
| X31C-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31C-2 | 0.0 | 49.5 | 0.0 | 0.0 | 0.0 | 0.0 | 247.3 | 0.0 | 0.0 | 0.0 |
| X31D-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31D-2 | 0.0 | 43.7 | 0.0 | 0.0 | 0.0 | 218.6 | 43.7 | 0.0 | 0.0 | 0.0 |
| X31D-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 221.9 | 44.4 | 0.0 | 0.0 | 0.0 |
| X31E-1 | 0.0 | 49.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1470.4 | 0.0 | 0.0 | 0.0 |
| X31E-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1195.4 | 199.2 | 0.0 | 0.0 | 0.0 |
| X31E-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31F-1 | 0.0 | 44.9 | 44.9 | 0.0 | 0.0 | 224.3 | 224.3 | 0.0 | 0.0 | 0.0 |
| X31G-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1735.0 | 1735.0 | 0.0 | 0.0 | 0.0 |
| X31G-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 27.9 | 0.0 | 0.0 | 0.0 |
| X31G-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31H-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 657.6 | 0.0 | 0.0 | 0.0 |
| X31H-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31J-1 | 0.0 | 76.1 | 0.0 | 76.1 | 0.0 | 380.3 | 76.1 | 0.0 | 0.0 | 0.0 |
| X31K-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31K-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31K-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31K-4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31L-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31L-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31L-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31M-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31M-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Tot. condensed | 0.0 | 348.9 | 44.9 | 76.1 | 0.0 | 3975.6 | 8608.9 | 0.0 | 0.0 | 0.0 |
| % of condensed | 0.0 | 1.7 | 0.2 | 0.4 | 0.0 | 18.9 | 41.0 | 0.0 | 0.0 | 0.0 |
| % of quaternary | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 1.9 | 4.0 | 0.0 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.17 | 0.38 | 0.00 | 0.00 | 0.00 |

| X31 - Non-riparian: Medium tree | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ID | *Grevillea robusta* | *Jacaranda mimosifolia* | *Melia azaderach* | *Morus alba* | *Privet* | *Quercus robur* | *Salix sp.* | *Sesbania sp.* |
| X31A-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31A-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31B-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31C-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31C-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31D-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31D-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31D-3 | 0.0 | 44.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31E-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31E-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31E-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31F-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31G-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31G-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31G-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31H-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31H-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31J-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31K-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31K-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31K-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31K-4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31L-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31L-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31L-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31M-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31M-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Tot. condensed | 0.0 | 44.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of condensed | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of quaternary | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

## X31 - Non-riparian: Tall shrub

| ID | *Agave sp.* | *Arundo donax* | *Caesalpinea decapetala* | *Chromelaena odorata* | *Cotoneaster sp.* | *Datura sp.* | *Lantana camara* | *Psidium guajava* | *Pueraria lobata* | *Ricinus communis* | *Rubus sp.* | *Senna didymobotrya* | *Senna sp.* | *Solanum maritianum* | *Solanum sp.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| X31A-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31A-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31B-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 98.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 98.5 | 0.0 |
| X31C-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31C-2 | 0.0 | 0.0 | 49.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 49.5 | 0.0 |
| X31D-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 196.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31D-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31D-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 44.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31E-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31E-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 199.2 | 0.0 | 0.0 | 0.0 | 1195.4 | 0.0 | 0.0 | 1195.4 | 0.0 |
| X31E-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31F-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 44.9 | 0.0 | 0.0 | 0.0 | 44.9 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31G-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1735.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31G-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 167.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31G-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 627.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31H-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31H-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31J-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 380.3 | 76.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 380.3 | 0.0 |
| X31K-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1197.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31K-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 18.5 | 0.0 | 0.0 |
| X31K-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 25.2 | 25.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31K-4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31L-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31L-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31L-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X31M-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 37.4 |
| X31M-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Tot. condensed | 0.0 | 0.0 | 49.5 | 0.0 | 0.0 | 0.0 | 4716.5 | 101.3 | 0.0 | 0.0 | 1240.2 | 0.0 | 18.5 | 1723.6 | 37.4 |
| % of condensed | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 22.5 | 0.5 | 0.0 | 0.0 | 5.9 | 0.0 | 0.1 | 8.2 | 0.2 |
| % of quaternary | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.2 | 0.0 | 0.0 | 0.0 | 0.6 | 0.0 | 0.0 | 0.8 | 0.0 |
| % of Inkomati | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.21 | 0.00 | 0.00 | 0.00 | 0.05 | 0.00 | 0.00 | 0.08 | 0.00 |

## X31 - Total condensed cover per sub-quaternary: Non-riparian

| ID | Total condensed area | % of Total condensed area | % of total area | | HA |
|---|---|---|---|---|---|
| X31A-1 | 2657.5 | 15.5 | 0.12 | | 17145.420 |
| X31A-2 | 818.9 | 15.0 | 0.04 | | 5459.239 |
| X31B-1 | 689.3 | 3.5 | 0.03 | | 19694.513 |
| X31C-1 | 0.0 | 0.0 | 0.00 | | 5738.868 |
| X31C-2 | 395.7 | 4.0 | 0.02 | | 9892.061 |
| X31D-1 | 196.4 | 15.0 | 0.01 | | 1309.552 |
| X31D-2 | 306.1 | 3.5 | 0.01 | | 8745.648 |
| X31D-3 | 355.1 | 4.0 | 0.02 | | 8877.617 |
| X31E-1 | 1519.4 | 15.5 | 0.07 | | 9802.347 |
| X31E-2 | 3984.6 | 50.0 | 0.17 | | 7969.113 |
| X31E-3 | 0.0 | 0.0 | 0.00 | | 3572.247 |
| X31F-1 | 628.0 | 7.0 | 0.03 | | 8972.114 |
| X31G-1 | 5204.9 | 45.0 | 0.23 | | 11566.457 |
| X31G-2 | 195.0 | 17.5 | 0.01 | | 1114.531 |
| X31G-3 | 627.7 | 15.0 | 0.03 | | 4184.814 |
| X31H-1 | 657.6 | 15.0 | 0.03 | | 4384.135 |
| X31H-2 | 0.0 | 0.0 | 0.00 | | 1506.382 |
| X31J-1 | 1445.3 | 9.5 | 0.06 | | 15213.571 |
| X31K-1 | 1197.7 | 15.0 | 0.05 | | 7984.363 |
| X31K-2 | 18.5 | 0.5 | 0.00 | | 3694.729 |
| X31K-3 | 50.5 | 1.0 | 0.00 | | 5049.485 |
| X31K-4 | 0.0 | 0.0 | 0.00 | | 9136.414 |
| X31L-1 | 0.0 | 0.0 | 0.00 | | 6700.435 |
| X31L-2 | 0.0 | 0.0 | 0.00 | | 6959.498 |
| X31L-3 | 0.0 | 0.0 | 0.00 | | 15858.429 |
| X31M-1 | 37.4 | 0.5 | 0.00 | | 7485.108 |
| X31M-2 | 0.0 | 0.0 | 0.00 | | 6342.746 |
| Tot. condensed ha | 20985.6 | 9.79 | 0.9 | Tot. ha for X31 | 214359.8 |
| Total condensed area as a; | | | | | |
| % of quaternary X31 | 9.79 | | | | |
| % of Inkomati | 0.92 | | | | |

| X32 - Non-riparian: Tall tree | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ID | *Acacia sp.* | *Acacia mearnsii* | *Acacia melanoxylon* | *Casuarina sp.* | *Cedrela toona* | *Eucalyptus sp.* | *Pinus sp.* | *Populus sp.* | *Spathoda sp.* | *Tipianu sp.* |
| X32A-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 18.9 | 18.9 | 0.0 | 0.0 | 0.0 |
| X32A-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32B-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 27.0 | 0.0 | 0.0 | 0.0 |
| X32C-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32C-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32C-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32C-4 | 0.0 | 0.0 | 0.0 | 23.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32C-5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32C-6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32C-7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32D-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 30.4 | 30.4 | 0.0 | 0.0 | 0.0 |
| X32D-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32E-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32E-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32F-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32F-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32F-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32F-4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32G-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32G-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32G-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32H-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32H-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Tot. condensed | 0.0 | 0.0 | 0.0 | 23.4 | 0.0 | 49.3 | 76.3 | 0.0 | 0.0 | 0.0 |
| % of condensed | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 | 2.2 | 3.3 | 0.0 | 0.0 | 0.0 |
| % of quaternary | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| X32 - Non-riparian: Medium tree | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ID | *Grevillea robusta* | *Jacaranda mimosifolia* | *Melia azaderach* | *Morus alba* | *Privet* | *Quercus robur* | *Salix sp.* | *Sesbania sp.* |
| X32A-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32A-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32B-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32C-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32C-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32C-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32C-4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32C-5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32C-6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32C-7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32D-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32D-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32E-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32E-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32F-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32F-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32F-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32F-4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32G-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32G-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32G-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32H-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32H-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Tot. condensed | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of condensed | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of quaternary | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| X32 - Non-riparian: Tall shrub | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ID | *Agave sp.* | *Arundo donax* | *Caesalpinea decapetala* | *Chromelaena odorata* | *Cotoneaster sp.* | *Datura sp.* | *Lantana camara* | *Psidium guajava* | *Pueraria lobata* | *Ricinus communis* | *Rubus sp.* | *Senna didymobotrya* | *Senna sp.* | *Solanum maritianum* | *Solanum sp.* |
| X32A-1 | 0.0 | 0.0 | 18.9 | 0.0 | 0.0 | 0.0 | 94.7 | 18.9 | 0.0 | 0.0 | 0.0 | 18.9 | 0.0 | 94.7 | 0.0 |
| X32A-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 36.2 | 0.0 | 36.2 | 0.0 |
| X32B-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 134.9 | 0.0 |
| X32C-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32C-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32C-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32C-4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 23.4 |
| X32C-5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32C-6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32C-7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32D-1 | 0.0 | 0.0 | 0.0 | 30.4 | 0.0 | 0.0 | 152.1 | 30.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 30.4 | 0.0 |
| X32D-2 | 0.0 | 0.0 | 18.0 | 0.0 | 0.0 | 0.0 | 90.1 | 18.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32E-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 431.8 | 0.0 | 0.0 | 0.0 | 431.8 | 0.0 | 0.0 | 431.8 | 0.0 |
| X32E-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32F-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32F-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32F-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32F-4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32G-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32G-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32G-3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32H-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| X32H-2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Tot. condensed | 0.0 | 0.0 | 37.0 | 30.4 | 0.0 | 0.0 | 768.6 | 67.4 | 0.0 | 0.0 | 431.8 | 55.1 | 0.0 | 727.9 | 23.4 |
| % of condensed | 0.0 | 0.0 | 1.6 | 1.3 | 0.0 | 0.0 | 33.6 | 2.9 | 0.0 | 0.0 | 18.8 | 2.4 | 0.0 | 31.8 | 1.0 |
| % of quaternary | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 | 0.1 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.6 | 0.0 |
| % of Inkomati | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.03 | 0.00 |

| X32 - Total condensed cover per sub-quaternary: Non-riparian | | | | | |
|---|---|---|---|---|---|
| ID | Total condensed area | % of Total condensed area | % of total area | | HA |
| X32A-1 | 284.0 | 7.5 | 0.01 | | 3787.303 |
| X32A-2 | 72.3 | 1.0 | 0.00 | | 7230.913 |
| X32B-1 | 161.9 | 3.0 | 0.01 | | 5397.044 |
| X32C-1 | 0.0 | 0.0 | 0.00 | | 1570.586 |
| X32C-2 | 0.0 | 0.0 | 0.00 | | 1289.941 |
| X32C-3 | 0.0 | 0.0 | 0.00 | | 1094.109 |
| X32C-4 | 46.9 | 1.0 | 0.00 | | 4688.037 |
| X32C-5 | 0.0 | 0.0 | 0.00 | | 6658.896 |
| X32C-6 | 0.0 | 0.0 | 0.00 | | 5878.438 |
| X32C-7 | 0.0 | 0.0 | 0.00 | | 1823.896 |
| X32D-1 | 304.1 | 5.0 | 0.01 | | 6082.240 |
| X32D-2 | 126.2 | 3.5 | 0.01 | | 3605.006 |
| X32E-1 | 1295.3 | 45.0 | 0.06 | | 2878.384 |
| X32E-2 | 0.0 | 0.0 | 0.00 | | 5061.647 |
| X32F-1 | 0.0 | 0.0 | 0.00 | | 6544.418 |
| X32F-2 | 0.0 | 0.0 | 0.00 | | 1418.129 |
| X32F-3 | 0.0 | 0.0 | 0.00 | | 2600.313 |
| X32F-4 | 0.0 | 0.0 | 0.00 | | 5761.754 |
| X32G-1 | 0.0 | 0.0 | 0.00 | | 19406.201 |
| X32G-2 | 0.0 | 0.0 | 0.00 | | 10617.395 |
| X32G-3 | 0.0 | 0.0 | 0.00 | | 1036.591 |
| X32H-1 | 0.0 | 0.0 | 0.00 | | 4998.298 |
| X32H-2 | 0.0 | 0.0 | 0.00 | | 11343.897 |
| Tot. condensed ha | 2290.7 | 1.90 | 0.1 | Tot. ha for X32 | 120773.4 |
| Total condensed area as a; | | | | | |
| % of quaternary X32 | 1.90 | | | | |
| % of Inkomati | 0.10 | | | | |

| X40C-1 Non-riparian: Tall tree | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ID | *Acacia sp.* | *Acacia mearnsii* | *Acacia melanoxylon* | *Casuarina sp.* | *Cedrela toona* | *Eucalyptus sp.* | *Pinus sp.* | *Populus sp.* | *Spathoda sp.* | *Tipianu sp.* |
| 40C-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

| X40C-1 Non-riparian: Medium tree | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ID | *Grevillea robusta* | *Jacaranda mimosifolia* | *Melia azaderach* | *Morus alba* | *Privet* | *Quercus robur* | *Salix sp.* | *Sesbania sp.* |
| X40C-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

| X40C – 1 Non-riparian: Tall shrub | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ID | *Agave sp.* | *Arundo donax* | *Caesalpinea decapetala* | *Chromelaena odorata* | *Cotoneaster sp.* | *Datura sp.* | *Lantana camara* | *Psidium guajava* | *Pueraria lobata* | *Ricinus communis* | *Rubus sp.* | *Senna didymobotrya* | *Senna sp.* | *Solanum maritianum* | *Solanum sp.* |
| X40C-1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

| X40C -1 Total condensed cover per sub-quaternary: Non-riparian | | | | | |
|---|---|---|---|---|---|
| ID | *Total condensed area* | *% of Total condensed area* | *% of total area* | | HA |
| X40C-1 | 0.0 | 0.0 | 0.00 | | 3665.180 |

# ANNEXURE 1.2

## Condensed cover per species per sub-quaternary

## RIPARIAN

| X11 - RIPARIAN: Tall tree | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sub-Quaternary | *Acacia sp.* | *Acacia mearnsii* | *Acacia melanoxylon* | *Casuarina sp.* | *Cedrela toona* | *Eucalyptus sp.* | *Pinus sp.* | *Populus sp.* | *Spathoda sp.* | *Tipianu sp.* |
| X11A-1 | 0 | 10078 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X11B-1 | 0 | 5408 | 0 | 0 | 0 | 901 | 0 | 5408 | 0 | 0 |
| X11B-2 | 0 | 118 | 0 | 0 | 0 | 3543 | 0 | 3543 | 0 | 0 |
| X11C-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X11D-1 | 0 | 642 | 0 | 0 | 0 | 0 | 642 | 3852 | 0 | 0 |
| X11D-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1433 | 0 | 0 |
| X11D-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3575 | 0 | 0 |
| X11E-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2331 | 0 | 0 |
| X11E-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X11F-1 | 0 | 2738 | 0 | 0 | 0 | 456 | 0 | 0 | 0 | 0 |
| X11G-1 | 0 | 659 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X11H-1 | 0 | 3981 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X11J-1 | 0 | 466 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X11K-1 | 0 | 0 | 0 | 0 | 0 | 0 | 33 | 163 | 0 | 0 |
| X11K-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X11K-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X11K-4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tot. condensed | 0.0 | 24090.1 | 0.0 | 0.0 | 0.0 | 4901.1 | 674.7 | 20306.6 | 0.0 | 0.0 |
| % of condensed | 0.0 | 46.7 | 0.0 | 0.0 | 0.0 | 9.5 | 1.3 | 39.4 | 0.0 | 0.0 |
| % of quaternary | 0.0 | 6.8 | 0.0 | 0.0 | 0.0 | 1.4 | 0.2 | 5.8 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 1.05 | 0.00 | 0.00 | 0.00 | 0.21 | 0.03 | 0.89 | 0.00 | 0.00 |

| X11 RIPARIAN: Medium tree | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sub-Quaternary | *Grevillea robusta* | *Jacaranda mimosifolia* | *Melia azaderach* | *Morus alba* | *Privet* | *Quercus robur* | *Salix sp.* | *Sesbania sp.* |
| X11A-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X11B-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X11B-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X11C-1 | 0 | 0 | 0 | 0 | 0 | 0 | 159 | 0 |
| X11D-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X11D-2 | 0 | 0 | 0 | 0 | 0 | 0 | 48 | 0 |
| X11D-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X11E-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X11E-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X11F-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X11G-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X11H-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X11J-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X11K-1 | 0 | 163 | 0 | 33 | 0 | 0 | 33 | 0 |
| X11K-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X11K-3 | 0 | 0 | 24 | 0 | 0 | 0 | 0 | 0 |
| X11K-4 | 0 | 0 | 101 | 0 | 0 | 0 | 0 | 0 |
| Tot. condensed | 0.0 | 162.9 | 124.5 | 32.6 | 0.0 | 0.0 | 239.8 | 0.0 |
| % of condensed | 0.0 | 0.3 | 0.2 | 0.1 | 0.0 | 0.0 | 0.5 | 0.0 |
| % of quaternary | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 |
| % of Inkomati | 0.00 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 |

## X11 – RIPARIAN: Tall shrub

| Sub-Quaternary | *Agave sp.* | *Arundo donax* | *Caesalpinea decapetala* | *Chromelaena odorata* | *Cotoneaster sp.* | *Datura sp.* | *Lantana camara* | *Psidium guajava* | *Pueraria lobata* | *Ricinus communis* | *Rubus sp.* | *Senna didymobotrya* | *Senna sp.* | *Solanum maritianum* | *Solanum sp.* | *Tithonia diversifolia* | *Zinnia peruviana* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| X11A-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X11B-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X11B-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 591 | 0 | 0 | 0 | 0 | 0 | 0 |
| X11C-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X11D-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X11D-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X11D-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X11E-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X11E-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X11F-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X11G-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X11H-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 133 | 0 | 0 | 0 |
| X11J-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 93 | 0 | 0 | 93 | 0 | 0 | 0 |
| X11K-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X11K-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X11K-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 24 | 0 | 0 | 0 |
| X11K-4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 101 | 0 | 0 | 0 |
| Tot. condensed | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 683.7 | 0.0 | 0.0 | 350.3 | 0.0 | 0.0 | 0.0 |
| % of condensed | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.3 | 0.0 | 0.0 | 0.7 | 0.0 | 0.0 | 0.0 |
| % of quaternary | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 |

## Total "condensed" cover per sub-quaternary

### X11 - RIPARIAN

| Sub-Quaternary | Total condensed area | % of Total condensed area | % of total area | | Tot. hectares of sub-quaternary |
|---|---|---|---|---|---|
| X11A-1 | 10078 | 15 | 0 | | 67188.381 |
| X11B-1 | 11718 | 33 | 1 | | 36053.970 |
| X11B-2 | 7796 | 33 | 0 | | 23622.801 |
| X11C-1 | 159 | 1 | 0 | | 31889.047 |
| X11D-1 | 5137 | 20 | 0 | | 25682.845 |
| X11D-2 | 1481 | 16 | 0 | | 9554.112 |
| X11D-3 | 3575 | 15 | 0 | | 23833.975 |
| X11E-1 | 2331 | 15 | 0 | | 15543.080 |
| X11E-2 | 0 | 0 | 0 | | 8594.418 |
| X11F-1 | 3194 | 18 | 0 | | 18253.836 |
| X11G-1 | 659 | 3 | 0 | | 26376.163 |
| X11H-1 | 4113 | 16 | 0 | | 26536.744 |
| X11J-1 | 652 | 4 | 0 | | 18623.990 |
| X11K-1 | 424 | 7 | 0 | | 6517.672 |
| X11K-2 | 0 | 0 | 0 | | 5774.422 |
| X11K-3 | 48 | 1 | 0 | | 4754.843 |
| X11K-4 | 201 | 5 | 0 | | 4029.472 |
| Tot. condensed ha | 51566.3 | 14.62 | 2.25 | Tot. ha for X11 | 352829.771 |
| Total condensed area as a; | | | | | |
| % of quaternary X11 | 14.62 | | | | |
| % of Inkomati | 2.25 | | | | |

| X12 – RIPARIAN: Tall tree | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sub-Quaternary | *Acacia sp.* | *Acacia mearnsii* | *Acacia melanoxylon* | *Casuarina sp.* | *Cedrela toona* | *Eucalyptus sp.* | *Pinus sp.* | *Populus sp.* | *Spathoda sp.* | *Tipianu sp.* |
| X12A-1 | 0 | 122 | 0 | 0 | 0 | 122 | 0 | 122 | 0 | 0 |
| X12B-1 | 0 | 2322 | 0 | 0 | 0 | 387 | 2322 | 0 | 0 | 0 |
| X12C-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X12C-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 72 | 0 | 0 |
| X12D-1 | 0 | 2083 | 0 | 0 | 0 | 0 | 0 | 347 | 0 | 0 |
| X12-D2 | 0 | 210 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X12E-1 | 0 | 832 | 0 | 0 | 0 | 0 | 0 | 166 | 0 | 0 |
| X12F-1 | 0 | 1420 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X12F-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X12F-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X12G-1 | 0 | 0 | 204 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X12G-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X12G-3 | 0 | 0 | 0 | 0 | 0 | 0 | 63 | 0 | 0 | 0 |
| X12H-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X12H-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X12H-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X12J-1 | 0 | 439 | 0 | 0 | 0 | 0 | 88 | 0 | 0 | 0 |
| X12J-2 | 0 | 34 | 0 | 0 | 0 | 0 | 34 | 0 | 0 | 0 |
| X12J-3 | 0 | 132 | 0 | 0 | 0 | 0 | 26 | 0 | 0 | 0 |
| X12K-1 | 0 | 119 | 0 | 0 | 0 | 0 | 0 | 119 | 0 | 0 |
| X12K-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tot. condensed | 0.0 | 7712.0 | 203.5 | 0.0 | 0.0 | 509.1 | 2532.4 | 826.7 | 0.0 | 0.0 |
| % of condensed | 0.0 | 39.0 | 1.0 | 0.0 | 0.0 | 2.6 | 12.8 | 4.2 | 0.0 | 0.0 |
| % of quaternary | 0.0 | 3.0 | 0.1 | 0.0 | 0.0 | 0.2 | 1.0 | 0.3 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.34 | 0.01 | 0.00 | 0.00 | 0.02 | 0.11 | 0.04 | 0.00 | 0.00 |

| X12 – RIPARIAN: Medium tree | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sub-Quaternary | *Grevillea robusta* | *Jacaranda mimosifolia* | *Melia azaderach* | *Morus alba* | *Privet* | *Quercus robur* | *Salix sp.* | *Sesbania sp.* |
| X12A-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X12B-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X12C-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X12C-2 | 0 | 0 | 72 | 0 | 0 | 0 | 0 | 0 |
| X12D-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X12-D2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X12E-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X12F-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X12F-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X12F-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X12G-1 | 0 | 0 | 41 | 0 | 0 | 0 | 0 | 0 |
| X12G-2 | 0 | 0 | 16 | 0 | 0 | 0 | 0 | 0 |
| X12G-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X12H-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X12H-2 | 0 | 0 | 70 | 0 | 0 | 0 | 0 | 0 |
| X12H-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 190 |
| X12J-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X12J-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X12J-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X12K-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X12K-2 | 0 | 0 | 24 | 0 | 0 | 0 | 0 | 24 |
| Tot. condensed | 0.0 | 0.0 | 221.6 | 0.0 | 0.0 | 0.0 | 0.0 | 214.1 |
| % of condensed | 0.0 | 0.0 | 1.1 | 0.0 | 0.0 | 0.0 | 0.0 | 1.1 |
| % of quaternary | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 |
| % of Inkomati | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |

## X12- RIPARIAN: Tall shrub

| Sub-Quaternary | *Agave sp.* | *Arundo donax* | *Caesalpinea decapetala* | *Chromelaena odorata* | *Cotoneaster sp.* | *Datura sp.* | *Lantana camara* | *Psidium guajava* | *Pueraria lobata* | *Ricinus communis* | *Rubus sp.* | *Senna didymobotrya* | *Senna sp.* | *Solanum maritianum* | *Solanum sp.* | *Tithonia diversifolia* | *Zinnia peruviana* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| X12A-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 122 | 0 | 0 |
| X12B-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 387 | 0 | 0 | 77 | 0 | 0 | 0 |
| X12C-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X12C-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 72 | 0 | 0 | 0 |
| X12D-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X12-D2 | 0 | 0 | 0 | 0 | 0 | 210 | 210 | 42 | 0 | 42 | 0 | 0 | 0 | 42 | 0 | 0 | 0 |
| X12E-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X12F-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X12F-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X12F-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X12G-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X12G-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 79 | 0 | 0 |
| X12G-3 | 0 | 0 | 0 | 0 | 0 | 0 | 63 | 63 | 0 | 0 | 63 | 0 | 63 | 63 | 0 | 0 | 0 |
| X12H-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 35 | 0 | 0 |
| X12H-2 | 0 | 0 | 0 | 0 | 0 | 0 | 70 | 0 | 0 | 0 | 0 | 70 | 0 | 0 | 70 | 0 | 0 |
| X12H-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X12J-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 439 | 0 | 0 | 439 | 0 | 0 | 0 |
| X12J-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1015 | 0 | 0 | 0 | 0 | 0 | 0 |
| X12J-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X12K-1 | 0 | 0 | 0 | 0 | 0 | 0 | 3579 | 0 | 0 | 119 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X12K-2 | 0 | 0 | 0 | 0 | 0 | 0 | 119 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tot. condensed | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 210.2 | 4040.7 | 105.0 | 0.0 | 161.3 | 1903.6 | 69.6 | 62.9 | 692.6 | 305.7 | 0.0 | 0.0 |
| % of condensed | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.1 | 20.4 | 0.5 | 0.0 | 0.8 | 9.6 | 0.4 | 0.3 | 3.5 | 1.5 | 0.0 | 0.0 |
| % of quaternary | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 1.6 | 0.0 | 0.0 | 0.1 | 0.7 | 0.0 | 0.0 | 0.3 | 0.1 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.18 | 0.00 | 0.00 | 0.01 | 0.08 | 0.00 | 0.00 | 0.03 | 0.01 | 0.00 | 0.00 |

| Total "condensed" cover per sub-quaternary | | | | | |
|---|---|---|---|---|---|
| X12 - RIPARIAN | | | | | |
| Sub-Quaternary | *Total condensed area* | *% of Total condensed area* | *% of total area* | | Tot. hectares of sub-quaternary |
| X12A-1 | 489 | 2 | 0.02 | | 24435.687 |
| X12B-1 | 5494 | 36 | 0.24 | | 15477.229 |
| X12C-1 | 0 | 0 | 0.00 | | 4246.951 |
| X12C-2 | 215 | 2 | 0.01 | | 14345.010 |
| X12D-1 | 2430 | 18 | 0.11 | | 13887.551 |
| X12-D2 | 757 | 9 | 0.03 | | 8406.806 |
| X12E-1 | 998 | 3 | 0.04 | | 33268.015 |
| X12F-1 | 1420 | 15 | 0.06 | | 9465.948 |
| X12F-2 | 0 | 0 | 0.00 | | 6391.499 |
| X12F-3 | 0 | 0 | 0.00 | | 15404.865 |
| X12G-1 | 244 | 3 | 0.01 | | 8140.664 |
| X12G-2 | 94 | 3 | 0.00 | | 3148.973 |
| X12G-3 | 378 | 3 | 0.02 | | 12584.357 |
| X12H-1 | 35 | 1 | 0.00 | | 7033.653 |
| X12H-2 | 278 | 2 | 0.01 | | 13924.799 |
| X12H-3 | 190 | 3 | 0.01 | | 7613.605 |
| X12J-1 | 1403 | 8 | 0.06 | | 17541.559 |
| X12J-2 | 1083 | 16 | 0.05 | | 6767.918 |
| X12J-3 | 158 | 3 | 0.01 | | 5264.857 |
| X12K-1 | 3937 | 17 | 0.17 | | 23860.688 |
| X12K-2 | 166 | 4 | 0.01 | | 4755.863 |
| Tot. condensed ha | 19771.0 | 7.72 | 0.86 | Tot. ha for X12 | 255966.497 |
| Total condensed area as a; | | | | | |
| % of quaternary X12 | 7.72 | | | | |
| % of Inkomati | 0.86 | | | | |

| X13 – RIPARIAN: Tall tree | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sub-Quaternary | *Acacia sp.* | *Acacia mearnsii* | *Acacia melanoxylon* | *Casuarina sp.* | *Cedrela toona* | *Eucalyptus sp.* | *Pinus sp.* | *Populus sp.* | *Spathoda sp.* | *Tipianu sp.* |
| X13A-1 | 0 | 612 | 0 | 0 | 0 | 612 | 612 | 0 | 0 | 0 |
| X13B-1 | 0 | 74 | 0 | 0 | 0 | 74 | 74 | 0 | 0 | 0 |
| X13B-2 | 0 | 0 | 0 | 0 | 0 | 44 | 44 | 0 | 0 | 0 |
| X13C-1 | 0 | 2928 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13D-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13E-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13F-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13F-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13G-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13G-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13G-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13H-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13H-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13J-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13J-2 | 403 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13J-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13J-4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13K-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13K-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13L-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13L-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tot. condensed | 402.9 | 3614.8 | 0.0 | 0.0 | 0.0 | 730.4 | 730.4 | 0.0 | 0.0 | 0.0 |
| % of condensed | 0.8 | 7.4 | 0.0 | 0.0 | 0.0 | 1.5 | 1.5 | 0.0 | 0.0 | 0.0 |
| % of quaternary | 0.1 | 1.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.0 | 0.0 | 0.0 |
| % of Inkomati | 0.02 | 0.16 | 0.00 | 0.00 | 0.00 | 0.03 | 0.03 | 0.00 | 0.00 | 0.00 |

| X13 – RIPARIAN: Medium tree | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sub-Quaternary | *Grevillea robusta* | *Jacaranda mimosifolia* | *Melia azaderach* | *Morus alba* | *Privet* | *Quercus robur* | *Salix sp.* | *Sesbania sp.* |
| X13A-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13B-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13B-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13C-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13D-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13E-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13F-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13F-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13G-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13G-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13G-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13H-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13H-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13J-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13J-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13J-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13J-4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13K-1 | 0 | 0 | 3822 | 0 | 0 | 0 | 0 | 0 |
| X13K-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13L-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13L-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tot. condensed | 0.0 | 0.0 | 3821.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of condensed | 0.0 | 0.0 | 7.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of quaternary | 0.0 | 0.0 | 1.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.00 | 0.17 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

## X13 – RIPARIAN: Tall shrub

| Sub-Quaternary | *Agave sp.* | *Arundo donax* | *Caesalpinea decapetala* | *Chromelaena odorata* | *Cotoneaster sp.* | *Datura sp.* | *Lantana camara* | *Psidium guajava* | *Pueraria lobata* | *Ricinus communis* | *Rubus sp.* | *Senna didymobotrya* | *Senna sp.* | *Solanum maritianum* | *Solanum sp.* | *Tithonia diversifolia* | *Zinnia peruviana* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| X13A-1 | 0 | 0 | 122 | 0 | 0 | 0 | 612 | 0 | 0 | 0 | 122 | 0 | 0 | 3672 | 0 | 0 | 0 |
| X13B-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13B-2 | 0 | 0 | 0 | 0 | 0 | 0 | 44 | 44 | 0 | 44 | 0 | 0 | 0 | 44 | 0 | 0 | 0 |
| X13C-1 | 0 | 0 | 98 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13D-1 | 0 | 0 | 0 | 2710 | 0 | 90 | 452 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13E-1 | 0 | 0 | 0 | 3173 | 0 | 0 | 529 | 0 | 0 | 0 | 0 | 106 | 0 | 0 | 106 | 0 | 0 |
| X13F-1 | 0 | 0 | 0 | 3079 | 0 | 0 | 3079 | 0 | 0 | 3079 | 0 | 0 | 0 | 3079 | 0 | 0 | 0 |
| X13F-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13G-1 | 0 | 0 | 0 | 1060 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1060 | 0 | 0 | 0 | 0 | 0 |
| X13G-2 | 0 | 0 | 0 | 3190 | 0 | 0 | 0 | 0 | 0 | 532 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13G-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 770 | 0 | 0 |
| X13H-1 | 0 | 0 | 0 | 1492 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13H-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 515 | 515 | 0 | 0 | 0 |
| X13J-1 | 0 | 0 | 0 | 176 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13J-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13J-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13J-4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13K-1 | 0 | 0 | 0 | 3822 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13K-2 | 0 | 0 | 0 | 183 | 0 | 0 | 183 | 0 | 0 | 183 | 0 | 915 | 0 | 0 | 0 | 0 | 0 |
| X13L-1 | 0 | 0 | 0 | 109 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X13L-2 | 0 | 34 | 0 | 170 | 0 | 0 | 0 | 34 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tot. condensed | 0.0 | 33.9 | 220.0 | 19164.4 | 0.0 | 90.3 | 4898.5 | 78.0 | 0.0 | 3837.6 | 122.4 | 2081.2 | 515.2 | 7310.1 | 875.5 | 0.0 | 0.0 |
| % of condensed | 0.0 | 0.1 | 0.5 | 39.5 | 0.0 | 0.2 | 10.1 | 0.2 | 0.0 | 7.9 | 0.3 | 4.3 | 1.1 | 15.1 | 1.8 | 0.0 | 0.0 |
| % of quaternary | 0.0 | 0.0 | 0.1 | 5.3 | 0.0 | 0.0 | 1.4 | 0.0 | 0.0 | 1.1 | 0.0 | 0.6 | 0.1 | 2.0 | 0.2 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.00 | 0.01 | 0.84 | 0.00 | 0.00 | 0.21 | 0.00 | 0.00 | 0.17 | 0.01 | 0.09 | 0.02 | 0.32 | 0.04 | 0.00 | 0.00 |

## Total "condensed" cover per sub-quaternary

### X13 - RIPARIAN

| Sub-Quaternary | Total condensed area | % of Total condensed area | % of total area | | Tot. hectares of sub-quaternary |
|---|---|---|---|---|---|
| X13A-1 | 6365 | 26 | 0.28 | | 24479.897 |
| X13B-1 | 223 | 2 | 0.01 | | 14861.280 |
| X13B-2 | 264 | 3 | 0.01 | | 8811.524 |
| X13C-1 | 3026 | 16 | 0.13 | | 19523.113 |
| X13D-1 | 3252 | 18 | 0.14 | | 18065.778 |
| X13E-1 | 3914 | 19 | 0.17 | | 21155.552 |
| X13F-1 | 12316 | 60 | 0.54 | | 20525.889 |
| X13F-2 | 0 | 0 | 0.00 | | 1172.886 |
| X13G-1 | 2121 | 30 | 0.09 | | 7069.950 |
| X13G-2 | 3722 | 18 | 0.16 | | 21268.667 |
| X13G-3 | 770 | 15 | 0.03 | | 5131.663 |
| X13H-1 | 1492 | 15 | 0.07 | | 9948.122 |
| X13H-2 | 1030 | 5 | 0.05 | | 20608.708 |
| X13J-1 | 176 | 3 | 0.01 | | 7024.405 |
| X13J-2 | 403 | 3 | 0.02 | | 16114.867 |
| X13J-3 | 0 | 0 | 0.00 | | 52251.429 |
| X13J-4 | 0 | 0 | 0.00 | | 3540.534 |
| X13K-1 | 7643 | 30 | 0.33 | | 25477.966 |
| X13K-2 | 1464 | 4 | 0.06 | | 36595.893 |
| X13L-1 | 109 | 1 | 0.00 | | 21852.724 |
| X13L-2 | 238 | 4 | 0.01 | | 6788.994 |
| Tot. condensed ha | 48527.3 | 13.40 | 2.12 | Tot. ha for X13 | 362269.841 |
| Total condensed area as a; | | | | | |
| % of quaternary X13 | 13.40 | | | | |
| % of Inkomati | 2.12 | | | | |

| X14 – RIPARIAN: Tall tree | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sub-Quaternary | *Acacia sp.* | *Acacia mearnsii* | *Acacia melanoxylon* | *Casuarina sp.* | *Cedrela toona* | *Eucalyptus sp.* | *Pinus sp.* | *Populus sp.* | *Spathoda sp.* | *Tipianu sp.* |
| X14A-1 | 0 | 352 | 0 | 0 | 0 | 70 | 0 | 0 | 0 | 0 |
| X14B-1 | 0 | 0 | 0 | 0 | 0 | 19 | 19 | 0 | 0 | 0 |
| X14B-2 | 0 | 0 | 0 | 0 | 0 | 370 | 370 | 0 | 0 | 0 |
| X14C-1 | 0 | 83 | 0 | 0 | 0 | 0 | 2486 | 0 | 0 | 0 |
| X14D-1 | 0 | 0 | 0 | 0 | 0 | 942 | 0 | 0 | 0 | 0 |
| X14D-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X14E-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X14F-1 | 0 | 0 | 0 | 0 | 0 | 1762 | 0 | 0 | 0 | 0 |
| X14G-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X14G-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X14G-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X14H-1 | 0 | 0 | 0 | 180 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tot. condensed | 0.0 | 434.9 | 0.0 | 179.9 | 0.0 | 3162.9 | 2874.5 | 0.0 | 0.0 | 0.0 |
| % of condensed | 0.0 | 1.8 | 0.0 | 0.8 | 0.0 | 13.3 | 12.1 | 0.0 | 0.0 | 0.0 |
| % of quaternary | 0.0 | 0.3 | 0.0 | 0.1 | 0.0 | 2.1 | 1.9 | 0.0 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.02 | 0.00 | 0.01 | 0.00 | 0.14 | 0.13 | 0.00 | 0.00 | 0.00 |

| X14 – RIPARIAN: Medium tree | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sub-Quaternary | *Grevillea robusta* | *Jacaranda mimosifolia* | *Melia azaderach* | *Morus alba* | *Privet* | *Quercus robur* | *Salix sp.* | *Sesbania sp.* |
| X14A-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X14B-1 | 0 | 0 | 0 | 0 | 19 | 0 | 0 | 0 |
| X14B-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X14C-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X14D-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X14D-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X14E-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X14F-1 | 0 | 0 | 59 | 0 | 0 | 0 | 0 | 0 |
| X14G-1 | 0 | 0 | 37 | 0 | 0 | 0 | 0 | 37 |
| X14G-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X14G-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X14H-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tot. condensed | 0.0 | 0.0 | 95.9 | 0.0 | 18.7 | 0.0 | 0.0 | 37.2 |
| % of condensed | 0.0 | 0.0 | 0.4 | 0.0 | 0.1 | 0.0 | 0.0 | 0.2 |
| % of quaternary | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

## X14 – RIPARIAN: Tall shrub

| Sub-Quaternary | *Agave sp.* | *Arundo donax* | *Caesalpinea decapetala* | *Chromelaena odorata* | *Cotoneaster sp.* | *Datura sp.* | *Lantana camara* | *Psidium guajava* | *Pueraria lobata* | *Ricinus communis* | *Rubus sp.* | *Senna didymobotrya* | *Senna sp.* | *Solanum maritianum* | *Solanum sp.* | *Tithonia diversifolia* | *Zinnia peruviana* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| X14A-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 352 | 0 | 0 | 70 | 0 | 0 | 0 |
| X14B-1 | 0 | 0 | 0 | 0 | 19 | 0 | 0 | 0 | 0 | 0 | 19 | 0 | 0 | 93 | 0 | 0 | 0 |
| X14B-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2219 | 0 | 0 | 2219 | 0 | 0 | 0 |
| X14C-1 | 0 | 0 | 83 | 83 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 83 | 83 | 0 | 0 |
| X14D-1 | 0 | 0 | 157 | 942 | 0 | 0 | 0 | 157 | 0 | 0 | 0 | 0 | 157 | 157 | 0 | 0 | 0 |
| X14D-2 | 0 | 0 | 165 | 987 | 0 | 165 | 33 | 0 | 0 | 0 | 0 | 0 | 33 | 0 | 0 | 0 | 0 |
| X14E-1 | 0 | 0 | 0 | 33 | 0 | 33 | 33 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X14F-1 | 0 | 0 | 59 | 1762 | 0 | 59 | 59 | 59 | 0 | 59 | 0 | 0 | 0 | 294 | 0 | 0 | 0 |
| X14G-1 | 0 | 0 | 37 | 186 | 0 | 0 | 37 | 37 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X14G-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X14G-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X14H-1 | 0 | 0 | 0 | 5397 | 0 | 180 | 180 | 0 | 0 | 180 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tot. condensed | 0.0 | 0.0 | 500.3 | 9390.3 | 18.7 | 436.5 | 342.0 | 252.9 | 0.0 | 238.6 | 2589.9 | 0.0 | 189.9 | 2916.4 | 82.9 | 0.0 | 0.0 |
| % of condensed | 0.0 | 0.0 | 2.1 | 39.5 | 0.1 | 1.8 | 1.4 | 1.1 | 0.0 | 1.0 | 10.9 | 0.0 | 0.8 | 12.3 | 0.3 | 0.0 | 0.0 |
| % of quaternary | 0.0 | 0.0 | 0.3 | 6.3 | 0.0 | 0.3 | 0.2 | 0.2 | 0.0 | 0.2 | 1.8 | 0.0 | 0.1 | 2.0 | 0.1 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.00 | 0.02 | 0.41 | 0.00 | 0.02 | 0.01 | 0.01 | 0.00 | 0.01 | 0.11 | 0.00 | 0.01 | 0.13 | 0.00 | 0.00 | 0.00 |

| Total "condensed" cover per sub-quaternary | | | | | |
|---|---|---|---|---|---|
| X14 - RIPARIAN | | | | | |
| Sub-Quaternary | Total condensed area | % of Total condensed area | % of total area | | Tot. hectares of sub-quaternary |
| X14A-1 | 845 | 6 | 0.04 | | 14081.582 |
| X14B-1 | 187 | 5 | 0.01 | | 3732.422 |
| X14B-2 | 5178 | 35 | 0.23 | | 14794.471 |
| X14C-1 | 2900 | 18 | 0.13 | | 16572.966 |
| X14D-1 | 2511 | 40 | 0.11 | | 6278.364 |
| X14D-2 | 1382 | 21 | 0.06 | | 6581.480 |
| X14E-1 | 100 | 1 | 0.00 | | 17732.462 |
| X14F-1 | 4170 | 36 | 0.18 | | 11747.809 |
| X14G-1 | 372 | 5 | 0.02 | | 7431.552 |
| X14G-2 | 0 | 0 | 0.00 | | 10940.591 |
| X14G-3 | 0 | 0 | 0.00 | | 2046.290 |
| X14H-1 | 6117 | 17 | 0.27 | | 35981.366 |
| Tot. condensed ha | 23762.2 | 16.06 | 1.04 | Tot. ha for X14 | 147921.355 |
| Total condensed area as a; | | | | | |
| % of quaternary X14 | 16.06 | | | | |
| % of Inkomati | 1.04 | | | | |

## Total "condensed" cover per sub-quaternary

### X21 - RIPARIAN

| Sub-Quaternary | *Total condensed area* | *% of Total condensed area* | *% of total area* | | Tot. hectares of sub-quaternary |
|---|---|---|---|---|---|
| X12A-1 | 0 | 0 | 0.00 | | 12494.168 |
| X21A-2 | 2089 | 15 | 0.09 | | 13929.475 |
| X21B-1 | 3450 | 45 | 0.15 | | 7665.673 |
| X21B-2 | 2026 | 18 | 0.09 | | 11575.313 |
| X21B-3 | 6130 | 33 | 0.27 | | 18577.099 |
| X21C-1 | 0 | 0 | 0.00 | | 16237.175 |
| X21C-2 | 0 | 0 | 0.00 | | 9266.519 |
| X21C-3 | 28 | 1 | 0.00 | | 5592.871 |
| X21D-1 | 3327 | 23 | 0.15 | | 14787.275 |
| X21D-2 | 1604 | 23 | 0.07 | | 7128.310 |
| X21E-1 | 209 | 1 | 0.01 | | 20900.520 |
| X21E-2 | 2042 | 15 | 0.09 | | 13611.804 |
| X21F-1 | 4233 | 21 | 0.18 | | 20650.570 |
| X21F-2 | 2852 | 15 | 0.12 | | 19012.526 |
| X21G-1 | 4119 | 31 | 0.18 | | 13286.374 |
| X21G-2 | 3539 | 17 | 0.15 | | 21447.696 |
| X21H-1 | 365 | 3 | 0.02 | | 14606.668 |
| X21H-2 | 207 | 3 | 0.01 | | 8279.533 |
| X21J-1 | 468 | 2 | 0.02 | | 31204.304 |
| X21J-2 | 639 | 15 | 0.03 | | 4258.989 |
| X21K-1 | 391 | 4 | 0.02 | | 11170.546 |
| X21K-2 | 3996 | 38 | 0.17 | | 10656.068 |
| X21K-3 | 497 | 19 | 0.02 | | 2688.006 |
| Tot. condensed ha | 42211.1 | 13.66 | 1.84 | Tot. ha for X21 | 309027.482 |
| Total condensed area as a; | | | | | |
| % of quaternary X21 | 13.66 | | | | |
| % of Inkomati | 1.84 | | | | |

| X22 – RIPARIAN: Tall tree | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sub-Quaternary | *Acacia sp.* | *Acacia mearnsii* | *Acacia melanoxylon* | *Casuarina sp.* | *Cedrela toona* | *Eucalyptus sp.* | *Pinus sp.* | *Populus sp.* | *Spathoda sp.* | *Tipianu sp.* |
| X22A-1 | 0 | 0 | 0 | 0 | 0 | 104 | 104 | 0 | 0 | 0 |
| X22A-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 108 | 0 | 0 |
| X22B-1 | 0 | 0 | 0 | 0 | 0 | 66 | 66 | 0 | 0 | 0 |
| X22B-2 | 0 | 0 | 0 | 0 | 48 | 0 | 0 | 48 | 0 | 0 |
| X22C-1 | 0 | 0 | 0 | 0 | 0 | 694 | 0 | 0 | 0 | 0 |
| X22C-2 | 0 | 286 | 0 | 0 | 0 | 286 | 0 | 0 | 0 | 0 |
| X22C-3 | 0 | 103 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X22D-1 | 0 | 0 | 0 | 0 | 0 | 0 | 20 | 0 | 0 | 0 |
| X22D-2 | 0 | 49 | 0 | 0 | 0 | 49 | 243 | 0 | 0 | 0 |
| X22D-3 | 0 | 68 | 0 | 0 | 0 | 341 | 68 | 68 | 0 | 0 |
| X22E-1 | 0 | 40 | 0 | 0 | 0 | 242 | 0 | 0 | 0 | 0 |
| X22E-2 | 0 | 725 | 0 | 0 | 0 | 24 | 121 | 0 | 0 | 0 |
| X22E-3 | 0 | 0 | 0 | 0 | 0 | 1329 | 1329 | 0 | 0 | 0 |
| X22F-1 | 0 | 53 | 0 | 0 | 0 | 1588 | 0 | 0 | 0 | 0 |
| X22F-2 | 0 | 266 | 0 | 0 | 0 | 266 | 53 | 0 | 0 | 0 |
| X22G-1 | 0 | 0 | 0 | 0 | 0 | 1158 | 193 | 0 | 0 | 0 |
| X22G-2 | 0 | 457 | 0 | 0 | 0 | 457 | 15 | 0 | 0 | 0 |
| X22H-1 | 0 | 33 | 0 | 0 | 0 | 993 | 0 | 0 | 0 | 0 |
| X22H-2 | 0 | 45 | 0 | 0 | 0 | 1354 | 0 | 0 | 0 | 0 |
| X22H-3 | 0 | 0 | 0 | 0 | 0 | 657 | 0 | 0 | 0 | 0 |
| X22J-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X22J-2 | 0 | 0 | 0 | 0 | 0 | 339 | 0 | 0 | 0 | 0 |
| X22K-1 | 0 | 0 | 0 | 0 | 0 | 257 | 51 | 0 | 0 | 0 |
| X22K-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X22K-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tot. condensed | 0.0 | 2125.7 | 0.0 | 0.0 | 47.7 | 10203.5 | 2264.8 | 223.5 | 0.0 | 0.0 |
| % of condensed | 0.0 | 5.6 | 0.0 | 0.0 | 0.1 | 26.8 | 5.9 | 0.6 | 0.0 | 0.0 |
| % of quaternary | 0.0 | 0.9 | 0.0 | 0.0 | 0.0 | 4.3 | 1.0 | 0.1 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.09 | 0.00 | 0.00 | 0.00 | 0.45 | 0.10 | 0.01 | 0.00 | 0.00 |

| X23 – RIPARIAN: Tall tree | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sub-Quaternary | *Acacia sp.* | *Acacia mearnsii* | *Acacia melanoxylon* | *Casuarina sp.* | *Cedrela toona* | *Eucalyptus sp.* | *Pinus sp.* | *Populus sp.* | *Spathoda sp.* | *Tipianu sp.* |
| X23A-1 | 0 | 129 | 0 | 0 | 0 | 129 | 26 | 0 | 0 | 0 |
| X23A-2 | 0 | 0 | 0 | 0 | 0 | 1128 | 38 | 0 | 0 | 0 |
| X23B-1 | 0 | 17 | 0 | 0 | 0 | 85 | 85 | 0 | 0 | 0 |
| X23B-2 | 0 | 0 | 0 | 0 | 0 | 49 | 49 | 0 | 0 | 0 |
| X23B-3 | 0 | 0 | 0 | 0 | 0 | 1469 | 0 | 0 | 0 | 0 |
| X23C-1 | 0 | 0 | 0 | 0 | 0 | 0 | 146 | 0 | 0 | 0 |
| X23C-2 | 0 | 0 | 0 | 0 | 0 | 11 | 0 | 0 | 0 | 0 |
| X23D-1 | 0 | 0 | 0 | 0 | 0 | 246 | 0 | 0 | 0 | 0 |
| X23D-2 | 0 | 0 | 0 | 0 | 42 | 0 | 0 | 0 | 0 | 0 |
| X23E-1 | 0 | 43 | 0 | 0 | 0 | 43 | 0 | 0 | 0 | 0 |
| X23E-2 | 0 | 47 | 0 | 0 | 0 | 234 | 0 | 0 | 0 | 0 |
| X23F-1 | 0 | 71 | 0 | 0 | 0 | 357 | 0 | 0 | 0 | 0 |
| X23F-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X23G-1 | 0 | 0 | 0 | 0 | 0 | 38 | 0 | 0 | 0 | 0 |
| X23G-2 | 0 | 0 | 0 | 0 | 0 | 373 | 0 | 0 | 0 | 0 |
| X23H-1 | 0 | 0 | 0 | 0 | 0 | 203 | 0 | 0 | 0 | 0 |
| X23H-2 | 0 | 0 | 0 | 0 | 0 | 275 | 0 | 0 | 0 | 0 |
| X23H-3 | 0 | 0 | 0 | 0 | 0 | 15 | 0 | 0 | 0 | 0 |
| X23H-4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X23H-5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tot. condensed | 0.0 | 307.6 | 0.0 | 0.0 | 41.7 | 4655.4 | 342.8 | 0.0 | 0.0 | 0.0 |
| % of condensed | 0.0 | 1.6 | 0.0 | 0.0 | 0.2 | 23.6 | 1.7 | 0.0 | 0.0 | 0.0 |
| % of quaternary | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 2.8 | 0.2 | 0.0 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.20 | 0.01 | 0.00 | 0.00 | 0.00 |

| X23 – RIPARIAN: Medium tree | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sub-Quaternary | *Grevillea robusta* | *Jacaranda mimosifolia* | *Melia azaderach* | *Morus alba* | *Privet* | *Quercus robur* | *Salix sp.* | *Sesbania sp.* |
| X23A-1 | 0 | 26 | 26 | 0 | 0 | 0 | 0 | 0 |
| X23A-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X23B-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X23B-2 | 0 | 243 | 243 | 49 | 0 | 0 | 0 | 0 |
| X23B-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X23C-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X23C-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X23D-1 | 0 | 0 | 49 | 0 | 0 | 0 | 0 | 0 |
| X23D-2 | 0 | 0 | 42 | 42 | 0 | 0 | 0 | 0 |
| X23E-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X23E-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X23F-1 | 0 | 357 | 357 | 0 | 0 | 0 | 0 | 0 |
| X23F-2 | 0 | 0 | 2504 | 0 | 0 | 0 | 0 | 0 |
| X23G-1 | 0 | 0 | 38 | 0 | 0 | 0 | 0 | 0 |
| X23G-2 | 0 | 0 | 2238 | 0 | 0 | 0 | 0 | 0 |
| X23H-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X23H-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X23H-3 | 0 | 75 | 0 | 0 | 0 | 0 | 0 | 0 |
| X23H-4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X23H-5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tot. condensed | 0.0 | 700.7 | 5497.0 | 90.4 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of condensed | 0.0 | 3.6 | 27.9 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of quaternary | 0.0 | 0.4 | 3.4 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.03 | 0.24 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

## X23 – RIPARIAN: Tall shrub

| Sub-Quaternary | *Agave sp.* | *Arundo donax* | *Caesalpinea decapetala* | *Chromelaena odorata* | *Cotoneaster sp.* | *Datura sp.* | *Lantana camara* | *Psidium guajava* | *Pueraria lobata* | *Ricinus communis* | *Rubus sp.* | *Senna didymobotrya* | *Senna sp.* | *Solanum maritianum* | *Solanum sp.* | *Tithonia diversifolia* | *Zinnia peruviana* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| X23A-1 | 0 | 0 | 0 | 0 | 0 | 0 | 26 | 0 | 0 | 0 | 26 | 0 | 0 | 129 | 0 | 0 | 0 |
| X23A-2 | 0 | 0 | 0 | 0 | 0 | 0 | 38 | 38 | 0 | 0 | 0 | 0 | 0 | 188 | 0 | 0 | 0 |
| X23B-1 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 0 | 0 | 0 | 17 | 0 | 0 | 17 | 0 | 0 | 0 |
| X23B-2 | 0 | 0 | 0 | 0 | 0 | 0 | 49 | 0 | 0 | 0 | 0 | 0 | 0 | 243 | 0 | 0 | 0 |
| X23B-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 245 | 0 | 0 | 0 | 0 | 0 | 0 |
| X23C-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 146 | 0 | 0 | 146 | 0 | 0 | 0 |
| X23C-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 0 | 0 | 0 |
| X23D-1 | 0 | 0 | 0 | 0 | 0 | 0 | 49 | 49 | 0 | 49 | 49 | 0 | 0 | 246 | 0 | 0 | 0 |
| X23D-2 | 0 | 0 | 0 | 0 | 0 | 0 | 42 | 0 | 0 | 42 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X23E-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 217 | 0 | 0 | 0 |
| X23E-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 234 | 0 | 0 | 0 |
| X23F-1 | 0 | 0 | 0 | 0 | 0 | 0 | 357 | 0 | 0 | 0 | 0 | 0 | 0 | 71 | 0 | 0 | 0 |
| X23F-2 | 0 | 83 | 0 | 0 | 0 | 0 | 83 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X23G-1 | 0 | 0 | 0 | 0 | 0 | 0 | 190 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X23G-2 | 0 | 0 | 0 | 0 | 0 | 0 | 2238 | 0 | 0 | 2238 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X23H-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X23H-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 55 | 0 | 0 | 0 | 55 | 0 | 0 | 0 |
| X23H-3 | 0 | 0 | 0 | 15 | 0 | 0 | 0 | 0 | 0 | 15 | 0 | 0 | 0 | 15 | 0 | 0 | 0 |
| X23H-4 | 0 | 165 | 0 | 0 | 0 | 165 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X23H-5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tot. condensed | 0.0 | 248.7 | 0.0 | 15.0 | 0.0 | 165.3 | 3087.8 | 86.8 | 0.0 | 2399.2 | 482.7 | 0.0 | 0.0 | 1573.0 | 0.0 | 0.0 | 0.0 |
| % of condensed | 0.0 | 1.3 | 0.0 | 0.1 | 0.0 | 0.8 | 15.7 | 0.4 | 0.0 | 12.2 | 2.5 | 0.0 | 0.0 | 8.0 | 0.0 | 0.0 | 0.0 |
| % of quaternary | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.1 | 1.9 | 0.1 | 0.0 | 1.5 | 0.3 | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.01 | 0.13 | 0.00 | 0.00 | 0.10 | 0.02 | 0.00 | 0.00 | 0.07 | 0.00 | 0.00 | 0.00 |

| Total "condensed" cover per sub-quaternary | | | | | |
|---|---|---|---|---|---|
| X23 - RIPARIAN | | | | | |
| Sub-Quaternary | *Total condensed area* | *% of Total condensed area* | *% of total area* | | Tot. hectares of sub-quaternary |
| X23A-1 | 516 | 10 | 0.02 | | 5163.716 |
| X23A-2 | 1428 | 19 | 0.06 | | 7517.645 |
| X23B-1 | 237 | 7 | 0.01 | | 3392.260 |
| X23B-2 | 924 | 10 | 0.04 | | 9728.812 |
| X23B-3 | 1714 | 18 | 0.07 | | 9792.303 |
| X23C-1 | 438 | 8 | 0.02 | | 5835.838 |
| X23C-2 | 23 | 1 | 0.00 | | 2293.166 |
| X23D-1 | 738 | 8 | 0.03 | | 9842.243 |
| X23D-2 | 209 | 3 | 0.01 | | 8344.944 |
| X23E-1 | 304 | 4 | 0.01 | | 8672.304 |
| X23E-2 | 515 | 6 | 0.02 | | 9367.335 |
| X23F-1 | 1569 | 11 | 0.07 | | 14262.550 |
| X23F-2 | 2671 | 16 | 0.12 | | 16696.238 |
| X23G-1 | 266 | 4 | 0.01 | | 7588.877 |
| X23G-2 | 7087 | 48 | 0.31 | | 14920.855 |
| X23H-1 | 203 | 3 | 0.01 | | 8131.307 |
| X23H-2 | 386 | 4 | 0.02 | | 11017.144 |
| X23H-3 | 135 | 5 | 0.01 | | 3004.127 |
| X23H-4 | 331 | 30 | 0.01 | | 1101.730 |
| X23H-5 | 0 | 0 | 0.00 | | 7352.141 |
| Tot. condensed ha | 19694.1 | 12.01 | 0.86 | Tot. ha for X23 | 164025.5 |
| Total condensed area as a; | | | | | |
| % of quaternary X23 | 12.01 | | | | |
| % of Inkomati | 0.86 | | | | |

| X24 – RIPARIAN: Tall tree | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sub-Quaternary | *Acacia sp.* | *Acacia mearnsii* | *Acacia melanoxylon* | *Casuarina sp.* | *Cedrela toona* | *Eucalyptus sp.* | *Pinus sp.* | *Populus sp.* | *Spathoda sp.* | *Tipianu sp.* |
| X24A-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X24A-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X24B-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X24B-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X24B-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X24C-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X24C-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X24D-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X24D-2 | 0 | 94 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X24E-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X24E-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X24F-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X24H-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X24H-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tot. condensed | 0.0 | 94.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of condensed | 0.0 | 2.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of quaternary | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| X24 – RIPARIAN: Medium tree | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sub-Quaternary | *Grevillea robusta* | *Jacaranda mimosifolia* | *Melia azaderach* | *Morus alba* | *Privet* | *Quercus robur* | *Salix sp.* | *Sesbania sp.* |
| X24A-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X24A-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X24B-1 | 0 | 0 | 88 | 0 | 0 | 0 | 0 | 0 |
| X24B-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X24B-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X24C-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X24C-2 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 0 |
| X24D-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X24D-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X24E-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X24E-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X24F-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X24H-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X24H-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tot. condensed | 0.0 | 13.4 | 88.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of condensed | 0.0 | 0.3 | 2.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of quaternary | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

## X24 – RIPARIAN: Tall shrub

| Sub-Quaternary | *Agave sp.* | *Arundo donax* | *Caesalpinea decapetala* | *Chromelaena odorata* | *Cotoneaster sp.* | *Datura sp.* | *Lantana camara* | *Psidium guajava* | *Pueraria lobata* | *Ricinus communis* | *Rubus sp.* | *Senna didymobotrya* | *Senna sp.* | *Solanum maritianum* | *Solanum sp.* | *Tithonia diversifolia* | *Zinnia peruviana* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| X24A-1 | 43 | 0 | 0 | 0 | 0 | 0 | 43 | 0 | 0 | 0 | 0 | 43 | 215 | 0 | 0 | 0 | 0 |
| X24A-2 | 0 | 0 | 0 | 0 | 0 | 0 | 886 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 148 | 0 | 0 |
| X24B-1 | 0 | 88 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 528 | 0 | 0 | 0 | 0 |
| X24B-2 | 0 | 0 | 59 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X24B-3 | 0 | 0 | 0 | 0 | 0 | 0 | 54 | 0 | 0 | 54 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X24C-1 | 0 | 0 | 0 | 0 | 0 | 0 | 373 | 0 | 0 | 75 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X24C-2 | 0 | 13 | 0 | 0 | 0 | 67 | 13 | 0 | 0 | 0 | 0 | 67 | 0 | 0 | 0 | 0 | 0 |
| X24D-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X24D-2 | 0 | 0 | 0 | 470 | 0 | 0 | 94 | 0 | 0 | 94 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X24E-1 | 0 | 0 | 0 | 0 | 0 | 14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X24E-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 34 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X24F-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 92 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X24H-1 | 0 | 0 | 0 | 0 | 0 | 0 | 286 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X24H-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tot. condensed | 42.9 | 101.4 | 58.7 | 470.3 | 0.0 | 81.1 | 1750.9 | 0.0 | 0.0 | 348.7 | 0.0 | 110.0 | 742.7 | 0.0 | 147.7 | 0.0 | 0.0 |
| % of condensed | 1.1 | 2.5 | 1.4 | 11.6 | 0.0 | 2.0 | 43.2 | 0.0 | 0.0 | 8.6 | 0.0 | 2.7 | 18.3 | 0.0 | 3.6 | 0.0 | 0.0 |
| % of quaternary | 0.0 | 0.1 | 0.0 | 0.4 | 0.0 | 0.1 | 1.4 | 0.0 | 0.0 | 0.3 | 0.0 | 0.1 | 0.6 | 0.0 | 0.1 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.08 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.03 | 0.00 | 0.01 | 0.00 | 0.00 |

| Total "condensed" cover per sub-quaternay | | | | | |
|---|---|---|---|---|---|
| X24 - RIPARIAN | | | | | |
| Sub-Quaternary | *Total condensed area* | *% of Total condensed area* | *% of total area* | | Tot. hectares of sub-quaternary |
| X24A-1 | 343 | 4 | 0.01 | | 8581.178 |
| X24A-2 | 1034 | 18 | 0.05 | | 5909.659 |
| X24B-1 | 704 | 20 | 0.03 | | 3521.371 |
| X24B-2 | 59 | 1 | 0.00 | | 11735.987 |
| X24B-3 | 109 | 1 | 0.00 | | 10868.874 |
| X24C-1 | 448 | 3 | 0.02 | | 14937.090 |
| X24C-2 | 174 | 7 | 0.01 | | 2682.122 |
| X24D-1 | 0 | 0 | 0.00 | | 2522.714 |
| X24D-2 | 753 | 4 | 0.03 | | 18812.896 |
| X24E-1 | 14 | 1 | 0.00 | | 2809.864 |
| X24E-2 | 34 | 1 | 0.00 | | 6818.982 |
| X24F-1 | 92 | 1 | 0.00 | | 18310.679 |
| X24H-1 | 286 | 3 | 0.01 | | 11450.552 |
| X24H-2 | 0 | 0 | 0.00 | | 2874.650 |
| Tot. condensed ha | 4050.0 | 3.32 | 0.18 | Tot. ha for X24 | 121836.6 |
| Total condensed area as a; | | | | | |
| % of quaternary X24 | 3.32 | | | | |
| % of Inkomati | 0.18 | | | | |

| X31 – RIPARIAN: Tall tree | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sub-Quaternary | *Acacia sp.* | *Acacia mearnsii* | *Acacia melanoxylon* | *Casuarina sp.* | *Cedrela toona* | *Eucalyptus sp.* | *Pinus sp.* | *Populus sp.* | *Spathoda sp.* | *Tipianu sp.* |
| X31A-1 | 0 | 86 | 0 | 0 | 0 | 86 | 86 | 86 | 0 | 0 |
| X31A-2 | 0 | 0 | 0 | 0 | 0 | 0 | 819 | 0 | 0 | 0 |
| X31B-1 | 0 | 98 | 0 | 0 | 0 | 492 | 98 | 0 | 0 | 0 |
| X31C-1 | 0 | 0 | 0 | 0 | 0 | 0 | 29 | 29 | 0 | 0 |
| X31C-2 | 0 | 0 | 0 | 0 | 0 | 247 | 0 | 0 | 0 | 0 |
| X31D-1 | 0 | 0 | 0 | 0 | 0 | 196 | 0 | 0 | 0 | 0 |
| X31D-2 | 0 | 0 | 0 | 0 | 0 | 1312 | 1312 | 0 | 0 | 0 |
| X31D-3 | 0 | 222 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31E-1 | 0 | 0 | 0 | 0 | 0 | 49 | 49 | 0 | 0 | 0 |
| X31E-2 | 0 | 0 | 0 | 0 | 0 | 1195 | 0 | 0 | 0 | 0 |
| X31E-3 | 0 | 0 | 0 | 0 | 0 | 18 | 0 | 0 | 0 | 0 |
| X31F-1 | 0 | 0 | 0 | 0 | 0 | 0 | 45 | 0 | 0 | 0 |
| X31G-1 | 0 | 0 | 0 | 0 | 0 | 289 | 58 | 0 | 0 | 0 |
| X31G-2 | 0 | 0 | 0 | 0 | 0 | 0 | 167 | 0 | 0 | 0 |
| X31G-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31H-1 | 0 | 0 | 0 | 0 | 0 | 658 | 658 | 0 | 0 | 0 |
| X31H-2 | 0 | 0 | 0 | 0 | 0 | 24 | 4 | 0 | 0 | 0 |
| X31J-1 | 0 | 0 | 0 | 0 | 0 | 2282 | 0 | 0 | 0 | 0 |
| X31K-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31K-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31K-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31K-4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31L-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31L-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31L-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31M-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31M-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tot. condensed | 0.0 | 406.1 | 0.0 | 0.0 | 0.0 | 6848.7 | 3324.1 | 114.4 | 0.0 | 0.0 |
| % of condensed | 0.0 | 2.9 | 0.0 | 0.0 | 0.0 | 49.5 | 24.0 | 0.8 | 0.0 | 0.0 |
| % of quaternary | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 3.2 | 1.6 | 0.1 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.30 | 0.15 | 0.00 | 0.00 | 0.00 |

| X31 – RIPARIAN: Medium tree | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sub-Quaternary | *Grevillea robusta* | *Jacaranda mimosifolia* | *Melia azaderach* | *Morus alba* | *Privet* | *Quercus robur* | *Salix sp.* | *Sesbania sp.* |
| X31A-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31A-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31B-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31C-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31C-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31D-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31D-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31D-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31E-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31E-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31E-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31F-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31G-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31G-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31G-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31H-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31H-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31J-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31K-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31K-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31K-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31K-4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31L-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31L-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31L-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31M-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31M-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tot. condensed | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of condensed | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of quaternary | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

## X31 – RIPARIAN: Tall shrub

| Sub-Quaternary | *Agave sp.* | *Arundo donax* | *Caesalpinea decapetala* | *Chromelaena odorata* | *Cotoneaster sp.* | *Datura sp.* | *Lantana camara* | *Psidium guajava* | *Pueraria lobata* | *Ricinus communis* | *Rubus sp.* | *Senna didymobotrya* | *Senna sp.* | *Solanum maritianum* | *Solanum sp.* | *Tithonia diversifolia* | *Zinnia peruviana* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| X31A-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 86 | 0 | 0 | 86 | 0 | 0 | 0 |
| X31A-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 27 | 0 | 0 | 27 | 0 | 0 | 0 |
| X31B-1 | 0 | 0 | 0 | 0 | 0 | 0 | 98 | 0 | 0 | 0 | 0 | 0 | 0 | 98 | 0 | 0 | 0 |
| X31C-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 29 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31C-2 | 0 | 0 | 49 | 0 | 0 | 0 | 0 | 49 | 0 | 0 | 0 | 0 | 49 | 247 | 0 | 0 | 0 |
| X31D-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31D-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31D-3 | 0 | 0 | 0 | 0 | 0 | 0 | 222 | 0 | 0 | 0 | 0 | 0 | 0 | 222 | 0 | 0 | 0 |
| X31E-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 49 | 0 | 0 | 245 | 0 | 0 | 0 |
| X31E-2 | 0 | 0 | 0 | 0 | 0 | 0 | 40 | 0 | 0 | 0 | 199 | 0 | 0 | 199 | 0 | 0 | 0 |
| X31E-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31F-1 | 0 | 0 | 0 | 0 | 0 | 0 | 45 | 0 | 0 | 0 | 224 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31G-1 | 0 | 0 | 0 | 0 | 0 | 0 | 58 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31G-2 | 0 | 0 | 0 | 0 | 0 | 0 | 28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31G-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31H-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31H-2 | 0 | 0 | 0 | 0 | 0 | 0 | 24 | 0 | 0 | 0 | 24 | 0 | 0 | 24 | 0 | 0 | 0 |
| X31J-1 | 0 | 0 | 0 | 0 | 0 | 0 | 76 | 0 | 0 | 0 | 0 | 0 | 76 | 0 | 0 | 0 | 0 |
| X31K-1 | 0 | 0 | 0 | 0 | 0 | 0 | 40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31K-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31K-3 | 0 | 0 | 0 | 0 | 0 | 126 | 0 | 0 | 0 | 126 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31K-4 | 0 | 0 | 0 | 0 | 0 | 46 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31L-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31L-2 | 0 | 0 | 0 | 0 | 0 | 0 | 174 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31L-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31M-1 | 0 | 0 | 0 | 0 | 0 | 37 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X31M-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tot. condensed | 0.0 | 0.0 | 49.5 | 0.0 | 0.0 | 209.3 | 804.8 | 49.5 | 0.0 | 126.2 | 638.3 | 0.0 | 125.5 | 1149.0 | 0.0 | 0.0 | 0.0 |
| % of condensed | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 1.5 | 5.8 | 0.4 | 0.0 | 0.9 | 4.6 | 0.0 | 0.9 | 8.3 | 0.0 | 0.0 | 0.0 |
| % of quaternary | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.4 | 0.0 | 0.0 | 0.1 | 0.3 | 0.0 | 0.1 | 0.5 | 0.0 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.04 | 0.00 | 0.00 | 0.01 | 0.03 | 0.00 | 0.01 | 0.05 | 0.00 | 0.00 | 0.00 |

## Total "condensed" cover per sub-quaternary

### X31 – RIPARIAN

| Sub-Quaternary | *Total condensed area* | *% of Total condensed area* | *% of total area* | | Tot. hectares of sub-quaternary |
|---|---|---|---|---|---|
| X31A-1 | 514 | 3 | 0.02 | | 17145.420 |
| X31A-2 | 873 | 16 | 0.04 | | 5459.239 |
| X31B-1 | 886 | 5 | 0.04 | | 19694.513 |
| X31C-1 | 86 | 2 | 0.00 | | 5738.868 |
| X31C-2 | 643 | 7 | 0.03 | | 9892.061 |
| X31D-1 | 196 | 15 | 0.01 | | 1309.552 |
| X31D-2 | 2624 | 30 | 0.11 | | 8745.648 |
| X31D-3 | 666 | 8 | 0.03 | | 8877.617 |
| X31E-1 | 392 | 4 | 0.02 | | 9802.347 |
| X31E-2 | 1634 | 21 | 0.07 | | 7969.113 |
| X31E-3 | 18 | 1 | 0.00 | | 3572.247 |
| X31F-1 | 314 | 4 | 0.01 | | 8972.114 |
| X31G-1 | 405 | 4 | 0.02 | | 11566.457 |
| X31G-2 | 195 | 18 | 0.01 | | 1114.531 |
| X31G-3 | 0 | 0 | 0.00 | | 4184.814 |
| X31H-1 | 1315 | 30 | 0.06 | | 4384.135 |
| X31H-2 | 100 | 7 | 0.00 | | 1506.382 |
| X31J-1 | 2434 | 16 | 0.11 | | 15213.571 |
| X31K-1 | 40 | 1 | 0.00 | | 7984.363 |
| X31K-2 | 0 | 0 | 0.00 | | 3694.729 |
| X31K-3 | 252 | 5 | 0.01 | | 5049.485 |
| X31K-4 | 46 | 1 | 0.00 | | 9136.414 |
| X31L-1 | 0 | 0 | 0.00 | | 6700.435 |
| X31L-2 | 174 | 3 | 0.01 | | 6959.498 |
| X31L-3 | 0 | 0 | 0.00 | | 15858.429 |
| X31M-1 | 37 | 1 | 0.00 | | 7485.108 |
| X31M-2 | 0 | 0 | 0.00 | | 6342.746 |
| Tot. condensed ha | 13845.5 | 6.46 | 0.60 | Tot. ha for X31 | 214359.836 |
| Total condensed area as a; | | | | | |
| % of quaternary X31 | 6.46 | | | | |
| % of Inkomati | 0.60 | | | | |

| X32 – RIPARIAN: Tall tree | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sub-Quaternary | *Acacia sp.* | *Acacia mearnsii* | *Acacia melanoxylon* | *Casuarina sp.* | *Cedrela toona* | *Eucalyptus sp.* | *Pinus sp.* | *Populus sp.* | *Spathoda sp.* | *Tipianu sp.* |
| X32A-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32A-2 | 0 | 0 | 0 | 0 | 0 | 0 | 36 | 0 | 0 | 0 |
| X32B-1 | 0 | 0 | 0 | 0 | 0 | 0 | 27 | 0 | 0 | 0 |
| X32C-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32C-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32C-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32C-4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32C-5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32C-6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32C-7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32D-1 | 0 | 0 | 0 | 0 | 0 | 152 | 30 | 0 | 0 | 0 |
| X32D-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32E-1 | 0 | 0 | 0 | 0 | 0 | 432 | 72 | 0 | 0 | 0 |
| X32E-2 | 0 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 0 |
| X32F-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32F-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32F-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32F-4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32G-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32G-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32G-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32H-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32H-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tot. condensed | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 609.1 | 165.5 | 0.0 | 0.0 | 0.0 |
| % of condensed | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 5.6 | 1.5 | 0.0 | 0.0 | 0.0 |
| % of quaternary | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.1 | 0.0 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.01 | 0.00 | 0.00 | 0.00 |

| X32 – RIPARIAN: Medium tree | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sub-Quaternary | *Grevillea robusta* | *Jacaranda mimosifolia* | *Melia azaderach* | *Morus alba* | *Privet* | *Quercus robur* | *Salix sp.* | *Sesbania sp.* |
| X32A-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32A-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32B-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32C-1 | 0 | 8 | 8 | 0 | 0 | 0 | 0 | 0 |
| X32C-2 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 |
| X32C-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32C-4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32C-5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32C-6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32C-7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32D-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32D-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 18 |
| X32E-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32E-2 | 0 | 0 | 25 | 0 | 0 | 0 | 0 | 0 |
| X32F-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32F-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32F-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32F-4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32G-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32G-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32G-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32H-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32H-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tot. condensed | 0.0 | 7.9 | 39.6 | 0.0 | 0.0 | 0.0 | 0.0 | 18.0 |
| % of condensed | 0.0 | 0.1 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 |
| % of quaternary | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

## X32 – RIPARIAN: Tall shrub

| Sub-Quaternary | *Agave sp.* | *Arundo donax* | *Caesalpinea decapetala* | *Chromelaena odorata* | *Cotoneaster sp.* | *Datura sp.* | *Lantana camara* | *Psidium guajava* | *Pueraria lobata* | *Ricinus communis* | *Rubus sp.* | *Senna didymobotrya* | *Senna sp.* | *Solanum maritianum* | *Solanum sp.* | *Tithonia diversifolia* | *Zinnia peruviana* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| X32A-1 | 0 | 0 | 0 | 0 | 0 | 0 | 19 | 0 | 0 | 19 | 0 | 0 | 0 | 19 | 0 | 0 | 0 |
| X32A-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 36 | 0 | 0 | 0 | 36 | 0 | 0 | 0 |
| X32B-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 27 | 0 | 0 | 0 | 0 | 0 |
| X32C-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32C-2 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32C-3 | 0 | 0 | 0 | 0 | 0 | 0 | 27 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32C-4 | 0 | 0 | 23 | 0 | 0 | 0 | 23 | 0 | 0 | 23 | 0 | 0 | 0 | 0 | 0 | 0 | 23 |
| X32C-5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32C-6 | 0 | 0 | 0 | 0 | 0 | 882 | 0 | 0 | 0 | 882 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32C-7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32D-1 | 0 | 0 | 30 | 30 | 0 | 0 | 912 | 0 | 0 | 0 | 30 | 0 | 0 | 30 | 0 | 0 | 0 |
| X32D-2 | 0 | 0 | 18 | 0 | 0 | 0 | 90 | 18 | 0 | 0 | 0 | 18 | 0 | 0 | 0 | 0 | 0 |
| X32E-1 | 0 | 0 | 0 | 0 | 0 | 0 | 14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32E-2 | 0 | 0 | 25 | 0 | 0 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 0 | 0 |
| X32F-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32F-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32F-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32F-4 | 0 | 0 | 0 | 0 | 0 | 0 | 29 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32G-1 | 0 | 0 | 0 | 0 | 0 | 485 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32G-2 | 0 | 0 | 0 | 0 | 0 | 1593 | 0 | 0 | 0 | 1593 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32G-3 | 0 | 0 | 0 | 0 | 0 | 155 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| X32H-1 | 0 | 0 | 0 | 0 | 0 | 750 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 0 | 25 | 0 | 0 |
| X32H-2 | 0 | 0 | 0 | 0 | 0 | 1702 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 284 | 0 | 0 |
| Tot. condensed | 0.0 | 0.0 | 97.2 | 30.4 | 0.0 | 5591.7 | 1121.8 | 18.0 | 0.0 | 2584.3 | 30.4 | 70.3 | 0.0 | 85.5 | 308.6 | 0.0 | 23.4 |
| % of condensed | 0.0 | 0.0 | 0.9 | 0.3 | 0.0 | 51.8 | 10.4 | 0.2 | 0.0 | 23.9 | 0.3 | 0.7 | 0.0 | 0.8 | 2.9 | 0.0 | 0.2 |
| % of quaternary | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 4.6 | 0.9 | 0.0 | 0.0 | 2.1 | 0.0 | 0.1 | 0.0 | 0.1 | 0.3 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.24 | 0.05 | 0.00 | 0.00 | 0.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 |

| Total "condensed" cover per sub-quaternary | | | | | |
|---|---|---|---|---|---|
| X32 - RIPARIAN | | | | | |
| Sub-Quaternary | *Total condensed area* | *% of Total condensed area* | *% of total area* | | *Tot. hectares of sub-quaternary* |
| X32A-1 | 57 | 2 | 0.00 | | 3787.303 |
| X32A-2 | 108 | 2 | 0.00 | | 7230.913 |
| X32B-1 | 54 | 1 | 0.00 | | 5397.044 |
| X32C-1 | 16 | 1 | 0.00 | | 1570.586 |
| X32C-2 | 19 | 2 | 0.00 | | 1289.941 |
| X32C-3 | 27 | 3 | 0.00 | | 1094.109 |
| X32C-4 | 94 | 2 | 0.00 | | 4688.037 |
| X32C-5 | 0 | 0 | 0.00 | | 6658.896 |
| X32C-6 | 1764 | 30 | 0.08 | | 5878.438 |
| X32C-7 | 0 | 0 | 0.00 | | 1823.896 |
| X32D-1 | 1216 | 20 | 0.05 | | 6082.240 |
| X32D-2 | 162 | 5 | 0.01 | | 3605.006 |
| X32E-1 | 518 | 18 | 0.02 | | 2878.384 |
| X32E-2 | 127 | 3 | 0.01 | | 5061.647 |
| X32F-1 | 0 | 0 | 0.00 | | 6544.418 |
| X32F-2 | 0 | 0 | 0.00 | | 1418.129 |
| X32F-3 | 0 | 0 | 0.00 | | 2600.313 |
| X32F-4 | 29 | 1 | 0.00 | | 5761.754 |
| X32G-1 | 485 | 3 | 0.02 | | 19406.201 |
| X32G-2 | 3185 | 30 | 0.14 | | 10617.395 |
| X32G-3 | 155 | 15 | 0.01 | | 1036.591 |
| X32H-1 | 800 | 16 | 0.03 | | 4998.298 |
| X32H-2 | 1985 | 18 | 0.09 | | 11343.897 |
| Tot. condensed ha | 10801.8 | 8.94 | 0.47 | Tot. ha for X32 | 120773.436 |
| Total condensed area as a; | | | | | |
| % of quaternary X32 | 8.94 | | | | |
| % of Inkomati | 0.47 | | | | |

**X40C-1 – RIPARIAN: Tall tree**

| Sub-Quaternary | *Acacia sp.* | *Acacia mearnsii* | *Acacia melanoxylon* | *Casuarina sp.* | *Cedrela toona* | *Eucalyptus sp.* | *Pinus sp.* | *Populus sp.* | *Spathoda sp.* | *Tipianu sp.* |
|---|---|---|---|---|---|---|---|---|---|---|
| X40 C-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| % of quaternary | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

**X40C-1 – RIPARIAN: Medium tree**

| Sub-Quaternary | *Grevillea robusta* | *Jacaranda mimosifolia* | *Melia azaderach* | *Morus alba* | *Privet* | *Quercus robur* | *Salix sp.* | *Sesbania sp.* |
|---|---|---|---|---|---|---|---|---|
| X40 C-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| % of quaternary | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

**X40C-1 – RIPARIAN: Tall shrub**

| Sub-Quaternary | *Agave sp.* | *Arundo donax* | *Caesalpinea decapetala* | *Chromelaena odorata* | *Cotoneaster sp.* | *Datura sp.* | *Lantana camara* | *Psidium guajava* | *Pueraria lobata* | *Ricinus communis* | *Rubus sp.* | *Senna didymobotrya* | *Senna sp.* | *Solanum maritianum* | *Solanum sp.* | *Tithonia diversifolia* | *Zinnia peruviana* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| X40 C-1 | 0 | 0 | 0 | 0 | 0 | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| % of quaternary | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| % of Inkomati | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| Total "condensed" cover per sub-quaternary | | | | | |
|---|---|---|---|---|---|
| X40C-1 - RIPARIAN | | | | | |
| Sub-Quaternary | *Total condensed area* | *% of Total condensed area* | *% of total area* | | Tot. hectares of sub-quaternary |
| X40 C-1 | 18 | 1 | 0.00 | Tot. ha for X40C-1 | 3665.180 |
| % of quaternary X40C-1 | 0.50 | | | | |
| % of Inkomati | 0.00 | | | | |

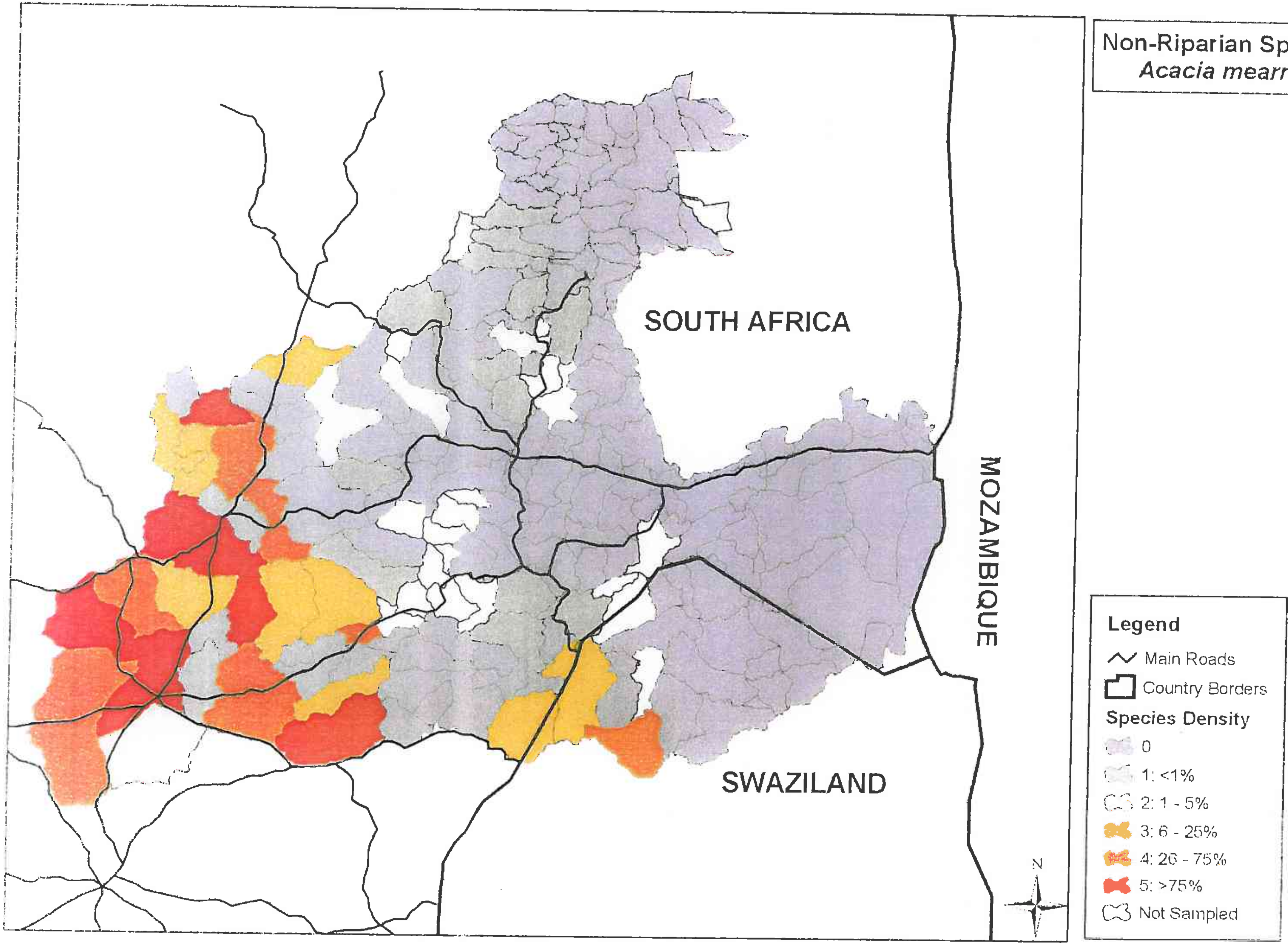
Figure 1

**Maps showing the distribution and densities per species.**

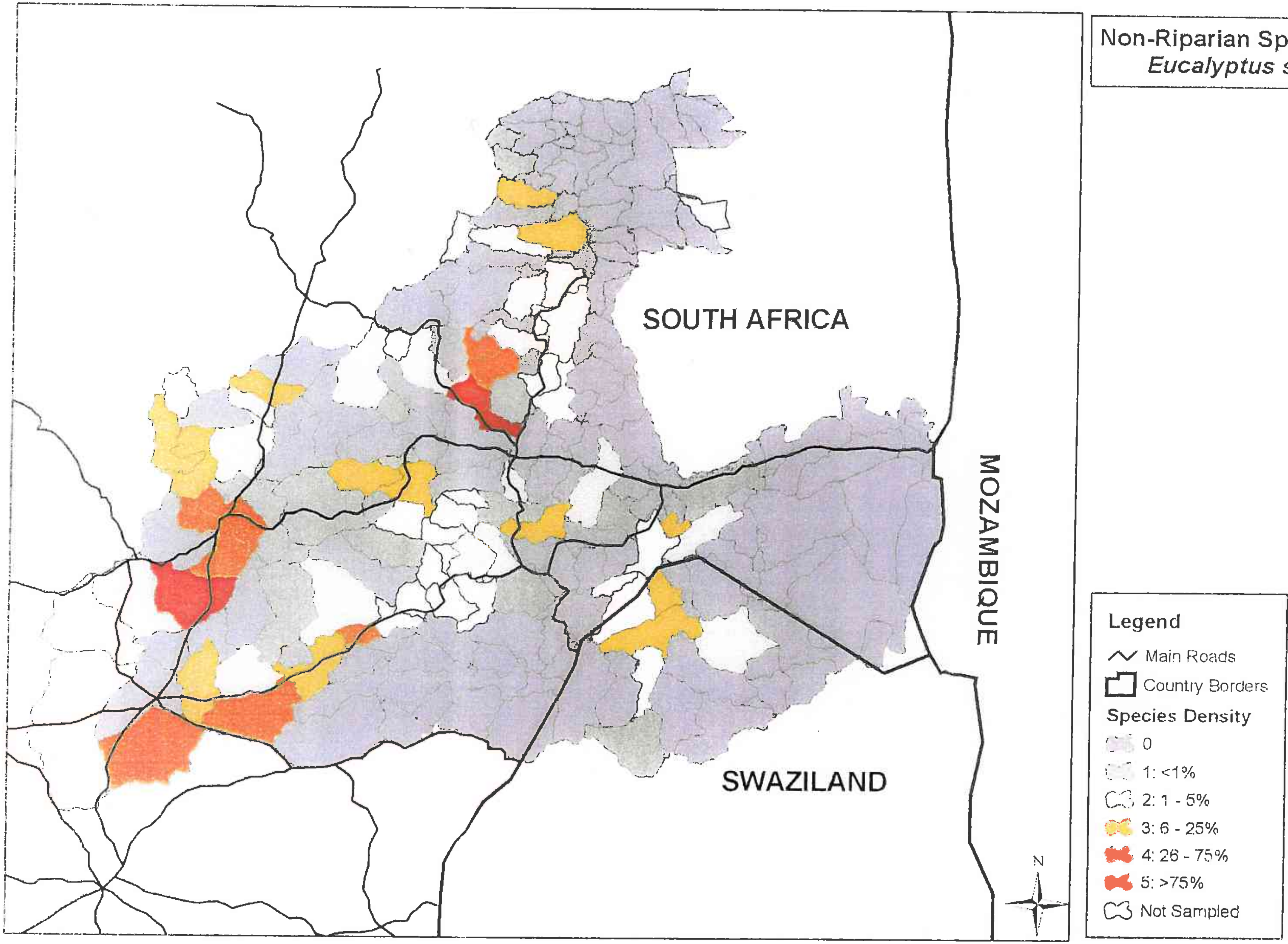
## Non-riparian

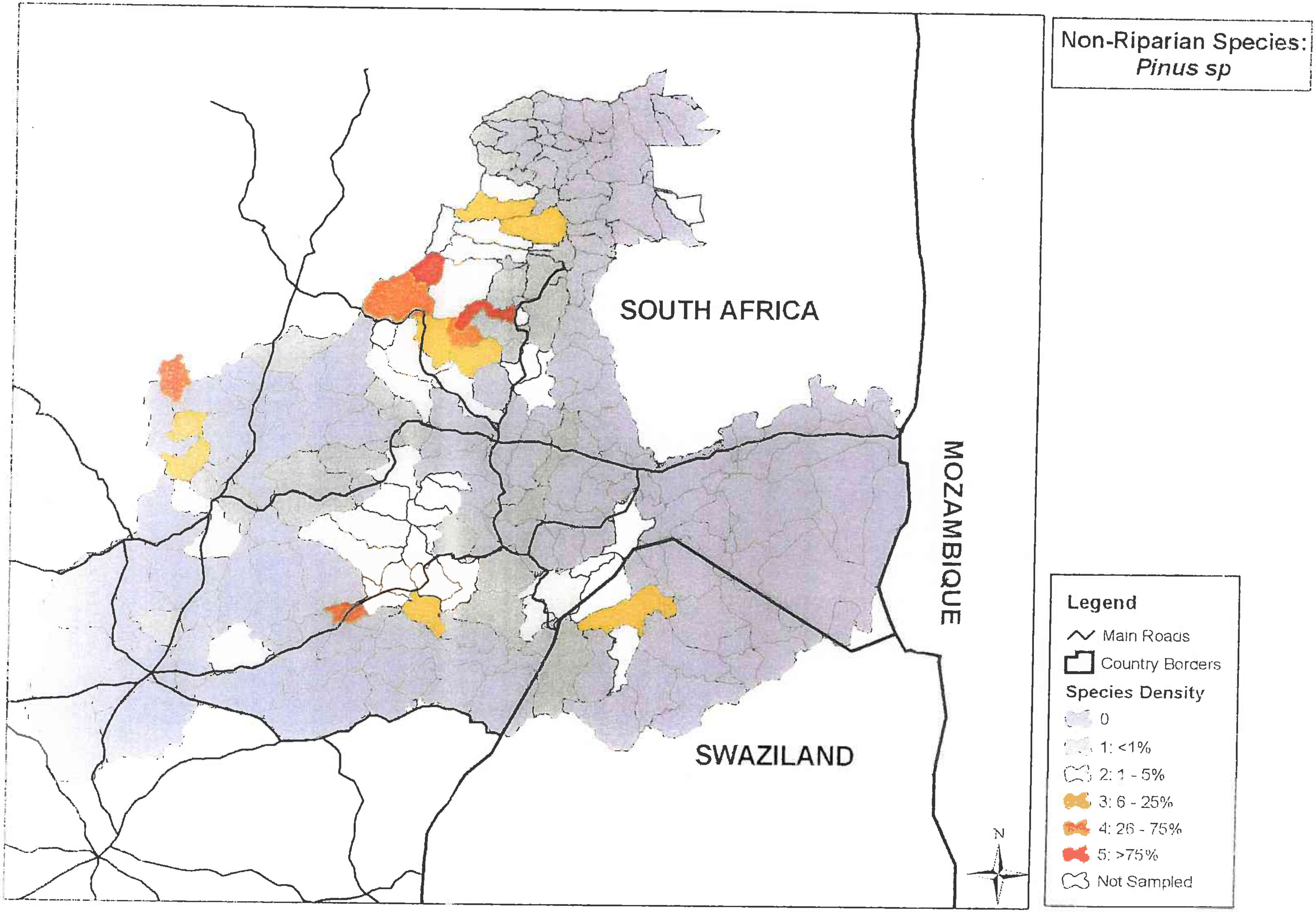
- ***Acacia mearnsii***
- ***Eucalyptus sp.***
- ***Pinus sp.***
- ***Melia azaderach***
- ***Jacaranda mimosifolia***
- ***Chromolaena odorata***
- ***Lantana camara***
- ***Solanum mauritianum***

Non-Riparian Species:
*Acacia mearnsii*

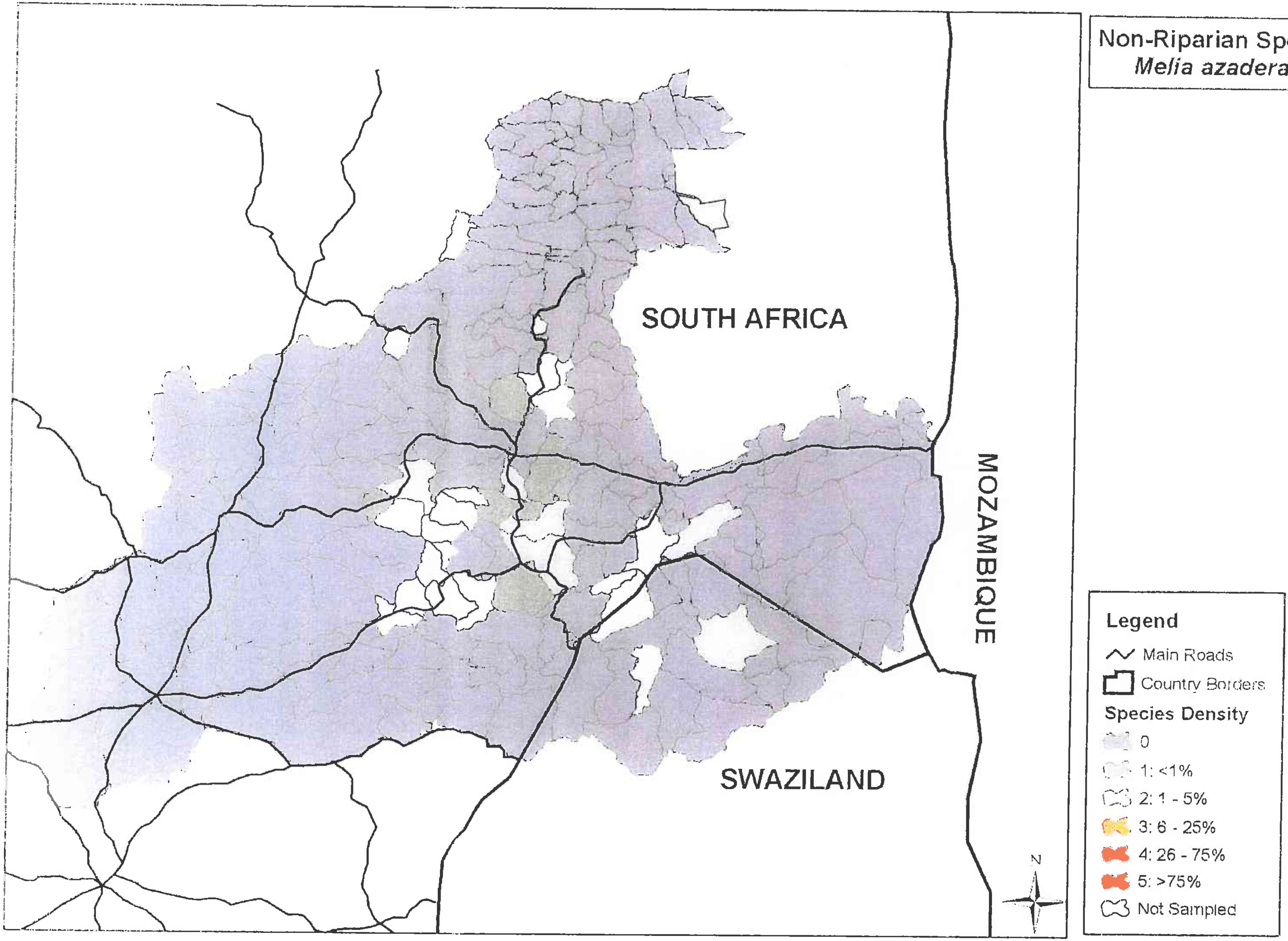


Non-Riparian Species:
*Eucalyptus sp*

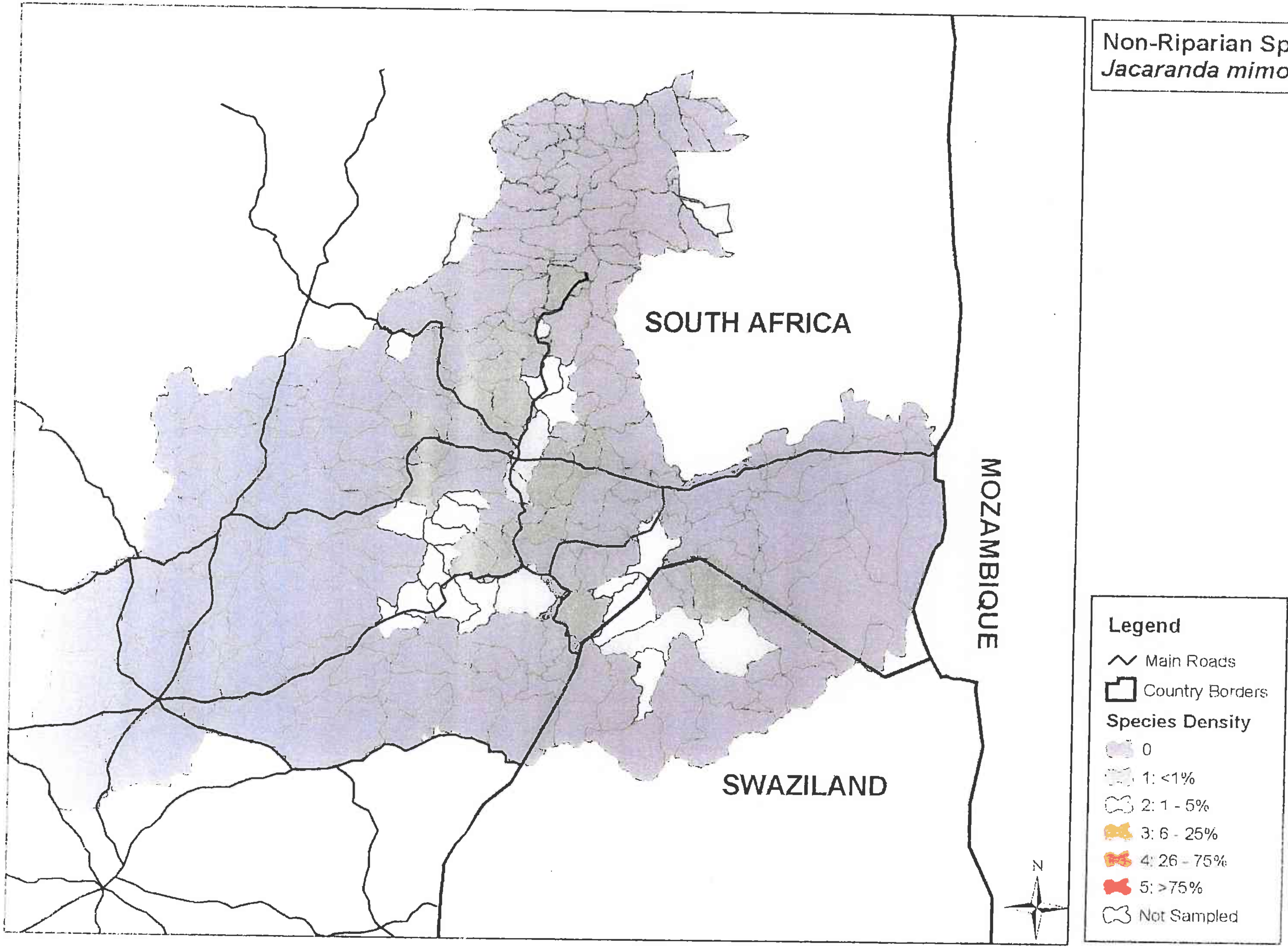



Non-Riparian Species:
*Pinus sp*
SOUTH AFRICA
MOZAMBIQUE
SWAZILAND
N
Legend
Main Roads
Country Borders
Species Density
0
1: <1%
2: 1 - 5%
3: 6 - 25%
4: 26 - 75%
5: >75%
Not Sampled

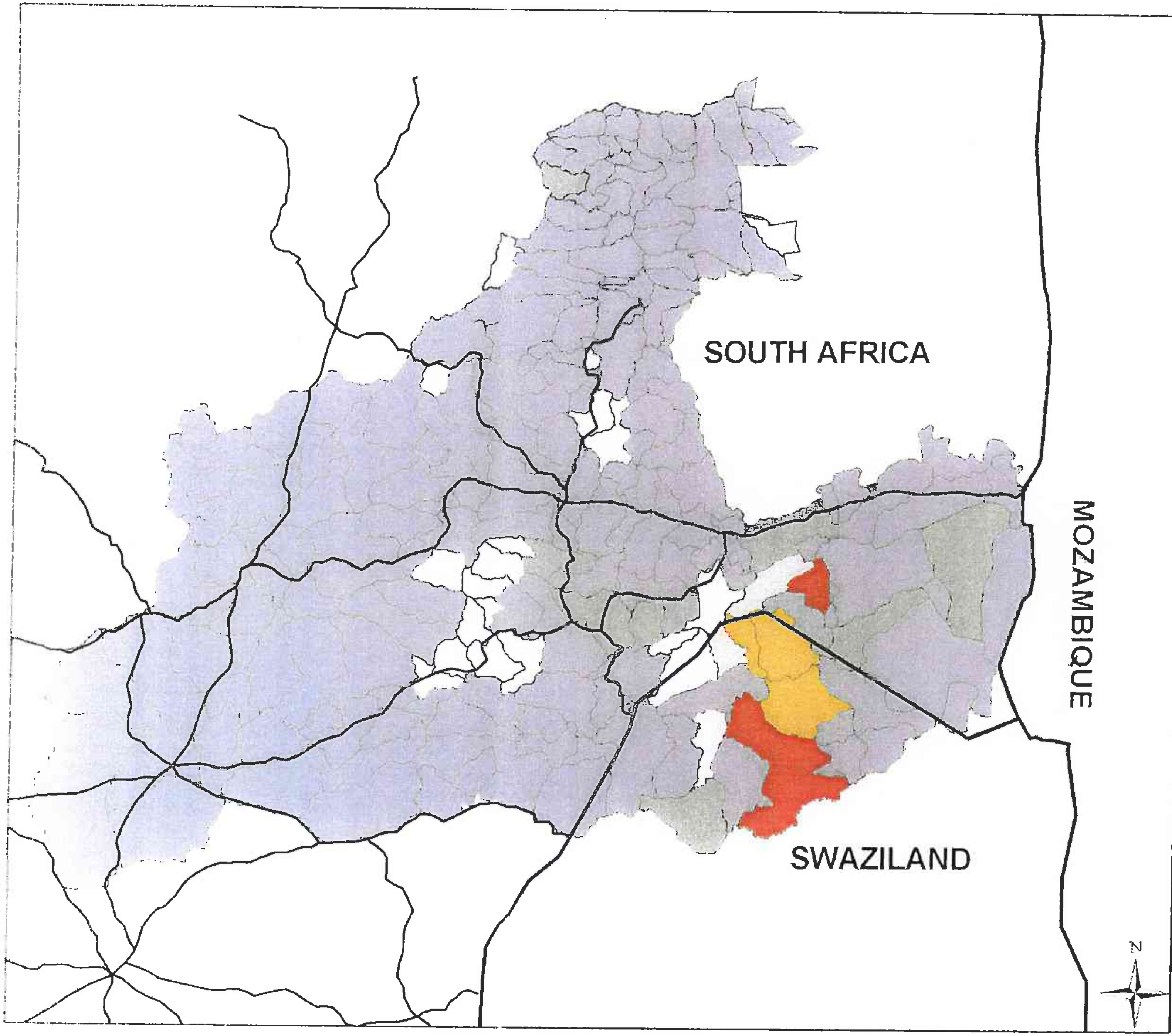
## Non-Riparian Species:
*Melia azaderach*

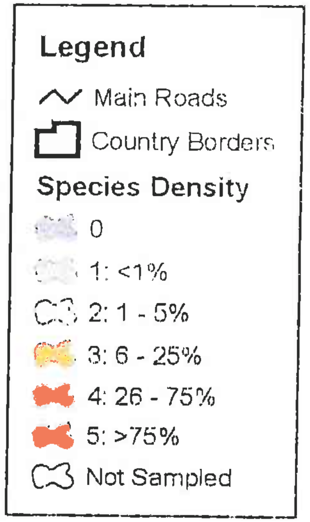


Non-Riparian Species: *Jacaranda mimosifolia*

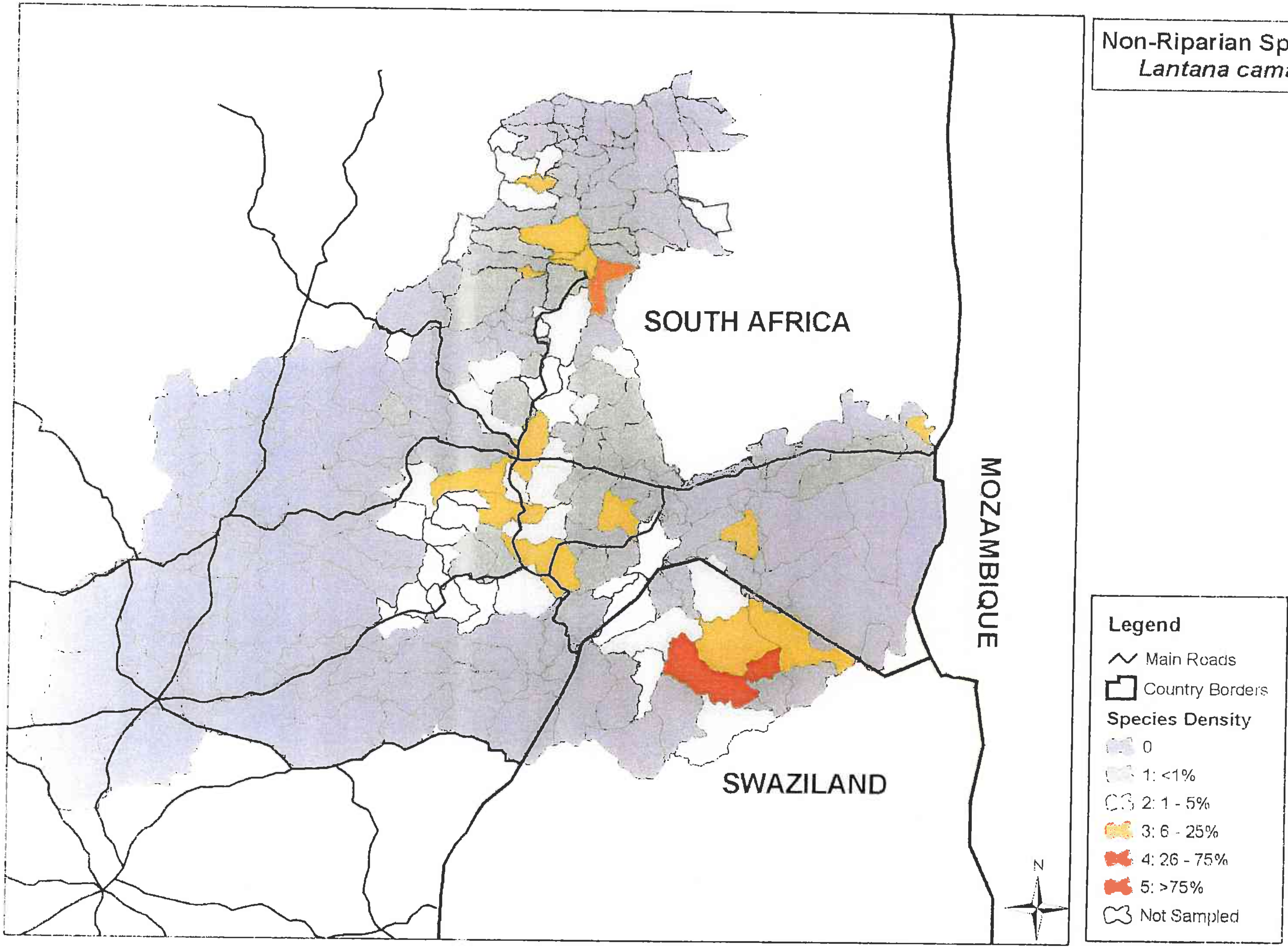


Non-Riparian Species: *Chromolaena odorata*



## Non-Riparian Species: *Lantana camara*



Non-Riparian Species:
*Solanum maritianum*

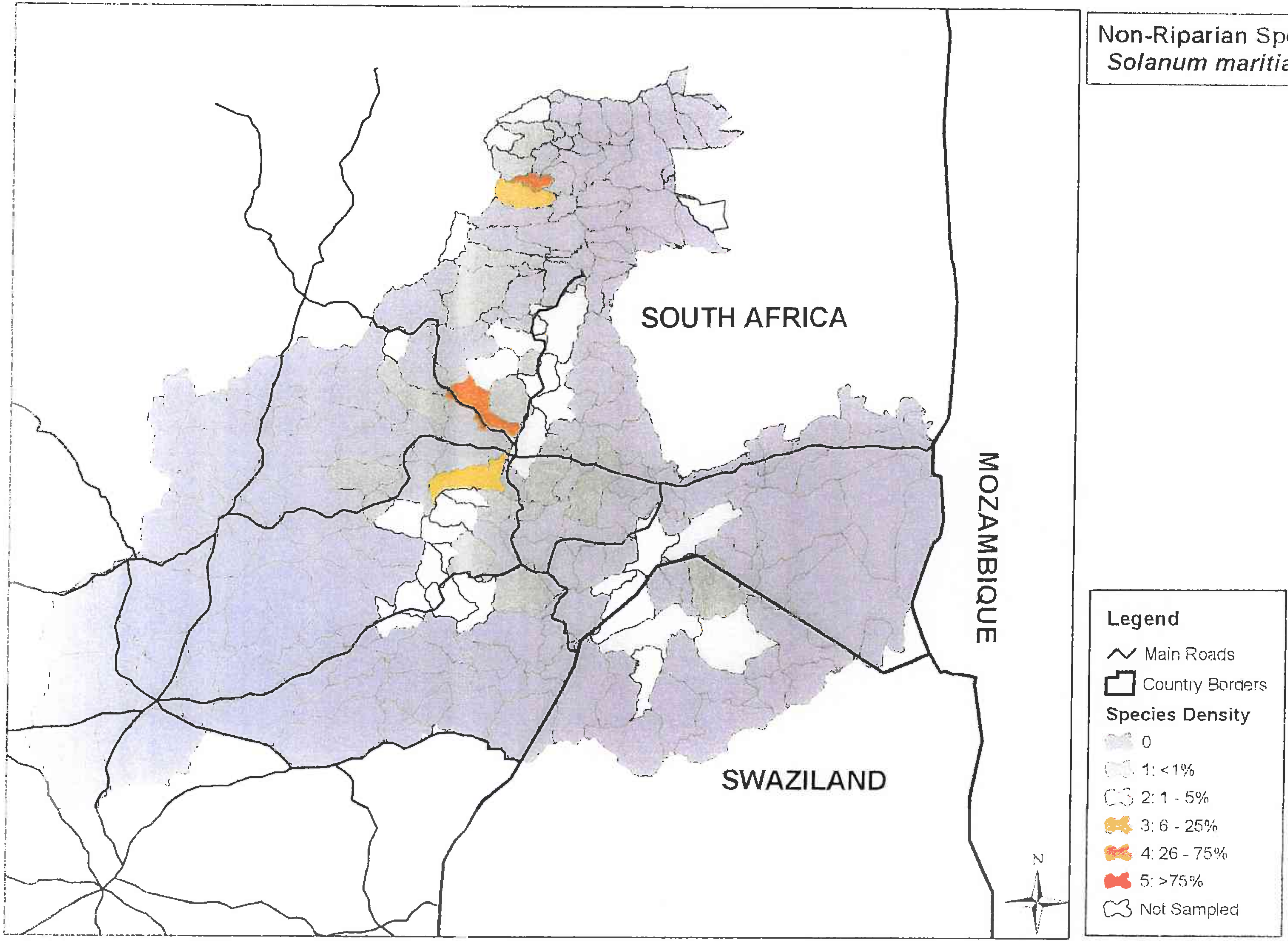
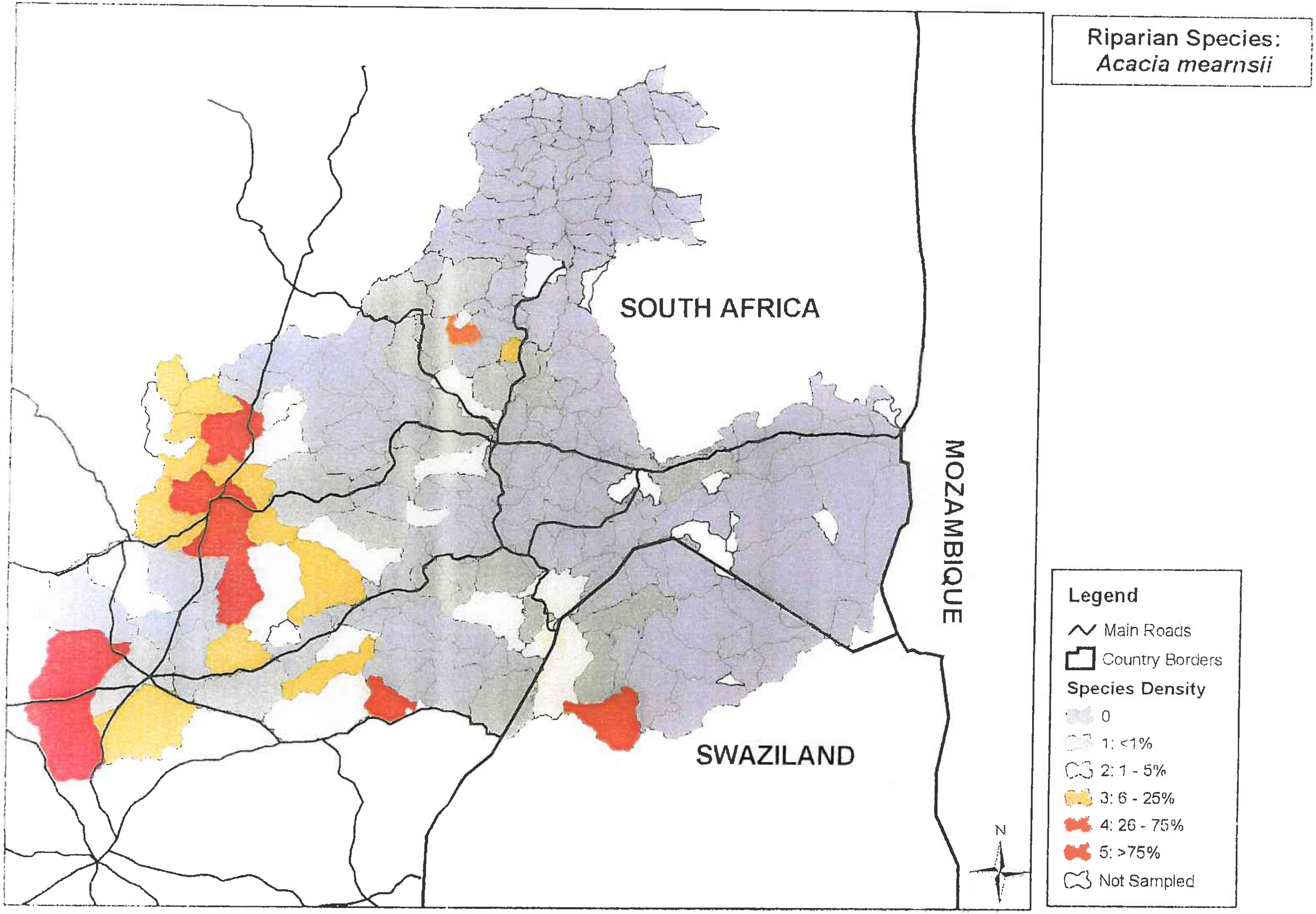


Figure 1

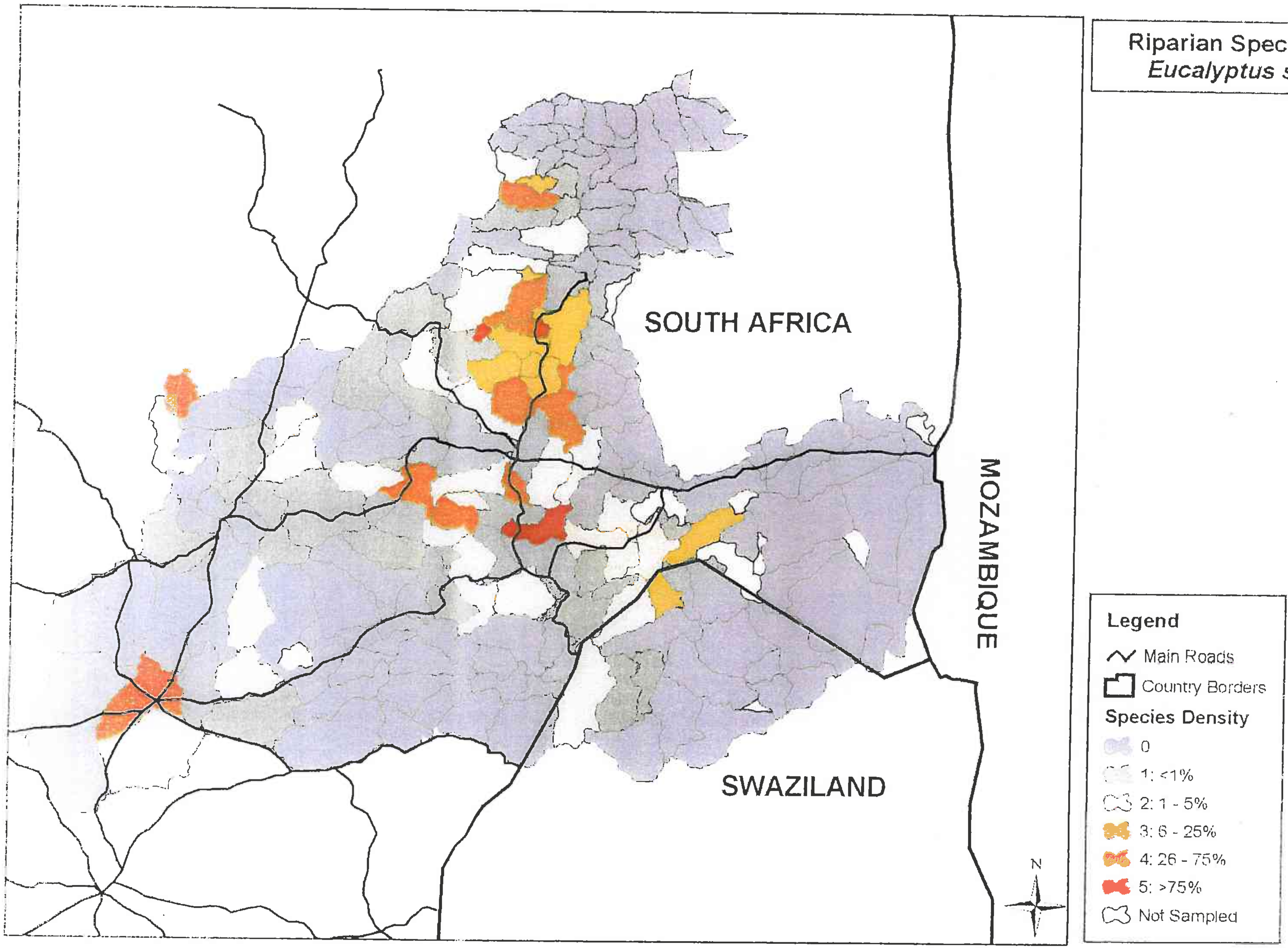
**Maps showing the distribution and densities per species.**

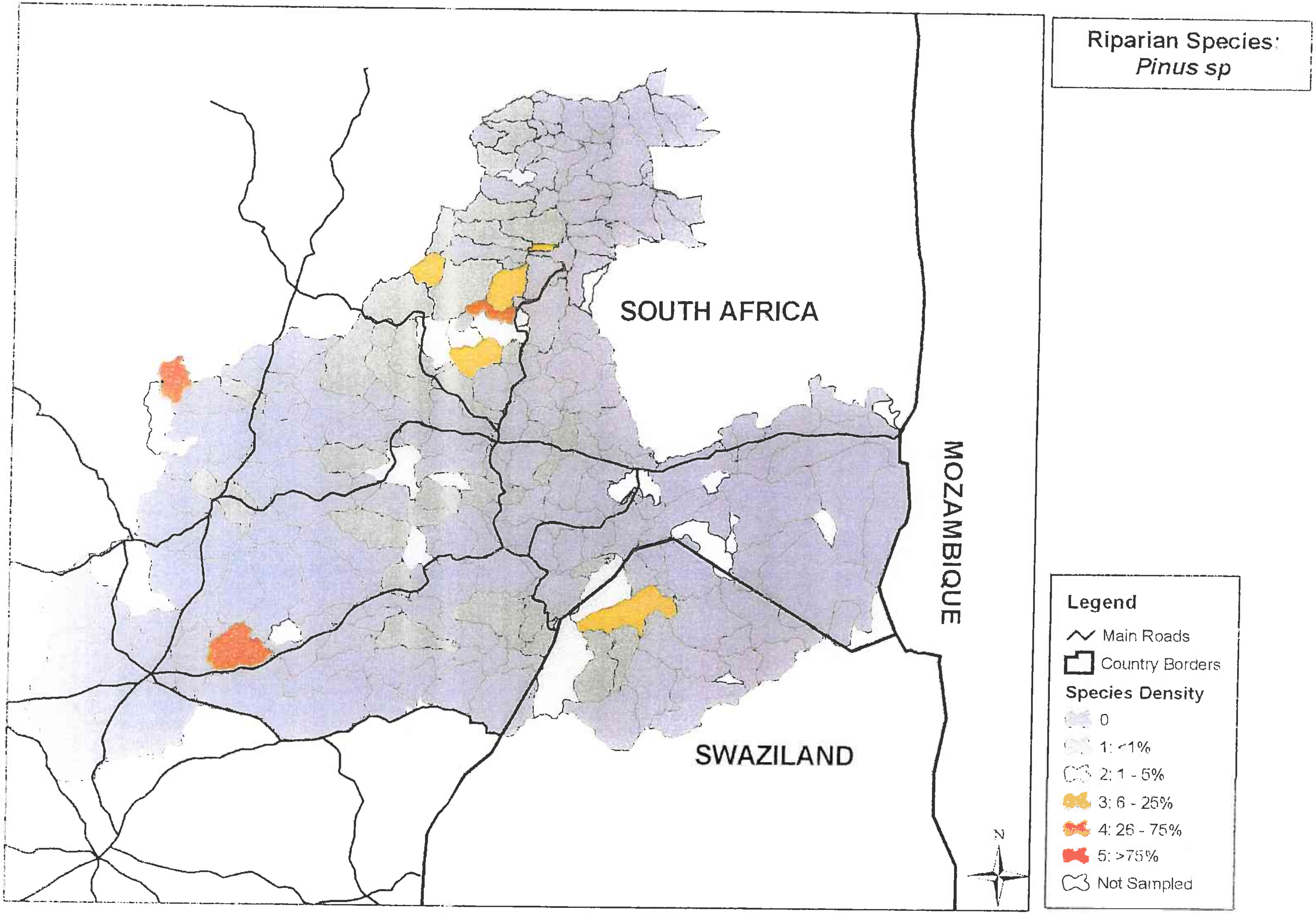
# Riparian

- ***Acacia mearnsii***
- ***Eucalyptus sp.***
- ***Pinus sp.***
- ***Melia azaderach***
- ***Jacaranda mimosifolia***
- ***Chromolaena odorata***
- ***Lantana camara***
- ***Solanum mauritianum***

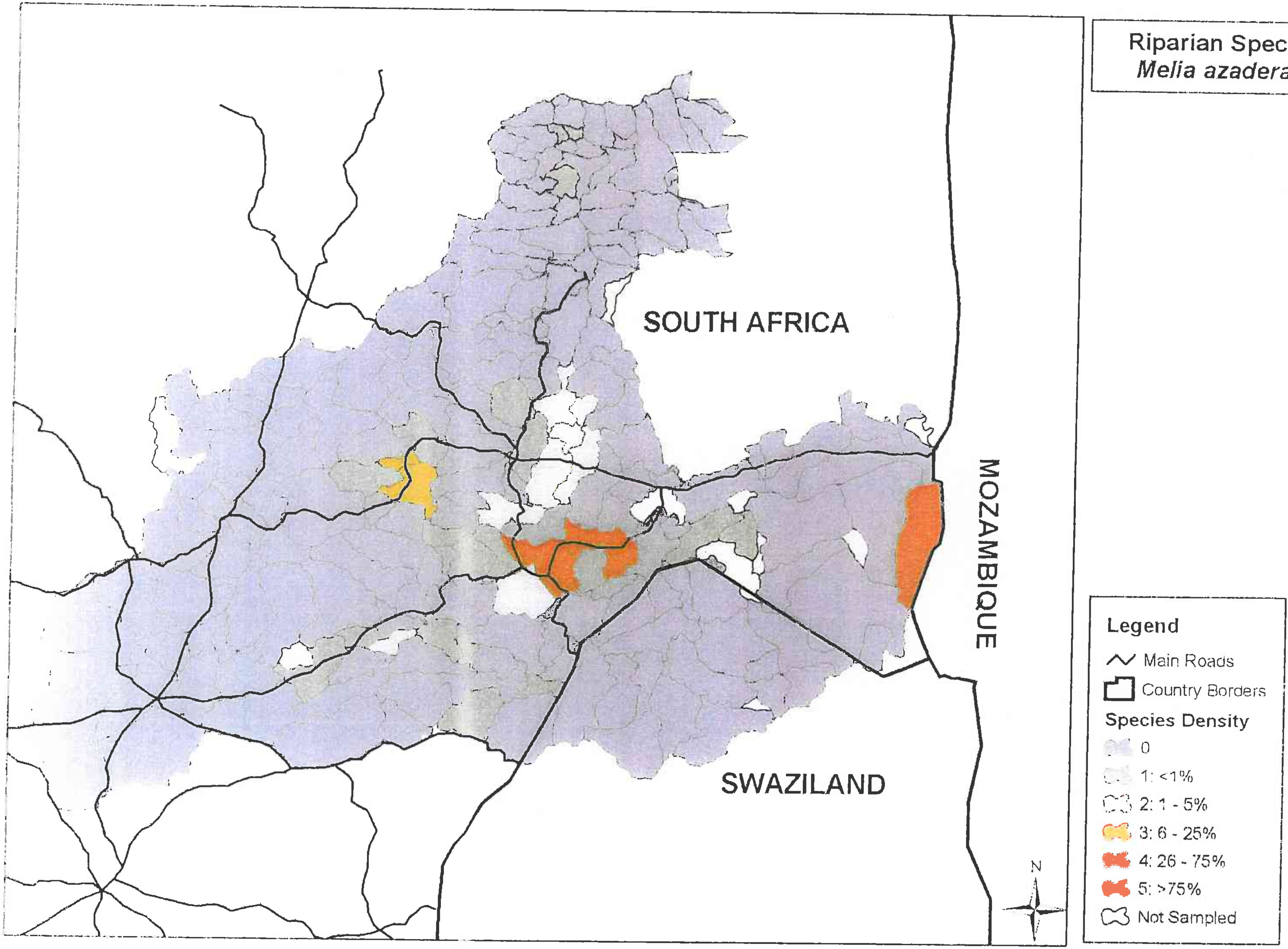

Riparian Species:
*Acacia mearnsii*
SOUTH AFRICA
MOZAMBIQUE
SWAZILAND
N
Legend
Main Roads
Country Borders
Species Density
0
1: <1%
2: 1 - 5%
3: 6 - 25%
4: 26 - 75%
5: >75%
Not Sampled

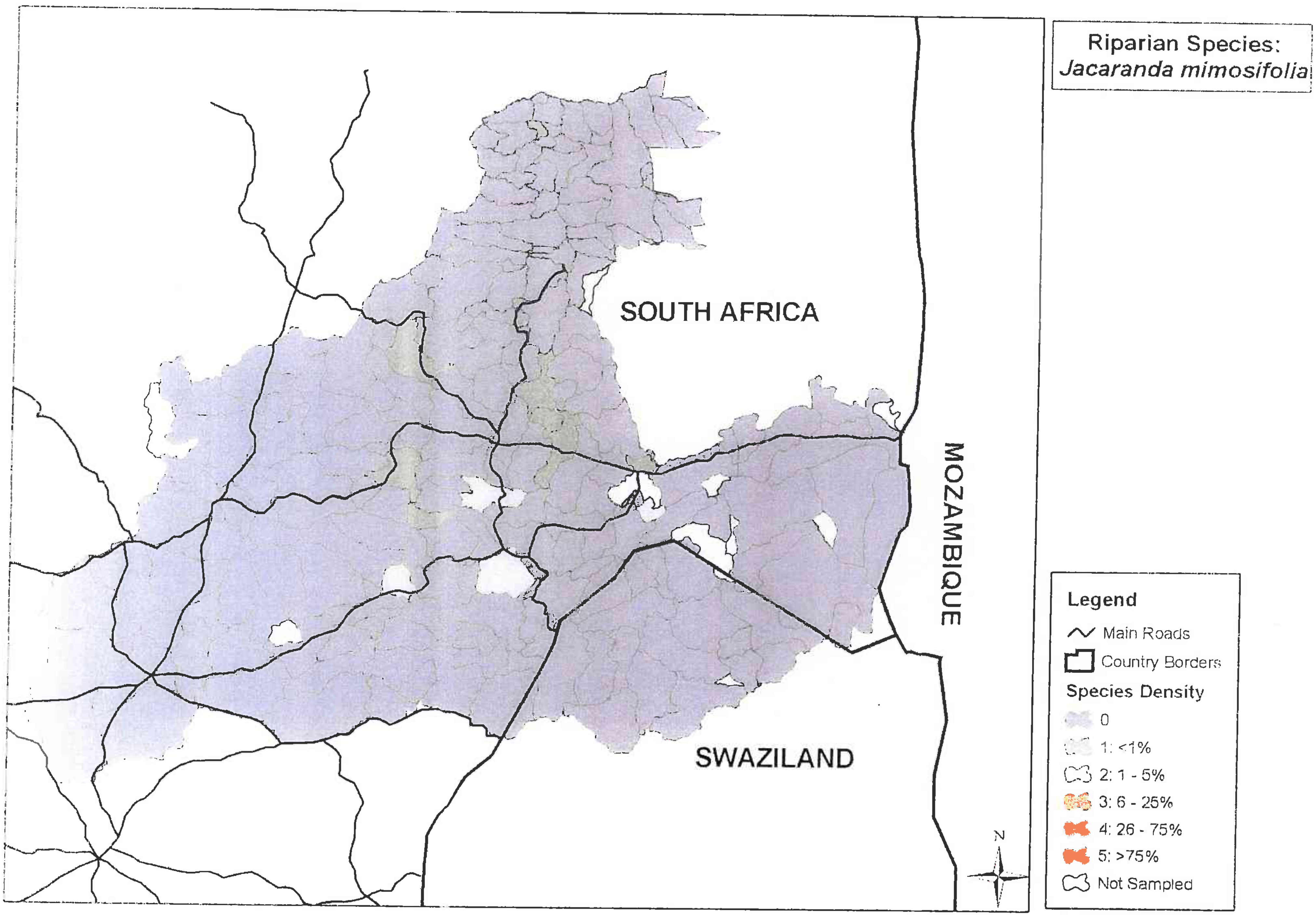
**Riparian Species:**
***Eucalyptus sp***



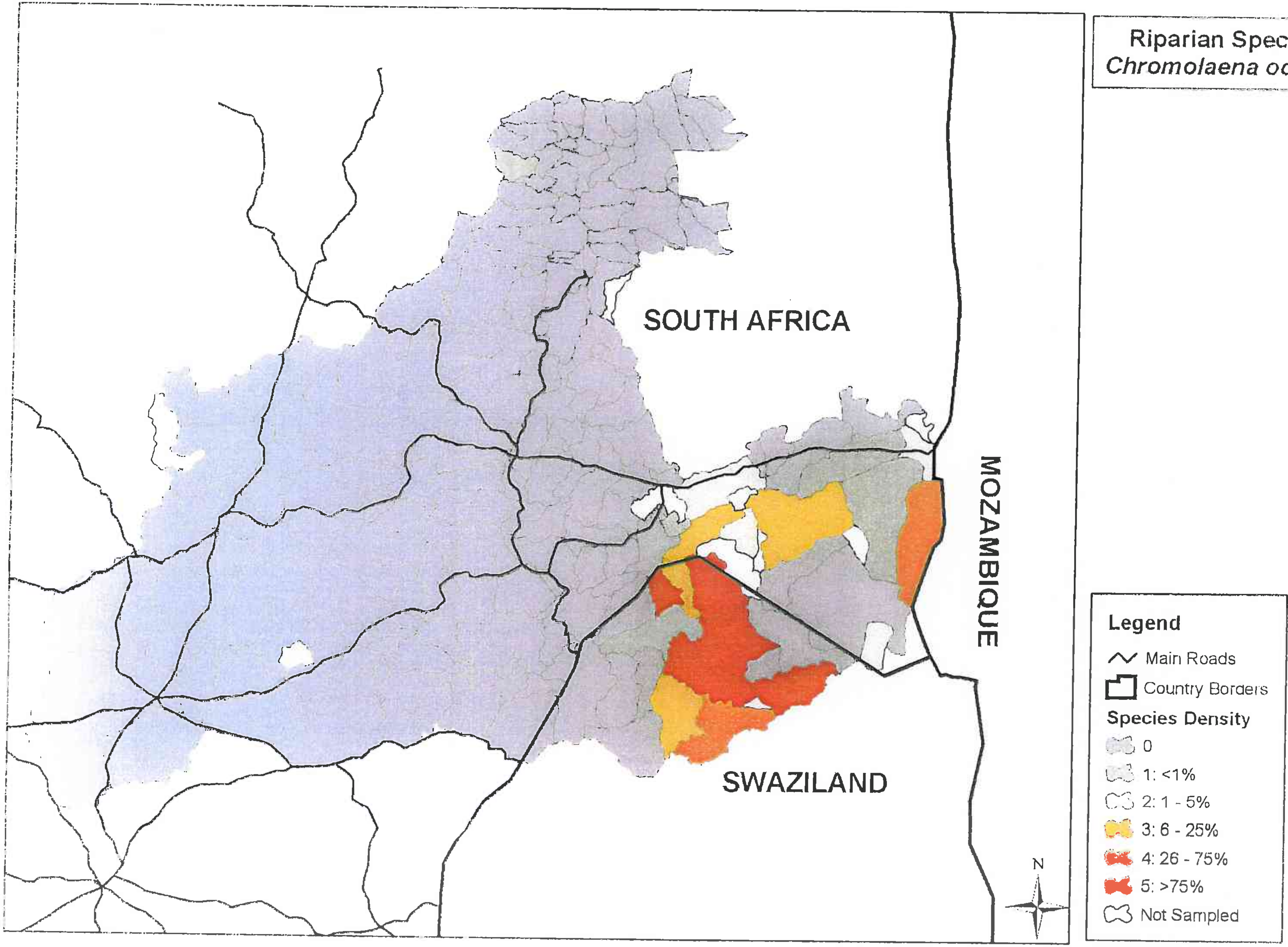

Riparian Species:
*Pinus sp*
SOUTH AFRICA
MOZAMBIQUE
SWAZILAND
N
Legend
Main Roads
Country Borders
Species Density
0
1: <1%
2: 1 - 5%
3: 6 - 25%
4: 26 - 75%
5: >75%
Not Sampled

## Riparian Species: *Melia azaderach*

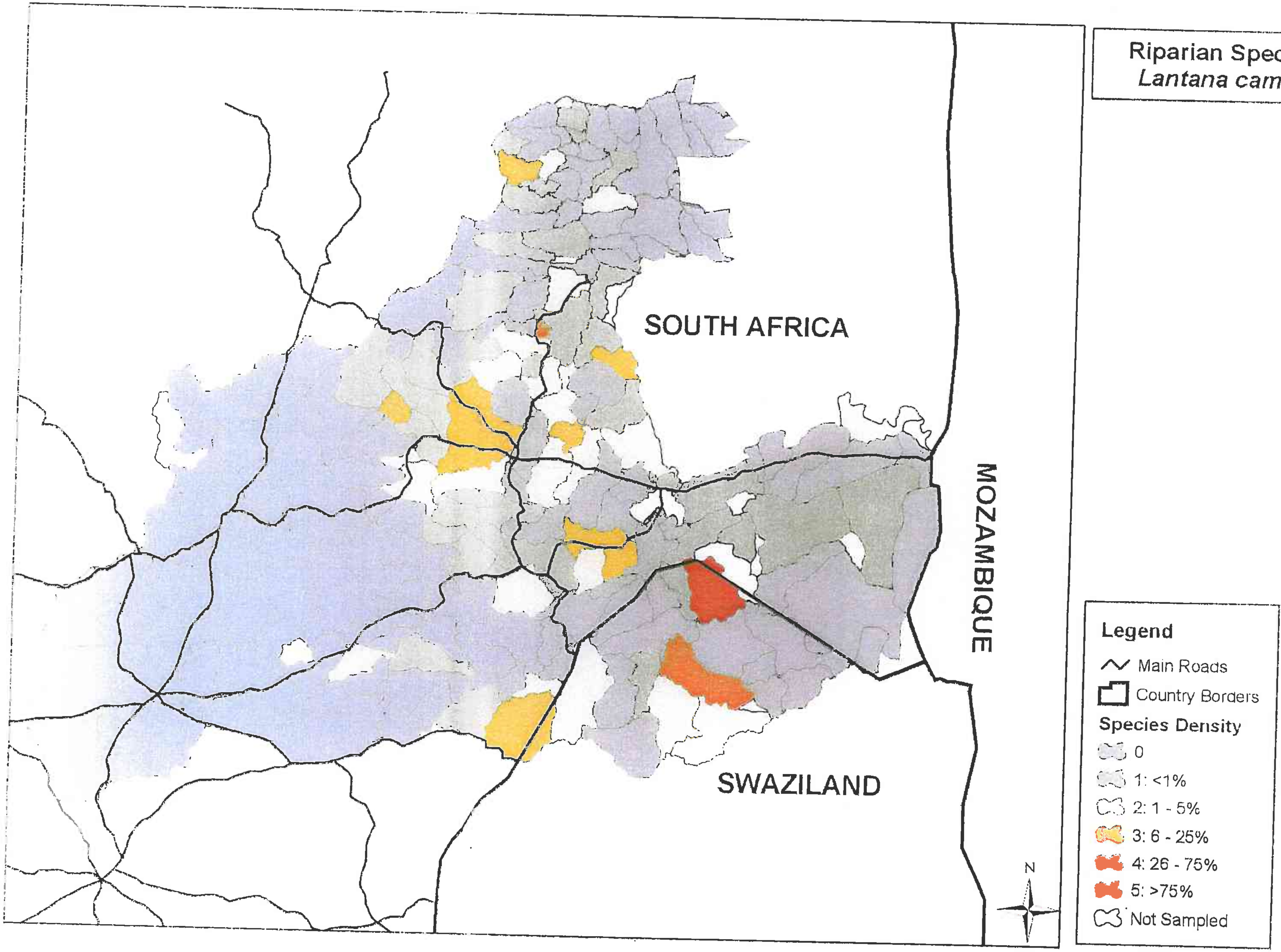



Riparian Species:
*Jacaranda mimosifolia*
SOUTH AFRICA
MOZAMBIQUE
SWAZILAND
N
Legend
Main Roads
Country Borders
Species Density
0
1: <1%
2: 1 - 5%
3: 6 - 25%
4: 26 - 75%
5: >75%
Not Sampled

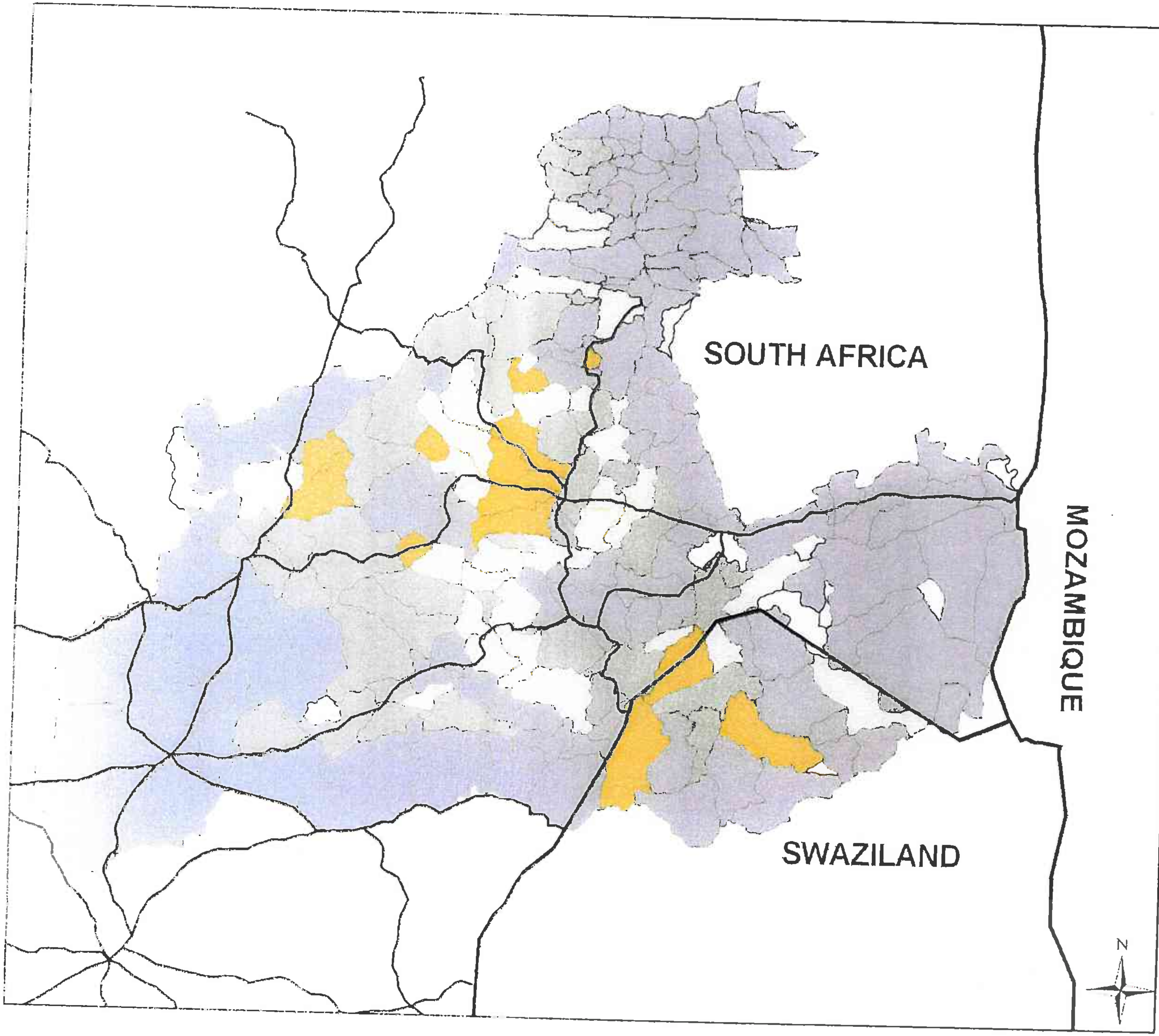
Riparian Species:
*Chromolaena odorata*

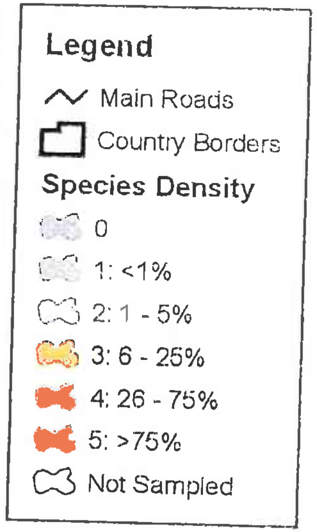


Riparian Species: *Lantana camara*



Riparian Species:
*Solanum maritianum*



# Survey sites recording no alien plants

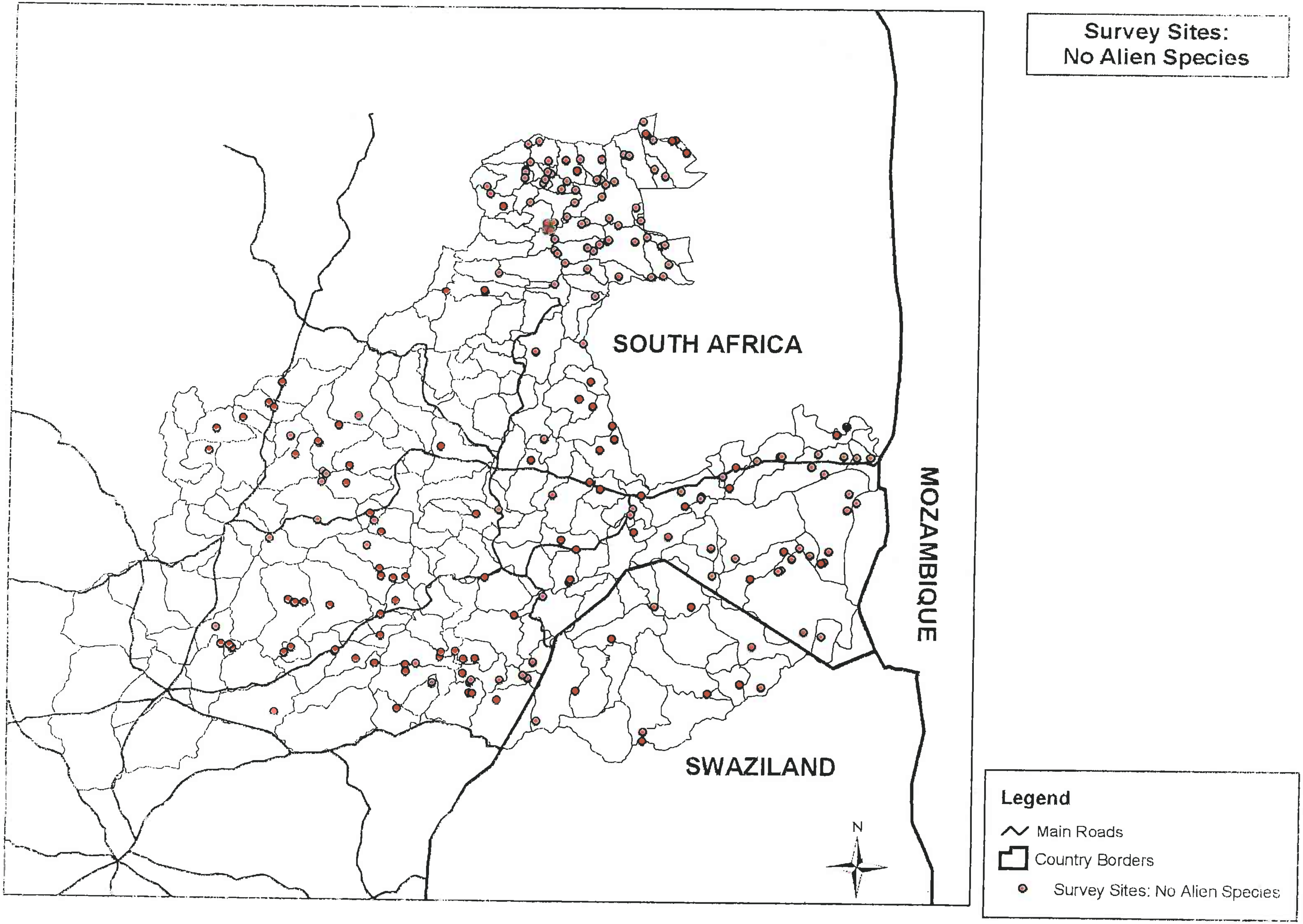
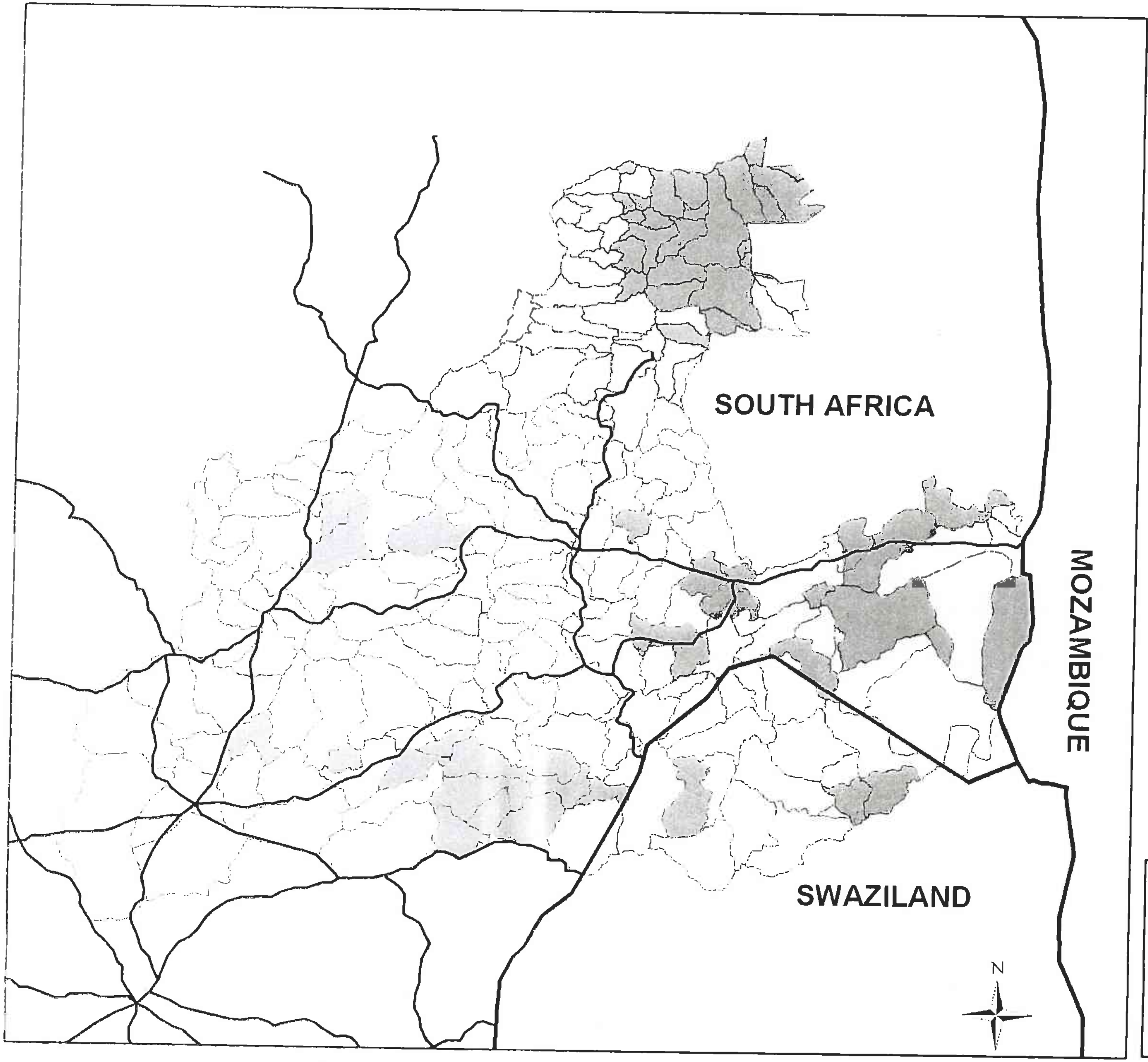

Survey Sites:
No Alien Species
SOUTH AFRICA
MOZAMBIQUE
SWAZILAND
N
Legend
Main Roads
Country Borders
Survey Sites: No Alien Species

Figure 2

Survey sites recording no alien plants

# Non-Riparian

## Non-Riparian Quinaries: No Alien Species



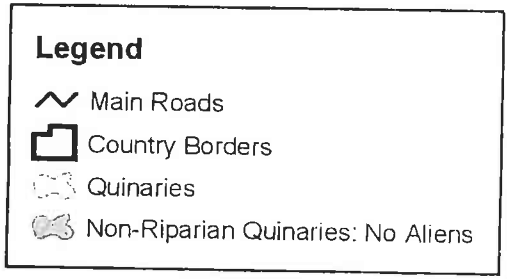
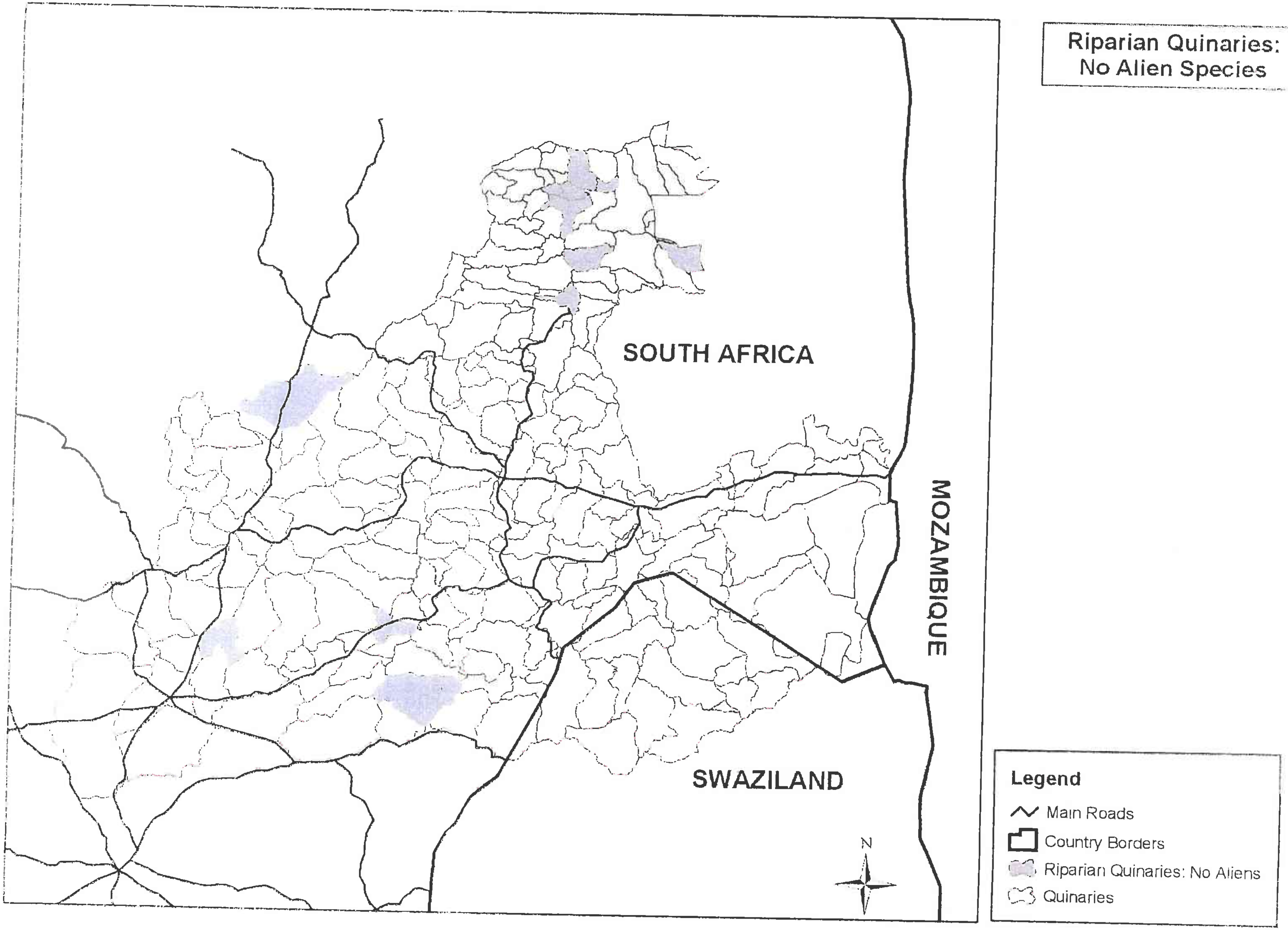



Figure 2

Survey sites recording no alien plants

# Riparian

**Riparian Quinaries: No Alien Species**



**Annexure 2: Sub-quaternaries not visited or insufficiently sampled were assessed using the following methods.**

| Site | lat | lon | Method of survey |
|---|---|---|---|
| 934 | -25.962739 | 31.885240 | Data supplied by Louis Loock of the Mpumalanga Parks board |
| 935 | -25.939124 | 31.818134 | |
| 936 | -25.709078 | 31.696968 | |
| 937 | -25.851322 | 31.747906 | |
| 938 | -26.035534 | 31.040518 | |
| 939 | -26.036747 | 31.020348 | |
| 940 | -25.837592 | 31.151741 | |
| 941 | -25.742294 | 31.071166 | |
| 942 | -25.715545 | 31.145191 | |
| 943 | -25.587297 | 30.941365 | |
| 944 | -25.498001 | 31.34653 | |
| 878 | -24.688676 | 31.164482 | Values based on field observations in adjacent sub-quaternaries. |
| 879 | -24.662634 | 31.134949 | |
| 880 | -24.710771 | 31.228997 | |
| 881 | -24.711297 | 31.217592 | |
| 883 | -24.615004 | 31.063585 | |
| 910 | -25.031888 | 31.004088 | Values based on my knowledge of this section of river through kayaking trips |
| 912 | -25.025599 | 30.967342 | |

**Annexure 2: Sub-quaternaries not visited or insufficiently sampled were assessed using the following methods.**

| Site | lat | lon | Method of survey |
|---|---|---|---|
| 907 | -25.245217 | 31.209993 | Values based on field observations |
| 909 | -25.917074 | 31.834500 | |
| 913 | -25.246500 | 31.039291 | |
| 914 | -25.330970 | 31.127590 | |
| 915 | -25.951343 | 30.432533 | |
| 916 | -26.149450 | 30.579328 | |
| 924 | -25.518392 | 30.958049 | |
| 948 | -25.850404 | 30.754818 | |
| 949 | -25.886750 | 30.663650 | |
| 950 | -26.016381 | 31.270936 | |
| 951 | -26.064263 | 31.554455 | |
| 952 | -25.677169 | 31.789911 | |
| 953 | -25.764452 | 31.204139 | |
| 954 | -25.815183 | 31.207123 | |
| 955 | -25.390378 | 30.107003 | |
| 956 | -25.598469 | 30.672704 | |
| 957 | -25.219562 | 30.647975 | |
| 958 | -25.282733 | 31.041043 | |
| 959 | -25.354759 | 31.081244 | |
| 960 | -25.663133 | 30.831989 | |
| 961 | -25.610573 | 30.843878 | |
| 962 | -25.583667 | 30.851178 | |
| 963 | -25.740290 | 30.744884 | |
| 964 | -25.711712 | 30.816989 | |
| 965 | -25.827928 | 30.766771 | |
| 966 | -25.784648 | 30.865696 | |
| 967 | -25.655227 | 31.295993 | |
| 968 | -25.559718 | 31.312755 | |
| 969 | -25.560350 | 31.521167 | |
| 970 | -25.380084 | 31.944951 | |
| 971 | -24.936961 | 30.836674 | |
| 972 | -25.171377 | 31.006082 | |
| 973 | -25.058351 | 31.200445 | |
| 974 | -24.887590 | 31.434732 | |
| 927 | -25.894211 | 31.451393 | |
| 928 | -26.068633 | 31.534204 | |
| 929 | -26.110344 | 30.710575 | |
| 896 | -25.345701 | 30.297867 | |
| 897 | -25.339941 | 30.287765 | |
| 890 | -25.583685 | 31.185855 | |
| 891 | -25.585798 | 31.185252 | |
| 892 | -25.655450 | 31.423400 | |
| 893 | -25.665400 | 31.137832 | |
| 895 | -25.689258 | 31.178165 | |
| 902 | -24.928943 | 31.035158 | |
| 903 | -24.931456 | 31.034002 | |
| 904 | -24.984965 | 31.057843 | |
| 905 | -24.987715 | 31.061087 | |

## Annexure 2: Sub-quaternaries not visited or insufficiently sampled were assessed using the following methods.

| Site | lat | lon | Method of survey |
|---|---|---|---|
| 917 | -26.094322 | 30.486858 | Values based on field observations and verified by satellite image |
| 918 | -26.092553 | 30.486202 | |
| 919 | -26.016615 | 30.895621 | |
| 920 | -26.016282 | 30.882800 | |
| 921 | -26.025346 | 30.972299 | |
| 922 | -26.033416 | 30.979426 | |
| 923 | -26.020989 | 31.042028 | |
| 930 | -25.778354 | 30.958615 | Values based on personal communications with Local resident Barberton. Roland Jones and field observations of my own |
| 931 | -25.776329 | 30.955735 | |
| 932 | -25.824588 | 30.984132 | |
| 933 | -25.823861 | 30.981971 | |
| 882 | -24.613197 | 31.050247 | Values based on site 297 |
| 886 | -24.823162 | 31.107539 | Values based on site 315 |
| 887 | -24.823162 | 31.105584 | Values based on site 316 |
| 899 | -25.393919 | 30.421256 | Values based on site 394 |
| 898 | -25.392061 | 30.410682 | Values based on site 395 |
| 889 | -25.863706 | 31.262313 | Values based on sites 470 to 472 |
| 871 | -24.781406 | 31.322239 | Values based on site 546 |
| 873 | -24.815837 | 31.337011 | |
| 870 | -24.783991 | 31.334843 | Values based on site 547 |
| 872 | -24.810491 | 31.336459 | |
| 876 | -24.659876 | 31.171741 | Values based on site 555 |
| 877 | -24.659559 | 31.229964 | |
| 866 | -24.707843 | 31.394933 | Values based on site 556 |
| 874 | -24.663150 | 31.188780 | |
| 875 | -24.666423 | 31.216870 | |
| 860 | -24.564054 | 31.357676 | Values based on site 557 |
| 865 | -24.677459 | 31.436484 | |
| 867 | -24.693970 | 31.374344 | |
| 863 | -24.611925 | 31.417197 | Values based on site 558 |
| 864 | -24.642731 | 31.455629 | |
| 868 | -24.684577 | 31.370414 | |
| 869 | -24.701694 | 31.400459 | |
| 861 | -24.561718 | 31.340156 | Values based on site 559 |
| 862 | -24.610099 | 31.427141 | Values based on site 560 |
| 888 | -24.735433 | 31.124390 | Values based on site 578 |
| 884 | -24.720487 | 31.076070 | Values based on site 583 |
| 885 | -24.711449 | 31.081605 | Values based on site 584 |
| 908 | -25.701748 | 31.315903 | Values based on site 638 and 472 |
| 894 | -25.684371 | 31.173897 | Values based on site 95 |
| 906 | -25.250643 | 31.209814 | Values based on sites 511 |
| 925 | -25.777126 | 31.161032 | Values based on Tony Ferrar's personal communication This area further upstream and south of mountain range has been cleared of wattle by Oosthuisen - farm owner |
| 926 | -25.768023 | 31.165201 | |

| | |
|---|---|
| Tony Ferrar | 072 3762581 |
| Louis Loock | 082 778 9472 013 – 759 5378 |
| Roland Jones | 072-376-2581 |

DEPARTMENT OF WATER AFFAIRS & FORESTRY

# INKOMATI WATER AVAILABILITY ASSESSMENT

## ECOLOGICAL WATER REQUIREMENTS

Report No. PWMA 05/X22/00/1008

June 2009

| | |
|---|---|
| **PROJECT NAME:** | INKOMATI WATER AVAILABILITY ASSESSMENT |
| **REPORT TITLE:** | Ecological Water Requirements |
| **AUTHORS:** | S Mallory |
| **REPORT STATUS:** | FINAL |
| **DWAF REPORT NO.:** | PWMA 05/X22/00/1008 |
| **DATE:** | June 2009 |

Submitted by Water for Africa in association with SRK and $CPH_2O$

SJL Mallory 30/9/2009
**SJL Mallory** (Date)

Project Leader

**DEPARTMENT OF WATER AFFAIRS AND FORESTRY**

Directorate of Water resource Planning Systems

Approved for Department of Water Affairs and Forestry by:

| | | | |
|---|---|---|---|
| N J van Wyk | 22/10/2009 | J A van Rooyen | 29/10/2009 |
| N J van Wyk | (Date) | J A van Rooyen | (Date) |
| Chief Engineer: Water Resource Planning (East) | | Director: Water Resource Planning | |

# SCHEDULE OF REPORTS

| | | |
|---|---|---|
| | PWMA 05/X22/00/0808 | Main Report |
| | PWMA 05/X22/00/0908 | Water Requirements Volume 1<br>Water Requirements Volume 2: Assessment of Alien Vegetation |
| **This Report** ☞ | PWMA 05/X22/00/1008 | Ecological Water Requirements |
| | PWMA 05/X22/00/1108 | Water Quality |
| | PWMA 05/X22/00/1208 | Infrastructure and Operating Rules Volume 1<br>Infrastructure and Operating Rules Volume 2: Appendices |
| | PWMA 05/X22/00/1308 | Rainfall Volume 1: Report<br>Rainfall Volume 2: Appendices |
| | PWMA 05/X22/00/1408 | Hydrology of Komati River Volume 1<br>Hydrology of Komati River Volume 2: Appendices |
| | PWMA 05/X22/00/1508 | Hydrology of Crocodile River Volume 1<br>Hydrology of Crocodile River Volume 2 Appendices |
| | PWMA 05/X22/00/1608 | Hydrology of Sabie River Volume 1<br>Hydrology of Sabie River Volume 2 Appendices |
| | PWMA 05/X22/00/1708 | Yield Modelling Volume 1<br>Yield Modelling Volume 2: Appendices |

# EXECUTIVE SUMMARY

The Inkomati Water Management Area (IWMA), located in the north-eastern corner of South Africa, incorporates the major catchments of the Komati, Crocodile and Sabie Rivers.

The Inkomati Water Management Area is considered to be stressed, meaning that water use requirements are in excess of the available water resources, particularly when the water requirements of Mozambique and the ecological Reserve are taken into account. As a result, the ecological Reserve is not met, and the cross-border flows into Mozambique have on occasion been less than those specified in various international agreements. The assurance of water supply to the irrigation sector is also very low in some areas, such as the lower reaches of the Crocodile and Komati rivers.

Water resource planning requires recognition of the ecological Reserve, and estimates of Ecological Water Requirements (EWRs) are therefore required. A comprehensive Reserve determination has been completed in the Komati catchment while similar studies are in progress in the Crocodile and Sabie/Sand River catchments. The preliminary results from the Crocodile and Sabie/Sand catchments have been used to develop scenarios for these catchments, while in the Komati catchment the Reserves have been extrapolated to each node in the system. A node in this case represents a sub-catchment which is typically a sub-division of the quaternary catchments as defined by the WR90 suite of reports (WRC, 1994). This extrapolation process has only recently been developed and the Komati catchment is the first in which it has been applied. This report therefore discusses the methodology used for this extrapolation in some detail. The reader is referred to the full report prepared for the WRC which is still in preparation.

The Reserves used in the water resource models set up for the Inkomati Water Availability Assessment are summarised in the table below.

**Komati River Reserves (Approved, comprehensive)**

| Sites | Ecological Status | MAR | EWR (PES) | % MAR |
|---|---|---|---|---|
| | | million m3/a | million m3/a | |
| K1-Gevonden | B/C | 180.0 | 35.9 | 19.9 |
| K2-Kromdraai | C | 525.0 | 86.8 | 16.5 |
| M1-Silingani *** | C | 857.0 | 222.6 | 26.0 |
| K3-Tonga* | D | 1007.0 | 146.2 | 14.5 |
| G1-Vaalkop | C/D | 37.7 | 25.5 | 67.6 |
| T1-Teespruit | C | 60.6 | 36.6 | 60.4 |
| L1-Kleindoringkop | C/D | 322.0 | 30.5 | 9.5 |

**Crocodile River Reserves**

| Sites | Ecological Status | MAR | EWR (PES) | % MAR |
|---|---|---|---|---|
| | | million m3/a | million m3/a | |
| C EWR 1 | A/B | 9.9 | 4.2 | 42.4 |
| C EWR 2 | B | 55.8 | 27.0 | 48.4 |
| C EWR 3 | B/C | 169.9 | 91.4 | 53.8 |
| C EWR 4 | C | 754.1 | 263.4 | 34.9 |
| C EWR 5 | C | 1006.2 | 267.7 | 26.6 |
| C EWR 6 | C | 1063.1 | 249.9 | 23.5 |
| C EWR 7 | C | 169.0 | 34.5 | 20.4 |

**Sabie/Sand River Reserves**

| Sites | Ecological Status | MAR | EWR (PES) | % MAR |
|---|---|---|---|---|
| | | million m3/a | million m3/a | |
| S EWR 1 | B/C | 140.0 | 54.0 | 38.6 |
| S EWR 2 | C | 262.0 | 63.3 | 24.2 |
| S EWR 3 | A/B | 496.0 | 187.0 | 37.7 |
| S EWR 4 | B | 65.8 | 29.6 | 45.0 |
| S EWR 5 | B/C | 157.1 | 43.2 | 27.5 |
| S EWR 6 | C | 45.0 | 13.7 | 30.4 |
| S EWR 7 | C | 28.9 | 9.7 | 33.6 |
| S EWR 8 | B | 133.6 | 39.3 | 29.4 |

The extrapolated Reserves for Komati catchment are not given in this executive summary but are listed in Appendix D of the report. Similar extrapolations will need to be carried out as for the Crocodile and Sabie/Sand catchments.

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## LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| CMA | Catchment Management Agency, |
| DWAF | National Department of Water Affairs and Forestry. |
| EC | Ecological category |
| EI | Ecological Importance |
| EIS | Ecological Importance and Sensitivity |
| EWR | Ecological Water Requirement |
| IWAAS | Inkomati Water Allocation Assessment Study |
| IWMA | Inkomati Water Management Area |
| MAR | Mean Annual Runoff |
| WAAS | Water Availability Assessment Study |
| PES | Present Ecological State |
| RU | Resource Unit |
| SCI | Social and Cultural Importance |
| SI | Social Importance |
| WMA | Water Management Area |
| WR90 | The Water Resources (Hydrology) of South Africa completed |
| WRC | Water Research Commission |
| WRSM | Water Resource Simulation Model |
| WRYM | Water Resource Yield Model |

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**LIST OF APPENDICES**

# 1. INTRODUCTION

The Inkomati Water Management Area (IWMA), located in the north-eastern corner of South Africa, incorporates the major catchments of the Komati, Crocodile and Sabie Rivers, as shown in Figure 1.1.

The Komati River rises in the south west corner of the WMA, flows through Swaziland then re-enters South Africa before flowing on into Mozambique. The Crocodile River, located in the centre of the WMA, joins the Komati River just before flowing into Mozambique. The Sabie River, with its main tributary the Sand River, forms a separate catchment in the north of the WMA, also flowing into Mozambique after flowing through the Kruger National Park. Once in Mozambique, the Sabie River joins the Komati River which at this point is referred to as the Inkomati River. The Inkomati River Basin is therefore an international river basin, shared by South Africa, Swaziland and Mozambique.

The IWMA is considered to be stressed, meaning that water requirements are in excess of the available water resource, particularly when the water requirements of Mozambique and the ecological Reserve are taken into account. As a result, the ecological Reserve is not met, and the cross-border flows into Mozambique have on occasion been less than those specified in various international agreements. The assurance of water supply to the irrigation sector is also very low in some areas, such as the lower reaches of the Crocodile and Komati rivers.

Water resource planning requires recognition of the ecological Reserve, and estimates of Ecological Water Requirements (EWRs) are therefore required. A comprehensive Reserve determination has been completed in the Komati catchment while similar studies are in progress in the Crocodile and Sabie River catchments. The preliminary results from the Crocodile and Sabie catchments have been used to develop scenarios for these catchments, while in the Komati catchment the Reserves have been extrapolated to each node in the system. A node in this case represents a sub-catchment which is typically a sub-division of the quaternary catchments as defined by the WR90 suite of reports. This extrapolation process has only recently been developed and the Komati catchment is the first in which it has been applied. This report therefore describes in some detail the methodology used for this extrapolation. The reader is referred to the full report by Kleynhans et al, 2008.

Ecological Reserve (quantity) determinations at the Comprehensive and Intermediate levels are generally determined for sites located along main-stem rivers and major tributaries, where water is often in high demand. Frequently, no EWR information is available for the smaller tributaries. The establishment of sites to provide EWRs at all the locations of interest that would be necessary for water resource planning is not practical, and is beyond available resources. There is therefore a need to develop a cost-effective and efficient method for estimating EWRs for numerous river locations in quaternary catchments, with reasonable levels of accuracy, using information gathered during the determination of the Reserve at main stem rivers and on major tributaries. Such a methodology has been developed as part of a Water Research Commission project entitled '*Principles of a process to estimate and/or extrapolate environmental flow requirements*'.

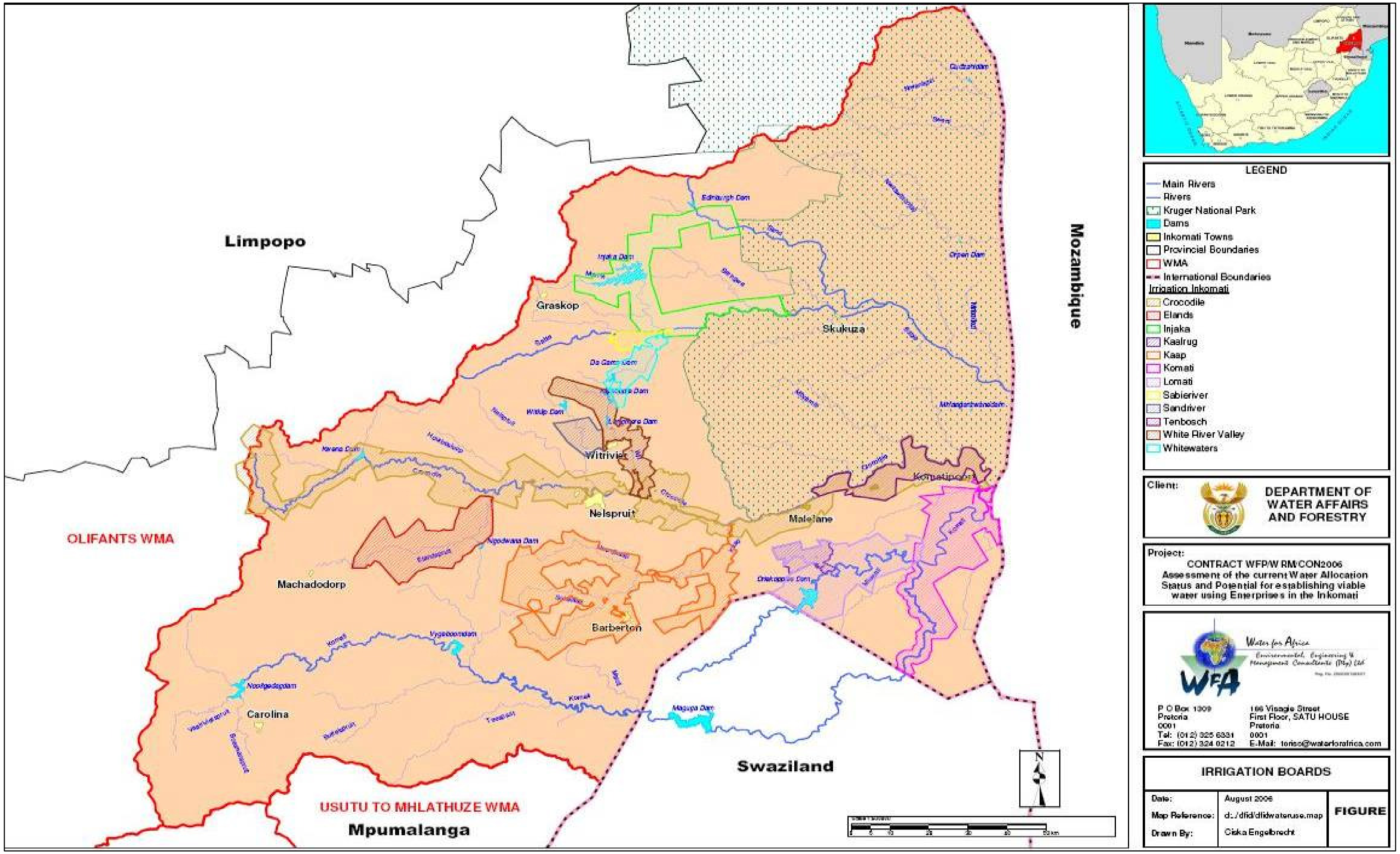


**Figure 1.1: The Inkomati WMA**

# 2. CROCODILE CATCHMENT

## 2.1 INTRODUCTION

The ecological Reserve study which is currently in progress has identified 7 sites at which the Reserve is being determined comprehensively. These sites are indicated in Figure 2.1. Table 2.1 gives a geographic description of these EWR sites.

**Table 2.1: EWR sites in the Crocodile River catchment**

| IFR Site | Site Name | River | Co-ordinates | |
|---|---|---|---|---|
| | | | Latitude | Longitude |
| 1 | Valy spruit | Crocodile | S25 29.647 | E30 08.656 |
| 2 | Goedenhoop | Crocodile | S25 24.555 | E30 18.955 |
| 3 | Poplar Creek | Crocodile | S25 27.127 | E30 40.865 |
| 4 | Ka- Nyamazane | Crocodile | S25 30.146 | E31 10.919 |
| 5 | Malelane | Crocodile | S25 28.972 | E31 30.464 |
| 6 | Nkongoma | Crocodile | S25 23.430 | E31 58.467 |
| 7 | Honeybird | Kaap | S25 38.968 | E31 14.572 |

## 2.2 PRELIMINARY RESULTS

Table 2.2 presents a summary of the preliminary ecological flow requirements in the Crocodile catchments. It must be noted that these are preliminary results that are likely to change especially at sites 5, 6 and 7 where the impact of meeting these flows will be the highest. The rule curves are attached as Appendix A.

**Table 2.2: Preliminary EWR requirements in the Crocodile River catchment**

| Sites | Ecological Status | MAR million m3/a | EWR (PES) million m3/a | % MAR |
|---|---|---|---|---|
| C EWR 1 | A/B | 9.9 | 4.2 | 42.4 |
| C EWR 2 | B | 55.8 | 27.0 | 48.4 |
| C EWR 3 | B/C | 169.9 | 91.4 | 53.8 |
| C EWR 4 | C | 754.1 | 263.4 | 34.9 |
| C EWR 5 | C | 1006.2 | 267.7 | 26.6 |
| C EWR 6 | C | 1063.1 | 249.9 | 23.5 |
| C EWR 7 | C | 169.0 | 34.5 | 20.4 |

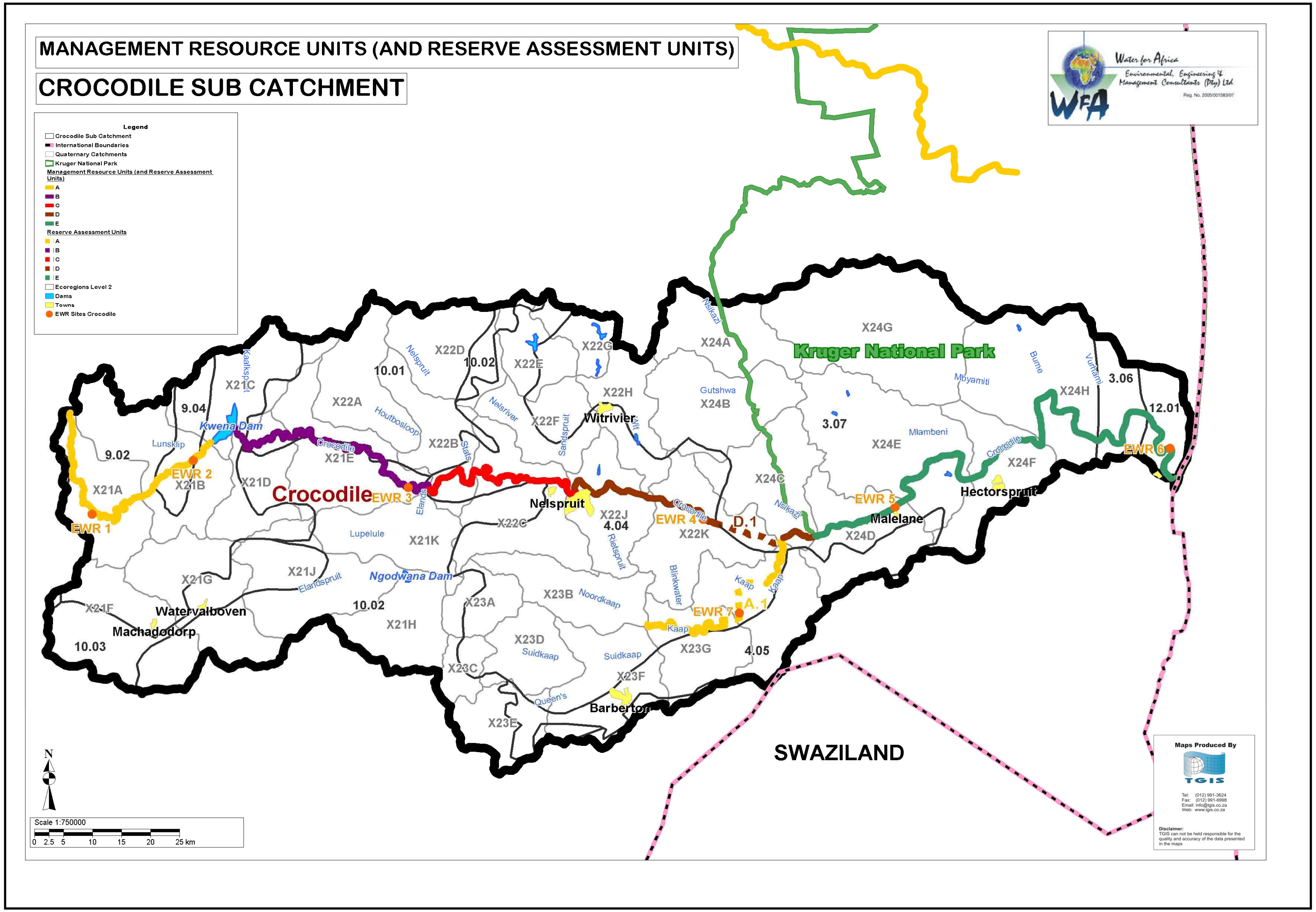


Figure 2.1: Ecological Reserve sites in the Crocodile River catchment

# 3 SABIE SAND RIVER CATCHMENT

## 3.1 INTRODUCTION

The ecological Reserve study which is currently in progress has identified 8 sites at which the Reserve is being determined comprehensively. These sites are indicated in Figure 3.1. Table 3.1 gives a geographic description of these EWR sites.

**Table 3.1: EWR sites in the Sabie/Sand River catchment**

| IFR Site | Site Name | River | Co-ordinates | |
|---|---|---|---|---|
| | | | Latitude | Longitude |
| 1 | UpperSabie | Sabie | S25 04.424 | E30 50.924 |
| 2 | Sabie_Aan de Vliet | Sabie | S25 01.675 | E31 03.099 |
| 3 | Kidney | Sabie | S24 59.256 | E31 17.572 |
| 4 | MacMac | MacMac | S25 00.800 | E31 00.243 |
| 5 | Marite | Marite | S25 01.077 | E31 07.997 |
| 7 | Mutlumuvi | Mutlumuvi | S24 45.352 | E31 07.923 |
| 8 | Tlulandziteka | Tlulandziteka (Sand) | S24 40.829 | E31 05.188 |
| 7 | Sand | Sand | S24 58.045 | E31 37.641 |

## 3.2 PRELIMINARY RESULTS

Table 3.2 presents a summary of the preliminary ecological flow requirements in the Sabie River catchment. It must be noted that these are preliminary results that are likely to change especially at sites 5, 6 and 7 where the impact of meeting these flows will be the highest. The rule curves are attached as Appendix B.

**Table 3.2: Preliminary EWR requirements in the Sabie/Sand River catchment**

| Sites | Ecological Status | MAR million m3/a | EWR (PES) million m3/a | % MAR |
|---|---|---|---|---|
| S EWR 1 | B/C | 140.0 | 54.0 | 38.6 |
| S EWR 2 | C | 262.0 | 63.3 | 24.2 |
| S EWR 3 | A/B | 496.0 | 187.0 | 37.7 |
| S EWR 4 | B | 65.8 | 29.6 | 45.0 |
| S EWR 5 | B/C | 157.1 | 43.2 | 27.5 |
| S EWR 6 | C | 45.0 | 13.7 | 30.4 |
| S EWR 7 | C | 28.9 | 9.7 | 33.6 |
| S EWR 8 | B | 133.6 | 39.3 | 29.4 |

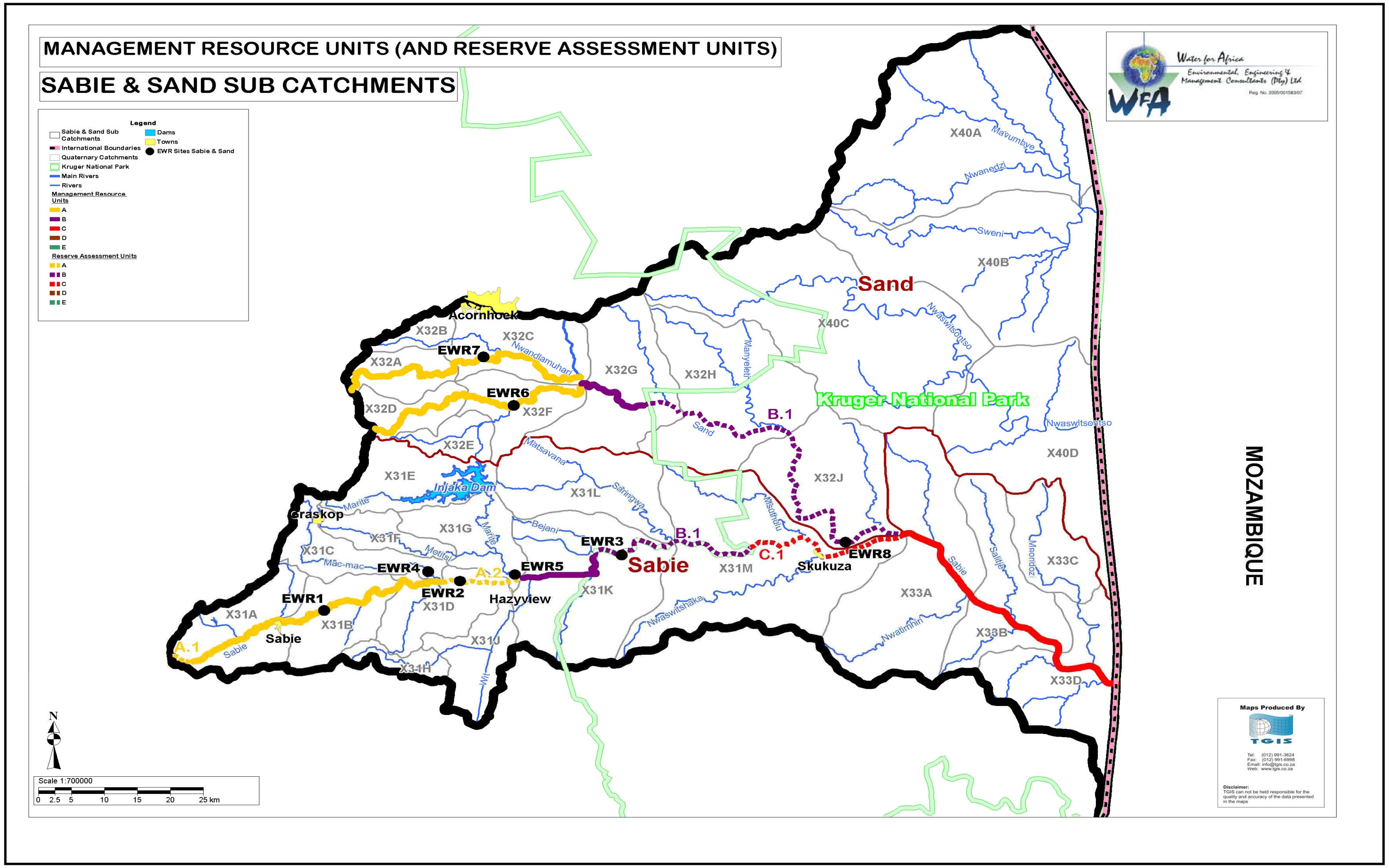


Figure 3.1: Ecological reserve sites in the Sabie/Sand River catchment

# 4. KOMATI RIVER CATCHMENT

## 4.1 COMPREHENSIVE RESERVE DETERMINATION

The preliminary determination of the Reserve for the Inkomati catchment was undertaken at comprehensive level, and the findings and a recommendation on the preferred flow scenario were presented to senior managers of DWAF at a briefing meeting on 27 September 2005. These findings were then used as the basis for the extrapolation and interpolation of the Reserve for the various quaternary catchments of the Inkomati river system. Figure 4.1 depicts the EWR sites which were used for the comprehensive Reserve determination within the Komati River catchment while Table 4.1 summarises the geographic location of these sites.

**Table 4.1: Locality of EWR sites**

| Site Name | River | RU | Locality |
|---|---|---|---|
| Komati River | | | |
| K1-Gevonden | Upper Komati | B | 25° 51'15.6"S;<br>30° 22' 35.9"E |
| K2-Kromdraai | Upper Komati | C | 26° 02'19.7"S;<br>31° 00'11.3"E |
| M1-Silingani *** | Middle Komati | Maguga | 26° 05.970'S:<br>31° 23.893'E |
| K3-Tonga* | Lower Komati | D | 25° 40'01.1"S<br>31° 48'04.8"E |
| K3A-Tonga** | Lower Komati | D | 25° 40'39.5"S<br>31° 47'26.0"E |
| K4-Elsana* | Lower Komati | E | 25° 38'33.6"S;<br>31° 48'54.8"E |
| K5-Lebombo** | Lower Komati | E | 25°26'55.9"S;<br>31°57'28.2"E |
| Tributaries | | | |
| G1-Vaalkop | Gladdespruit | G | 25° 46'18.2"S<br>30° 37'37.8"E |
| T1-Teespruit | Teespruit | T | 26° 01'09.5"S;<br>30° 51'07.3"E |
| L1-Kleindoringkop | Lomati | M | 25° 38'58.0"S:<br>31° 37'23.5"E |

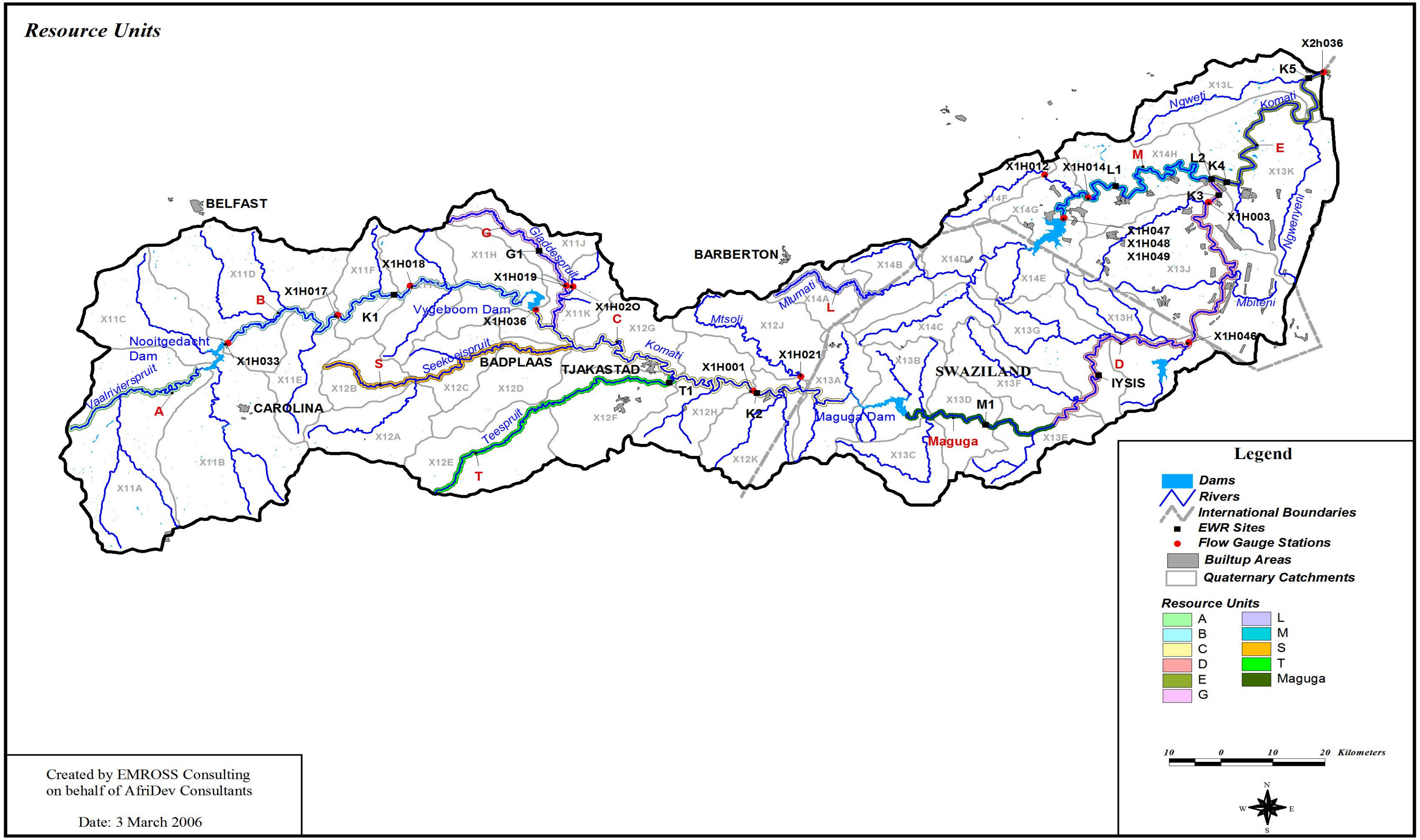


**Figure 4.1: Study area, EWR sites, and resource units**

### 4.1.2 Study team

The preliminary determination of the Reserve for the Komati River catchment was undertaken by AfriDev Consultants (Pty) Ltd, and managed by Water for Africa (Pty) Ltd (previously known as Tlou & Mallory (Pty) Ltd), on behalf of the Department of Water Affairs and Forestry (DWAF), Directorate: Resource Directed Measures (RDM).

### 4.1.3 Methodology

In order to achieve the highest possible level of confidence in recommendations for the Preliminary Reserve for the Komati River System, a comprehensive approach was adopted using widely accepted methodologies for the determination of each component.

***Ecoclassification***

Ecoclassification refers to the categorisation of the Present Ecological State (PES) of various biophysical attributes compared to the natural (or near natural), reference condition. The Ecoclassification process supports the scenario based approach where a range of ecological endpoints (Ecological Categories) is considered. The approach and methodology used is contained within IWR Source-to-Sea (eds). 2004. A Comprehensive EcoClassification and Habitat Flow Stressor Response Manual. Prepared for IWQS: DWAF, Project no. 2002-148

***Ecological Water Requirements***

Ecological Water Requirement (EWR) refers to the flow patterns (magnitude, timing and duration) and water quality needed to maintain a riverine ecosystem in a particular condition. The process did not consider whether these flows could be supplied or managed and impacts on users were not considered. The generic framework of the Building Block Method of assessing EWRs was used in the study, as outlined in DWAF (1999): Resource Directed Measures for Protection of Water Resources; Volume 3: River Ecosystems Version 1.0. This method was modified to incorporate alternative scenarios and separate assessments were made for low flows (base flows) and high flows (freshets and floods).

The recommendations for low flows were determined for each EWR site using the Habitat-Flow-Stressor-Response (HFSR) methods described by Hughes, A. and O'Keeffe, J. H. 2004. Flow-stressor response approach to Ecological Water Requirement Assessment. Extract from WRC Project No K5/1160/0/1 presented In: IWR Source-to-Sea (eds). 2004. A Comprehensive EcoClassification and Habitat Flow Stressor Response Manual. Prepared for IWQS: DWAF, Project no. 2002-148.

Recommendations for high flows were determined for each EWR site using the Downstream Response to Imposed Flow Transformations (DRIFT) outlined in Brown C. and King J., 2000. Environmental flow assessment for rivers. A summary of the DRIFT process. Southern Waters information Report No 01/00.

The methodology for the water quality component of the ecological Reserve can be found in:

Jooste, S. and Rossouw, J. N. 2002. Hazard-Based Water Quality EcoSpecs For The Ecological Reserve In Fresh Surface Water Resources. Report No. N/0000/REQ0000. Institute for Water Quality Studies, Department of Water Affairs and Forestry, Pretoria, South Africa.

Department of Water Affairs and Forestry (DWAF). 2002. Methods for Assessing Water Quality in Ecological Reserve Determinations for Rivers. Pretoria.

Table 4.2 provides details of the level of assessment for each component on which the recommendations for the Preliminary Reserve were based.

**Table 4.2: Aspects included in the determination of the Reserve for the Komati River System**

| Component | Level of Assessment |
|---|---|
| Ecological Water Requirements: | |
| river flow quantity and quality; | Comprehensive |
| Groundwater | Scoping |
| Wetlands | Scoping |
| Regional Economics | Preliminary |
| Goods and Services | Preliminary |
| Capacity Building | Comprehensive |
| Eco-specifications and monitoring plan | Preliminary |

### *Stakeholder involvement*

Stakeholder involvement during the Reserve determination was limited to the distribution of newsletters in the study area, and a presentation that was made to the Komati Water User Association.

### *Basic Human needs Reserve*

The Basic Human Needs Reserve was not separately determined, as users in this catchment are dependent on the formal water networks for their basic water requirements rather than on run of river, for their daily domestic water supply. The basic human needs requirement will therefore be met with the implementation of the recommended ecological Reserve.

### 4.1.4 Scenario analysis

*Introduction*

The comprehensive Reserve determination consisted of all the elements that were likely to be contained in the classification system, which at that time was still to be developed and promulgated. An integrated approach for considering a range of ecological categories, and their consequences, was adopted based on the:

- ecological importance and sensitivity (EIS),
- social and cultural importance (SCI) and
- the economic importance (EI) or value of in-river and out of river use of the resource

so as to better inform decision-making regarding the Reserve. This approach included scenario analysis consistent with basic principles of Integrated Water Resource Management (IWRM), i.e. consideration of all realistic alternatives to a specific proposal.

*Operational scenarios*

Operational scenarios refer to flow scenarios that are realistic in the sense that they incorporate the availability of water, operational constraints and user demands. The Water Resources Yield Model (WRYM) was used and analyses were done using the historic inflow time series from 1921 to 1999 to determine supply to users for each scenario.

A series of meetings were held with regional water managers to develop appropriate operational scenarios.

In regulated Resource Units (RU), the high flow component of EWRs was modified to account for the limited outlet capacities of upstream dams. High flow requirements that could not be met because of outlet constraints were removed completely as a demand, and not capped at the maximum outlet capacity.

*Consequences of the flow scenarios*

The operational scenarios were assessed in terms of their ecological and water quality consequences. The water quality consequences were assessed using simple concentration modelling. This and the other driver consequences were then used to assess the response consequences for each different flow scenario. The ecological consequence assessment was made within the EcoClassification process.

Consequences of the operational scenarios on the yield of the system were assessed using the WRYM (2000).

The methodology for assessing the consequences of the flow scenarios on the goods and services and economy can be found in AfriDev 2006. Main Report. Komati Catchment Ecological Water Requirements Study. Department of Water Affairs and Forestry, Pretoria. Report No. RDM X100-00-CON-COMPR2-1205, chapter 14.

### 4.1.5 Results

The output of the study was a preliminary Reserve, selected from the range of scenarios that were derived during the study. To allow informed decision-making, ecological, socio-economic and Goods and Services impacts of each of the flow scenarios were determined. This information and a recommendation on the preferred scenario, was presented to senior managers of DWAF at a briefing meeting on 27 September 2005.

#### *Preliminary determination of the resource class*

Eleven ecologically distinct Resource Units (RUs) were identified in the Komati River catchment as shown in Figure 1. The PES and REC of each RU is described in Table 4.3.

**Table 4.3: Present Ecological State and Ecological Category for each Resource Unit in the Komati River System**

| Resource Unit | PES | IMPORTANCE | | Recommended Ecological Category (REC) |
|---|---|---|---|---|
| | | Economic Importance and sensitivity (EIS) | Social Importance (SI) | |
| KOMATI RIVER | | | | |
| A | B | M | L | B |
| B | B/C | H | M | B/C |
| C | C | H | H | C |
| MAGUGA | C | H | V.H | C |
| D | E | M | V.H | D |
| E | E | M | V.H | D |
| GLADDESPRUIT RIVER | | | | |
| G | D | L | L | D |
| SEEKOEISPRUIT RIVER | | | | |
| S | C | M | M | C |
| TEESPRUIT RIVER | | | | |
| T | C | H | M | C |
| LOMATI RIVER | | | | |
| L | B | V.H | H | B |
| M | C/D | H | H | C/D |

L = Low; M = Moderate; H = High; VH = Very High

The PES for the RUs ranges from category B to category E. The EC for each RU, except for D and E, in the lower Komati River, is to remain unchanged from the PES. The EC of RUs D and E are to be improved from category E to category D, in order to achieve a base level of sustainability.

The ecological Reserves approved by DWAF as a result of this comprehensive study are listed in Appendix C, while a summary of these requirements is given in Table 4.4.

**Table 4.4: Summary of the Ecological Reserves of the Komati River catchment**

| Sites | Ecological Status | MAR Million $m^3/a$ | EWR (PES) Million $m^3/a$ | %MAR |
|---|---|---|---|---|
| K1-Gevonden | B/C | 180.0 | 35.9 | 19.9 |
| K2-Kromdraai | C | 525.0 | 86.8 | 16.5 |
| M1-Silingani*** | C | 857.0 | 222.6 | 26.0 |
| K3-Tonga | D | 1007.0 | 146.2 | 14.5 |
| G1-Vaalkop | C/D | 37.7 | 25.5 | 67.6 |
| T1-Teespruit | C | 60.6 | 36.6 | 60.4 |
| L1-Kleindoringkop | C/D | 322.0 | 30.5 | 9.5 |

### *Preliminary determination of the Reserve for quantity*

The Ecological Reserve for quantity in the Komati River catchment was determined on a preliminary basis and is defined by the assurance tables in Annexure C of Appendix 1. The Reserve at any point in the Komati River System can be determined by extrapolating the flow regime up or downstream, from an existing EWR site, as described in section 3 of this report.

### *Preliminary determination of the Reserve for quality*

The Ecological Reserve for quality in the Komati River catchment was determined on a preliminary basis and is defined by the minimum quality specifications in Annexure D of Appendix A.

The final preliminary determination of the Reserve and Resource Class in terms of Section 14(1) (b) and 17 (1) (b) of the National Water act, 1998 (Act No. 36 of 1998) is included as Appendix A of this report

### *Flow (Ecospecs)*

Through an iterative process and considering impact on yield, operational constraints, economics and Goods and Services, the quantity component of the Reserve is recommended at each of the above EWR sites. The information is provided as IFR assurance rules. IFR assurance rules are the IFR provided as a duration table, i.e. flows that should be met or exceeded for a certain % of time.

Maintenance flows were set at 70% assurance for all sites. Droughts were set at the value of between 0 and 10% assurance.

EWR rule tables and natural duration curves for sites K1, 2 and 3, and sites G1, T1, L1 and M1 are provided in Appendix 1 of this report, together with the information pertaining to the preliminary ecological Reserve – water quality (quality ecospecs).

### 4.1.6 Level of confidence of the Reserve determination

- Biological data: generally high for the main river, and less so for the tributaries
- Low-flow hydraulics: generally high
- High-flow hydraulics: low, due to extended dry period, which made it impossible to calibrate the hydraulics under high flow conditions.
- Sites selected: high, with the notable exception of EWR Site K3 (Tonga), which had been historically inundated by backup from a weir, and was re-inundated during the course of the study.
- Hydrology: moderate for most sites, with the notable exception EWR Site G1 (Gladdespruit), where confidence was low.

## 4.2 EXTRAPOLATION OF PRELIMINARY COMPREHENSIVE RESERVE TO QUATERNARY CATCHMENTS IN THE INKOMATI SYSTEM

### 4.2.1 Background

Ecological Reserve (quantity) determinations at the Comprehensive and Intermediate levels have generally been determined for sites located along main-stem rivers and major tributaries, where water resources are often in high demand. Frequently, no EWR information is available for the smaller tributaries. The establishment of sites to provide EWRs at all locations of interest necessary for water resource planning is not practical and beyond available resources. There is therefore a need to develop a cost-effective and efficient method for estimating EWRs for numerous river locations with reasonable levels of accuracy.

The Inkomati Water Availability Assessment Study (IWAAS), initiated in 2006, requires an assessment of the EWRs for numerous locations (approximately 70 hydro-nodes) on rivers within the Inkomati River catchment for yield modelling purposes. The Inkomati River Comprehensive Reserve assessment (Afridev, 2006), completed in 2005, provided ecological flow recommendations for three sites along the main stem Inkomati River, and three of it's major tributaries, including, the Lomati River, Gladdespruit and Teespruit.

Extrapolation of Ecological Reserve results to the hydro-nodes applies a hydrological scaling, taking no account of biological information (e.g. actual biota present in the river), habitat preferences (e.g. rheophilic guilds) and habitat availability (e.g. physical size of the river). Whereas the ecological similarity concept provides guidance on the biological appropriateness of hydrological extrapolation, this study considered the development of an improved means for estimating EWRs taking explicit consideration of these factors. The first step was to develop sets of "habitat preference rules" (or HabSpecs) as a function of river and hydrological condition (through the use of wet and dry seasons, and drought and maintenance conditions, and EC).

### 4.2.2 Application of HabSpecs for estimating ecological flows

The use of optimised HabSpecs (Tables 4.5 and 4.6) was tested for a limited number of sites within the upper Inkomati River catchment.

**Table 4.5: Optimised HabSpecs for small rheophilic and large semi-rheophilic fish guilds for small and large rivers**

| Hydrological variability | Ecological Category | Season | Fish guilds | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Small rheophilic (Length < 10 to 15 cm) | | | Large semi - rheophilic (Length > 25 to 30 cm) | | |
| | | | Mean annual runoff (Mm3/a) | | | | | |
| | | | 5 to 30 | | | 60 to 520 | | |
| | | | Hydraulic parameter or flow-class | | | | | |
| | | | y (cm) | F (%) | F.1 (%) | y (cm) | F (%) | F.2 (%) |
| Drought | | Wet | 19 | 13 | 4 | 34 | 21 | 18 |
| | | Dry | 16 | 2 | 1 | 30 | 11 | 8 |
| Maintenance | C | Wet | 22 | 23 | 10 | 38 | 31 | 28 |
| | | Dry | 18 | 12 | 2 | 33 | 20 | 17 |
| | B | Wet | 28 | 43 | 26 | 47 | 53 | 45 |
| | | Dry | 21 | 25 | 11 | 35 | 28 | 23 |

Abbreviations:

y=maximum depth

F=fast flow (velocity greater than 0.3 m/s)

F.1=fast flow with a depth greater than 0.1 m

F.2=fast flow with a depth greater than 0.2 m

**Table 4.6: Optimised HabSpecs for cobble dwelling rheophilic invertebrate communities determined separately for small and large rivers**

| Hydrological variability | Hydrological Category | Season | Mean annual runoff (million $m^3$/annnum) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 5 to 30 | | | | 50 to 530 | | | |
| | | | Hydraulic parameter or flow-class | | | | | | | |
| | | | y (cm) | yav (cm) | vav (cm/s) | FCS (%) | y (cm) | yav (cm) | vav (cm/s) | FCS (%) |
| Drought | | Wet | 19 | 8 | 15 | 5 | 28 | 15 | 16 | 7 |
| | | Dry | 16 | 5 | 8 | 1 | 23 | 12 | 12 | 4 |
| Maintenance | C | Wet | 22 | 10 | 23 | 14 | 32 | 20 | 29 | 24(18) |
| | | Dry | 18 | 7 | 13 | 4 | 29 | 17 | 16 | 8 |
| | B | Wet | 27 | 11 | 27 | 20 | 36 | 24 | 38 | 29 |
| | | Dry | 21 | 9 | 22 | 12 | 28(30) | 16(19) | 27 | 21 |

Abbreviations:

y=maximum depth

yav=average depth

vav=average velocity

FCS=fast flow (velocity greater than 0.3 m/s) over coarse substrate (greater than 16 mm dia.)

FCS values apply to a standardised proportion of coarse sediment (50%)

(x) - adjusted value based on adjacent categories

### 4.2.3 Data collection

To test the HabSpecs, Rapid level III-type hydraulic data were collected at eleven river sites in the upper Inkomati River catchment (upstream of Swaziland) during the period 14 to 17 May 2007. Figure 4.3 depicts the eleven river sites.

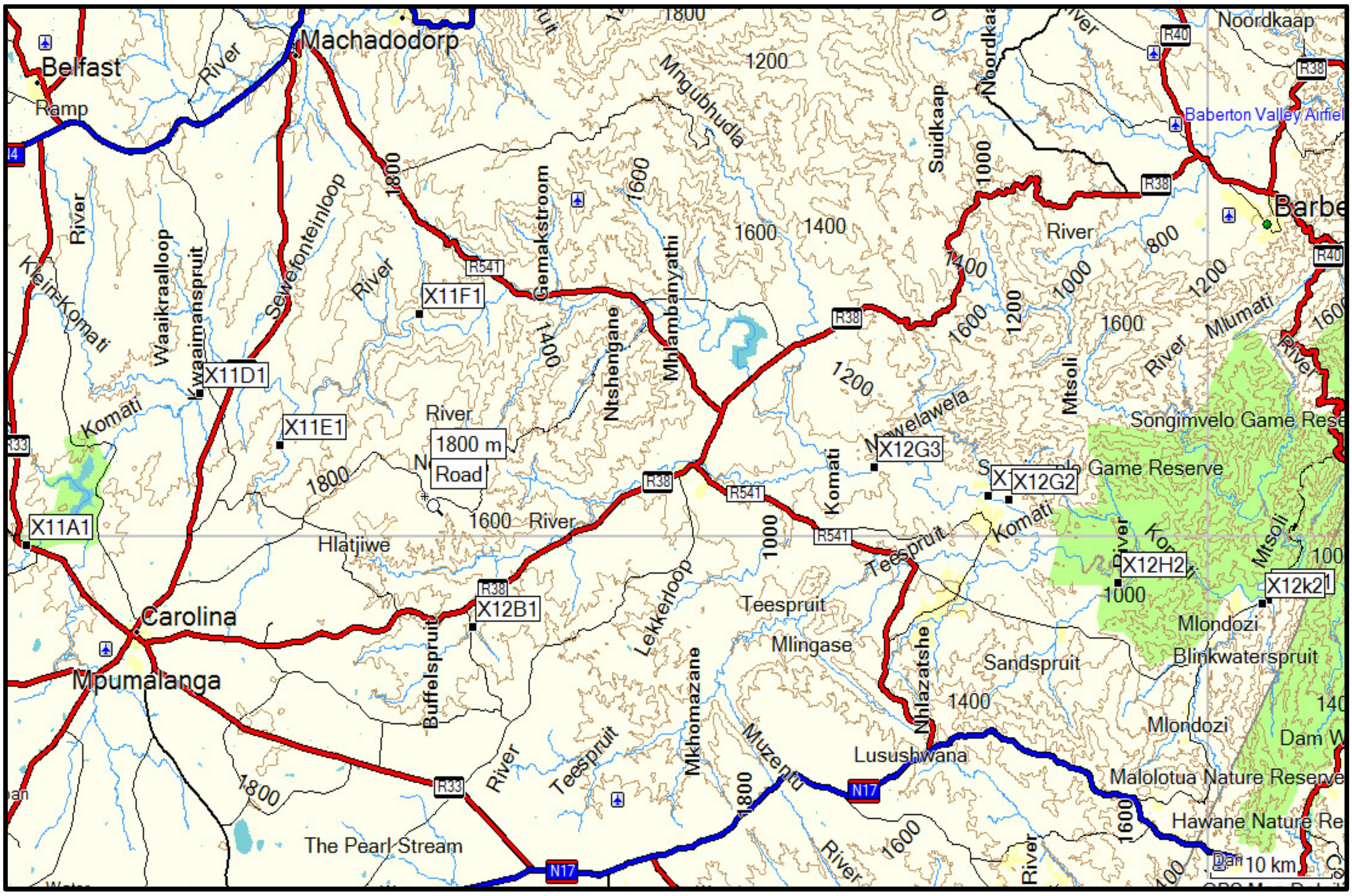


**Figure 4.3: Location of sites (Table 4.7) in the upper Inkomati catchment.**

The site locations were selected using the “ecological similarity concept” with sites having been chosen that are ecologically similar to as many of the hydro-nodes as possible, but also being useful in terms of Rapid level III hydraulic assessments (ie. a single rating point at a low-flow). Table 6 provides selected site information, with ten sites located on various tributaries of the upper Inkomati River, and one site on the main stem below Vygeboom Dam in quaternary X12G.

**Table 4.7: Location of river sites in the upper Inkomati River catchment and measured discharges during the period of 14 to 17 May 2007**

| River name | Quaternary | Site name | MAR* (million $m^3/a$) | Discharge ($m^3/s$) | Latitude | Longitude |
|---|---|---|---|---|---|---|
| Phalangampepe | X12K | X12K1 | 4.2 | 0.050 | 25 02 42.7 | 31 03 00.7 |
| Bergstroom | X12G | X12G2 | 4.8 | 0.026 | 25 58 04.4 | 30 50 33.0 |
| Bankspruit | X11F | X11F1 | 6.7 | 0.075 | 25 50 48.9 | 30 21 02.0 |
| Sandspruit | X12H | X12H2 | 7.5 | 0.037 | 26 02 59.2 | 30 53 49.7 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Mawelawala | X12G | X12G1 | 10.2 | 0.037 | 25 57 49.8 | 30 49 12.8 |
| Swartspruit | X11E | X11E1 | 15.4 | 0.045 | 25 55 57.5 | 30 14 05.5 |
| Mlondozi | X12K | X12K2 | 16.8 | 0.17 | 26 02 49.6 | 31 02 39.1 |
| Klein Komati | X11D | X11D1 | 20.6 | 0.050 | 25 53 16.7 | 30 07 13.0 |
| Vaalrivierspruit | X11A | X11A1 | 25.5 | 0.019 | 26 00 20.0 | 30 01 50.0 |
| Buffelspruit | X12B | X12B1 | 27.9 | 0.086 | 26 03 45.7 | 30 23 37.6 |
| Komati | X12G | X12G3 | 370 | 1.5 | 25 57 10.5 | 30 43 29.0 |

*MAR sourced from the IWAAS Hydrology study (Report number PWMA 05/X22/00/1408).

The MAR for the upper Inkomati River tributaries vary from 4.2 to 27.9 million $m^3$/annum – i.e. all within the "small" river range where there is limited information from previous EWRs.

### 4.2.4 Application of HabSpecs to selected sites

Results from the application of HabSpecs for the ten upper Inkomati River tributary sites, and one main stem site, are provided in Table 4.8.

The modelled natural flows and Desktop generated EWR's are also given for wet and dry seasons, and drought and maintenance conditions. For natural flows, discharges are linked at the 99th and 70th percentile for comparison with drought and maintenance conditions, respectively. It may be noted from table 4.7 that the HabSpec EWR estimates are higher than modelled natural flows (i.e. also estimated), the occurrence of which increases with higher EC and reducing stream size (i.e. lower MAR). Clearly the EWR must be bounded by natural flows, but again it needs to be stresses that the natural flows are estimated, and confidence in these predictions reduces with reducing runoff and concomitant stream size. The data in Table 4.7 also indicates that the HabSpec generated EWRs approach the existing Desktop generated values with increasing runoff (i.e. for certain ECs on Vaalrivierspruit, Buffelspruit and the Inkomati River site).

The suitability of the HabSpec generated EWR in providing adequate habitat were assessed by fish and invertebrate ecologists for the eleven upper Inkomati River catchment sites.

Overall, the HabSpec generated ecological flows were considered to provide more reasonable estimates compared with Desktop generated values for the smaller streams with lower MARs, where the latter predictions were regarded as underestimates.

**Table 4.8: Results of application of optimised HabSpecs for 11 sites in the upper Inkomati River catchment**

| River | Natural ($m^3/s$) | | | | Desktop ($m^3/s$) | | | | | | HabSpec ($m^3/s$) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 99% | | 70% | | Drought | | Maint C | | Maint B | | Drought | | Maint C | | Maint B | |
| | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet |
| Phalangampepe | 0.015 | 0.042 | 0.023 | 0.107 | 0.006 | 0.016 | 0.012 | 0.031 | 0.019 | 0.055 | 0.015 | 0.045 | 0.041 | 0.091 | 0.080 | 0.150 |
| Bergstroom | 0.012 | 0.054 | 0.019 | 0.180 | 0.006 | 0.020 | 0.011 | 0.038 | 0.017 | 0.066 | 0.025 | 0.075 | 0.070 | 0.180 | 0.150 | 0.300 |
| Bankspruit | 0.023 | 0.110 | 0.035 | 0.230 | 0.010 | 0.026 | 0.018 | 0.051 | 0.030 | 0.090 | 0.023 | 0.069 | 0.065 | 0.160 | 0.140 | 0.280 |
| Sandspruit | 0.062 | 0.110 | 0.090 | 0.240 | 0.018 | 0.027 | 0.032 | 0.051 | 0.055 | 0.090 | 0.028 | 0.100 | 0.094 | 0.220 | 0.200 | 0.370 |
| Mawelawala | 0.027 | 0.132 | 0.046 | 0.318 | 0.014 | 0.041 | 0.026 | 0.078 | 0.043 | 0.137 | 0.029 | 0.100 | 0.080 | 0.230 | 0.180 | 0.340 |
| Swartspruit | 0.054 | 0.250 | 0.081 | 0.510 | 0.023 | 0.055 | 0.043 | 0.109 | 0.070 | 0.195 | 0.050 | 0.190 | 0.180 | 0.440 | 0.370 | 0.750 |
| Mlondozi | 0.062 | 0.170 | 0.093 | 0.430 | 0.025 | 0.064 | 0.046 | 0.124 | 0.076 | 0.218 | 0.038 | 0.077 | 0.077 | 0.170 | 0.150 | 0.290 |
| Klein Nkomati | 0.077 | 0.340 | 0.110 | 0.700 | 0.033 | 0.078 | 0.059 | 0.148 | 0.098 | 0.261 | 0.100 | 0.150 | 0.130 | 0.220 | 0.200 | 0.390 |
| Vaalrivierspruit | 0.042 | 0.198 | 0.089 | 0.459 | 0.022 | 0.076 | 0.044 | 0.161 | 0.070 | 0.283 | 0.038 | 0.061 | 0.053 | 0.140 | 0.110 | 0.190 |
| Buffelspruit | 0.150 | 0.620 | 0.220 | 1.100 | 0.062 | 0.117 | 0.121 | 0.215 | 0.187 | 0.378 | 0.021 | 0.110 | 0.110 | 0.280 | 0.250 | 0.550 |
| | | | | | | | | | | | | | | | | |
| Komati | 1.4 | 7.6 | 2.0 | 14.5 | 0.62 | 1.4 | 1.1 | 2.8 | 1.8 | 4.9 | 0.85 | 1.3 | 1.3 | 1.7 | 1.4 | 3.0 |

Furthermore, the flow-habitat assessment indicated that the HabSpec estimates be bounded by the Desktop values as lower limit and predicted natural flows as upper limit. This is reasonable even though natural flows are generally modelled. This is because the HabSpec estimated flows are determined independently of hydrology, but it is necessary to provide hydrological context since the modelled hydrology underlies the management of the water resource. Changes in the modelled hydrology, therefore, require that the EWRs be reassessed.

### 4.2.5 Application of HabSpecs to hydro-nodes

Habitat specifications provide a simple and consistent rule-based approach for estimating EWRs where hydraulic characterisation of flow conditions is available, ie. at Rapid III level assessments and higher. The hydraulic characterisation requires a cross-sectional survey through the critical geomorphological unit (usually riffle or rapid), rating measurement at a low-flow, and assessment of the bed substrate - as undertaken for 11 sites in the upper Inkomati River catchment. Use of HabSpecs at the desktop level, however, requires hydraulic characterisation in the absence of field data. This is not yet possible, and an alternative means of estimating EWRs using HabSpecs, or the results of the analyses described so far, is necessary.

Figure 4.4 is a plot of the mean monthly natural low-flow per unit inundated width against mean monthly EWR (expressed as a percentage of the mean monthly natural low-flow).

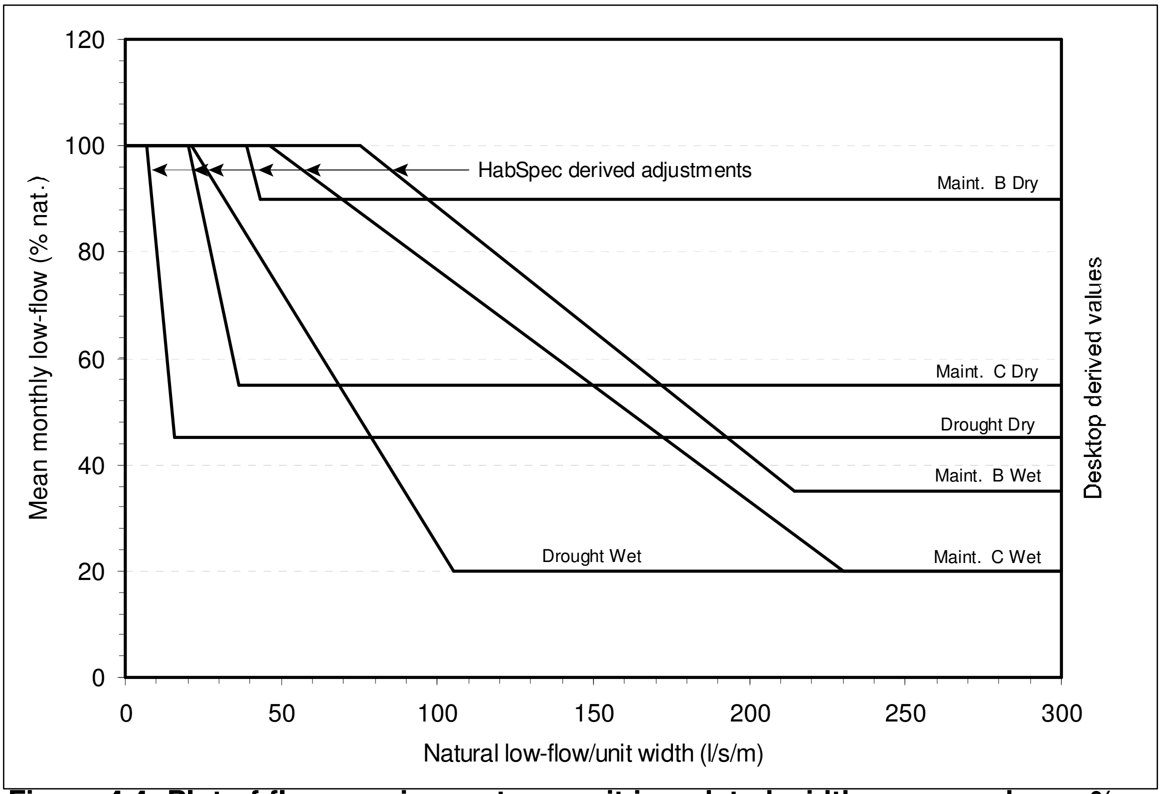


**Figure 4.4: Plot of flow requirement per unit inundated width expressed as a % of natural mean monthly runoff derived from the application of HabSpecs for 11 sites in the upper Komati River catchment.**

These relationships were developed to allow the HabSpec seasonal low-flow drought and maintenance EWR estimates to be considered within the context of the existing Desktop Reserve model and natural low-flow regime. The width in the independent variable (x-axis) refers to the inundated cross-channel width at a maximum depth of 0.2 m. This channel width is therefore relevant to low-flows, and an appropriate mid-range maximum depth has been selected from Tables 4.5 and 4.6 for the range of ECs considered. The relevant month is the driest or wettest in the natural (modelled) record, and refers to each of the ECs.

The existing Desktop Reserve model gives an approximately fixed proportion of natural flow (horizontal lines) as a function of hydrological characteristics, position on the flow duration curve (as denoted by drought or maintenance) and EC. Estimation of ecological flows using HabSpecs indicates that for small streams (natural runoff < ~30 million $m^3$/annum), the estimated flow requirements are higher than Desktop generated values, increasing to naturally occurring values (albeit modelled natural) as runoff (and stream size) reduces. This provides a means for adjusting the Desktop model values (dry and wet season), based on stream size (using runoff), as derived from the application of HabSpecs.

Although the proposed adjustment in Figure 4.4 is expressed in terms of natural low-flows, it is not derived from natural flow hydrology. Habitat specifications are derived from ecological and habitat considerations and the use of natural flows allows comparison with the existing Desktop Reserve model. Furthermore, it is important to reiterate that the Desktop adjustment indicated in Figure 4.4 refers to rivers with specific hydrological characteristics, fish guilds and invertebrate communities (ie. small rheophilic fish and cobble-dwelling rheophilic invertebrates).

A Desktop adjustment for small (lower runoff) rivers, as illustrated in Figure 4.4 for the upper Inkomati River catchment, may ultimately be coded into the existing Desktop Reserve Model for ease of application. Prof. D. Hughes felt, however, that there is insufficient data to justify its inclusion in the Desktop model at this stage, particularly given its potential implications to the Ecological Reserve process and Water Resource Management resulting from the significant finding that appreciably larger quantities of the natural low-flows (even up to 100% of modelled values) are required with reducing stream size for rivers with sensitive (rheophilic) biota. It must be stressed, once again, that this is with reference to modelled natural low-flows, which are low-confidence predictions for small river systems. The finding that larger proportions of the natural flow regime are required with reducing stream size in systems with sensitive biota is supported by studies reported in the international literature (eg. Maret et al, 2006; Conservation Ontario (2005); Jowett (1997) and Beecher (1990)). The Desktop model allows for manual adjustment of certain default Desktop parameters, however, and this is utilised for adjusting Desktop generated EWRs for hydro-nodes in the Inkomati River catchment using a simple fixed unit width requirements, upon which the Desktop adjustments in Figure 4.4 are based.

The HabSpec generated flows in Table 4.8 are expressed as a function of the inundated width (at a maximum depth of 0.2 m) in Table 4.9.

**Table 4.9: Desktop Adjustment Method using fixed flow requirements/unit width of inundated channel and estimated channel width**

| River | Width (m) @ 0.2m | HabSpec ($m^3/s/m$) | | | | | | DAM ($m^3/s$) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Drought | | Maint C | | Maint B | | Drought | | Maint C | | Maint B | |
| | | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet |
| Phalangampepe | 2.0 | 0.008 | 0.023 | 0.021 | 0.046 | 0.040 | 0.075 | 0.015 | 0.042 | 0.023 | 0.103 | 0.023 | 0.107 |
| Bergstroom | 3.9 | 0.006 | 0.019 | 0.018 | 0.046 | 0.038 | 0.077 | 0.012 | 0.052 | 0.019 | 0.113 | 0.019 | 0.180 |
| Bankspruit | 3.7 | 0.006 | 0.019 | 0.018 | 0.043 | 0.038 | 0.076 | 0.021 | 0.062 | 0.035 | 0.137 | 0.035 | 0.223 |
| Sandspruit | 5.2 | 0.005 | 0.019 | 0.018 | 0.042 | 0.038 | 0.071 | 0.022 | 0.066 | 0.063 | 0.145 | 0.090 | 0.236 |
| Mawelawala | 4.3 | 0.007 | 0.023 | 0.019 | 0.053 | 0.042 | 0.079 | 0.025 | 0.076 | 0.046 | 0.167 | 0.046 | 0.272 |
| Swartspruit | 5.6 | 0.009 | 0.034 | 0.032 | 0.079 | 0.066 | 0.134 | 0.030 | 0.090 | 0.081 | 0.197 | 0.081 | 0.321 |
| Mlondozi | 5.1 | 0.007 | 0.015 | 0.015 | 0.033 | 0.029 | 0.057 | 0.031 | 0.093 | 0.088 | 0.203 | 0.093 | 0.331 |
| Klein Nkomati | 4.2 | 0.024 | 0.036 | 0.031 | 0.052 | 0.048 | 0.093 | 0.033 | 0.099 | 0.095 | 0.218 | 0.110 | 0.355 |
| Vaalrivierspruit | 2.6 | 0.015 | 0.023 | 0.020 | 0.054 | 0.042 | 0.073 | 0.035 | 0.106 | 0.089 | 0.233 | 0.089 | 0.380 |
| Buffelspruit | 3.8 | 0.006 | 0.029 | 0.029 | 0.074 | 0.066 | 0.145 | 0.062 | 0.117 | 0.121 | 0.239 | 0.203 | 0.390 |
| Mean requirement | | 0.007 | 0.021 | 0.020 | 0.046 | 0.039 | 0.075 | | | | | | |

With the exception of two outliers per season (dry or wet), the unit-width low-flows are remarkably constant. Scatter in the data is expected, given the low-confidence hydraulic analyses associated with the Rapid level III assessments undertaken. Interestingly, the outliers are associated with three sites, two of which (the Swartspruit and Buffelspruit) are characterised by large bed substrates (large cobbles and small boulders) and mild water surface gradients. Cross-sections were positioned to facilitate Rapid level III hydraulic analyses with reasonable confidence, but may not have characterised critical hydraulic habitat. Neglecting the outliers, the average flow requirement per unit width for the various ECs (of which some are interpolated), is provided in Table 4.9.

**Table 4.10: Flow requirements per unit width of channel for small rheophilic fish guilds and cobble-dwelling rheophilic invertebrates**

| Hydrological Variability | Ecological Category | EWR (litres/s/m) | |
|---|---|---|---|
| | | Season | |
| | | Dry | Wet |
| Drought | | 7 | 21 |
| Maintenance | D | 11 | 29 |
| | C/D | 16 | 38 |
| | C | 20 | 46 |
| | B/C | 30 | 61 |
| | B | 39 | 75 |

The average absolute error, using values from Table 4.5 and all ten sites is 47% and 25% for drought dry and drought wet, respectively, and between 20% and 25% for the maintenance ECs. Neglecting the outliers, the average absolute error reduces to between 11% and 19%. The values in Table 4.5 define the x-ordinates (natural low-flow per unit width values) in Figure 4.4 where the Desktop adjusted percentages (of mean monthly low-flow) equate to the natural low-flows (i.e. 100%). The flows in Table 4.5 are therefore critical, defining the minimum seasonal drought and maintenance discharges required to achieve the recommended EC for the sensitive biota considered. For small rivers, this may equate to a substantial proportion of the natural low-flow but this reduces with increasing natural low-flow runoff, as illustrated in Figure 4.4.

It is a significant finding that the low-flow EWR per unit width of inundated channel (at an appropriate low-flow depth) gives an approximately constant value. This finding is likely related to the use of multi-parameter HabSpecs that incorporate the two fundamental determinants of discharge (viz. depth and velocity), and satisfying minimum values for these parameters for critical habitat for rheophilic species (provided within a riffle) gives a constant unit width discharge.

The Desktop Adjustment Method (DAM) (Figure 4.4 or Table 4.5) is dependant on a fundamental parameter - channel width at an appropriate low-flow depth (0.2 m maximum depth has been used). Although channel width is easily measured in the field, it needs to be derived from available information within the context of a desktop estimation approach. As a starting point, an obvious parameter to correlate channel width against is MAR. Figure 4.5 is a plot of the low-flow channel width against MAR (natural) for the EWR sites listed in Table 4.3.

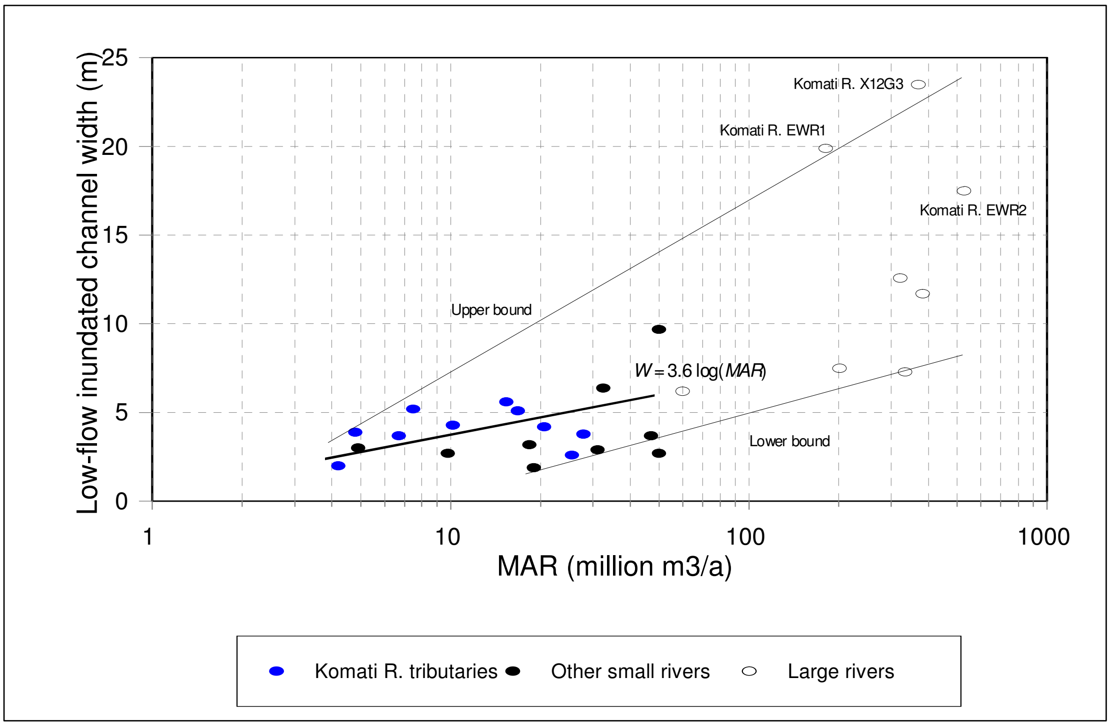


**Figure 4.5: Low-flow inundated channel width as a function of natural MAR.**

The low-flow channel widths correspond to low-flow maximum depths as provided by the HabSpecs : ~0.2 m and ~0.35 m for small (MAR < ~50 million $m^3$/annum) and large (MAR > ~50 million $m^3$/annum) rivers, respectively (approximate mid-range maximum depths for the range of ECs considered). These are the approximate dry season depth requirements for small rheophilic and large semi-rheophilic fish guilds, respectively. Ultimately, it may be necessary to use the dry and wet season depths to estimate the corresponding channel widths for the dry and wet seasons, respectively.

The plot indicates a general trend of increasing width with MAR over the runoff range (5 to 500 million $m^3$/annum), although there is substantial scatter. The data indicates upper and lower limits, bounding a wide range of channel widths that increase with MAR. The data points for small rivers have reduced range of channel widths than implied by the upper boundary (ranging from 2.0 m to 9.0 m), and a gentle slope indicating increasing width with MAR. Given that the DAM is relevant to small rivers (refer to Figure 4.4), an approximate relationship over the MAR range 4 to 50 million m$^3$/annum is proposed, as indicated in Figure 4.5. This relationship should be used with caution given the scatter displayed in the data. Given the importance of low-flow channel width in the DAM and ease with which it can be measured in the field, it is recommended that width is measured where possible (for critical riffle and/or rapid geomorphic units) for the purpose of estimating EWRs using the DAM.

Further investigation is required concerning the relationship between low-flow channel width and hydrological characteristics and of the influence of channel shape. Initial indications are that the relationship is also a function of channel shape ("flat-bottomed" versus "v-shaped") and substrate size, and the influence of these determinants requires further study using measured data. Nevertheless, the DAM is considered by the authors to provide higher confidence low-flow EWRs than the existing Desktop model for small rivers (MAR $\tilde{<}$ 50 million m$^3$/annum) with sensitive rheophilic biota (small rheophilic fish guilds less than 10 to 15cm in length and rheophilic invertebrate communities) and with similar hydrological and ecological characteristics. For larger river systems (MAR $\tilde{>}$ 50 million m$^3$/annum), the proposed estimation method using HabSpecs indicates use of the Desktop model (Figure 4.4) to extrapolate Reserve EWRs where ecological similarity permits.

The DAM EWR low-flow estimates for drought and maintenance (C and B) for dry and wet seasons are given in Table 4.9 for the ten tributary sites in the upper Inkomati River catchment, using estimated channel widths (i.e. Figure 4.5 relationship). The DAM estimates are required to be higher than Desktop generated values and lower than natural (modelled) low-flows. These are plotted in Figure 4.6, together with the HabSpec generated values.

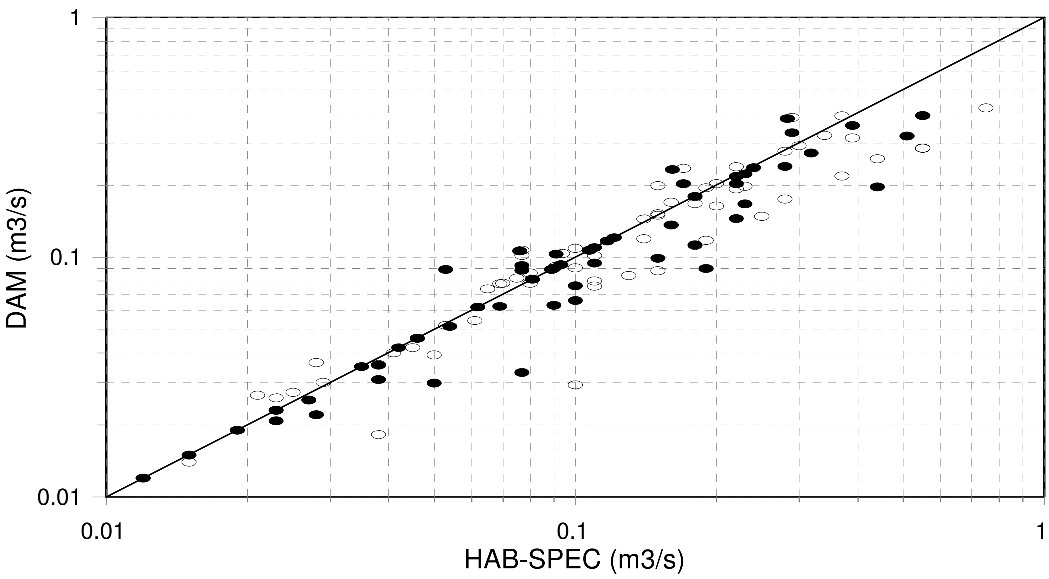


**Figure 4.6: Plot of HabSpec versus DAM EWR requirements for the ten tributaries in the upper Inkomati River catchment for drought and maintenance conditions**

For the ten tributary sites using surveyed channel widths, the average absolute error between the HabSpec and DAM estimates of the EWR (drought and maintenance C and B) is 19%. This reduces to 15% when flows are confined to between natural and Desktop generated values. Excluding upper (natural) and lower (Desktop) limits increases the average absolute error to 24%. Given that this estimation method for small streams is at the desktop level, such errors are reasonable. The unfilled markers are estimates taking no account of the (modelled) natural hydrology and using surveyed channel width. The filled markers are estimates confined by lower and upper limits by Desktop estimates and modelled natural flows, respectively, with the DAM based on estimated channel widths).

### 4.2.6 Procedure for application of the DAM to hydro-nodes

For hydro-nodes with large-semi rheophilic fish guilds (generally MAR $\gtrsim$ 50 million $m^3$/annum), the EWRs can be determined by extrapolating Reserve results where ecological similarity permits, or alternatively by using the Desktop model.

For nodes with small rheophilic fish guilds and MAR $\lesssim$ 50 million $m^3$/annum:

- Apply the Desktop model using default parameters;
- Determine the natural drought (95% exceedance) and maintenance (70% exceedance) flows for the driest and wettest months from the natural flow duration table (provided in the .RUL file);
- Estimate the channel width (W) at 0.2 m depth, using W = 3.6log(MAR) where the MAR is expressed in Mm3/a.
- Estimate the EWR using the flow requirements per unit channel width together with the estimate of channel width;
- If these estimates are greater than the Desktop generated values, adjust the Desktop values for drought and/or maintenance. Do not reduce Desktop generated values nor exceed natural low-flows.

EWRs were generated at all hydro-nodes, a summary of which is attached as Appenidix D while the Rule curves have been provided electronically on a CD.

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## APPENDIX A

## PRELIMINARY RULES CURVES FROM THE CROCODILE ECOLOGICAL RESERVE STUDY

# APPENDIX A1: EWR1 (Crocodile)

Desktop Version 2, Printed on 2008/07/15
Summary of IFR rule curves for : CE1 Natural Flows
Determination based on defined BBM Table with site specific assurance rules.
Regional Type : E.Escarp     ERC = A/B

Data are given in m^3/s mean monthly flow

| | % Points | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Month | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 99% |
| Oct | 0.078 | 0.077 | 0.077 | 0.075 | 0.073 | 0.068 | 0.059 | 0.047 | 0.033 | 0.021 |
| Nov | 0.177 | 0.176 | 0.174 | 0.171 | 0.164 | 0.152 | 0.132 | 0.104 | 0.070 | 0.044 |
| Dec | 0.196 | 0.195 | 0.193 | 0.190 | 0.182 | 0.169 | 0.148 | 0.117 | 0.081 | 0.054 |
| Jan | 0.526 | 0.480 | 0.440 | 0.404 | 0.367 | 0.307 | 0.266 | 0.209 | 0.142 | 0.093 |
| Feb | 0.239 | 0.238 | 0.236 | 0.232 | 0.225 | 0.211 | 0.189 | 0.158 | 0.121 | 0.094 |
| Mar | 0.320 | 0.304 | 0.290 | 0.276 | 0.259 | 0.232 | 0.205 | 0.167 | 0.121 | 0.087 |
| Apr | 0.198 | 0.198 | 0.197 | 0.194 | 0.188 | 0.177 | 0.159 | 0.132 | 0.100 | 0.076 |
| May | 0.165 | 0.165 | 0.164 | 0.161 | 0.157 | 0.148 | 0.133 | 0.110 | 0.083 | 0.062 |
| Jun | 0.136 | 0.136 | 0.135 | 0.133 | 0.130 | 0.122 | 0.110 | 0.090 | 0.066 | 0.048 |
| Jul | 0.109 | 0.109 | 0.108 | 0.107 | 0.104 | 0.098 | 0.088 | 0.072 | 0.051 | 0.036 |
| Aug | 0.085 | 0.085 | 0.084 | 0.083 | 0.080 | 0.075 | 0.067 | 0.053 | 0.037 | 0.025 |
| Sep | 0.072 | 0.072 | 0.071 | 0.070 | 0.067 | 0.063 | 0.055 | 0.044 | 0.030 | 0.019 |
| Reserve flows without High Flows | | | | | | | | | | |
| Oct | 0.078 | 0.077 | 0.077 | 0.075 | 0.073 | 0.068 | 0.059 | 0.047 | 0.033 | 0.021 |
| Nov | 0.111 | 0.111 | 0.110 | 0.108 | 0.104 | 0.097 | 0.086 | 0.070 | 0.051 | 0.037 |
| Dec | 0.133 | 0.132 | 0.131 | 0.129 | 0.124 | 0.116 | 0.103 | 0.085 | 0.063 | 0.047 |
| Jan | 0.188 | 0.187 | 0.185 | 0.182 | 0.175 | 0.164 | 0.147 | 0.122 | 0.093 | 0.072 |
| Feb | 0.239 | 0.238 | 0.236 | 0.232 | 0.225 | 0.211 | 0.189 | 0.158 | 0.121 | 0.094 |
| Mar | 0.207 | 0.206 | 0.205 | 0.201 | 0.195 | 0.183 | 0.164 | 0.137 | 0.104 | 0.080 |
| Apr | 0.198 | 0.198 | 0.197 | 0.194 | 0.188 | 0.177 | 0.159 | 0.132 | 0.100 | 0.076 |
| May | 0.165 | 0.165 | 0.164 | 0.161 | 0.157 | 0.148 | 0.133 | 0.110 | 0.083 | 0.062 |
| Jun | 0.136 | 0.136 | 0.135 | 0.133 | 0.130 | 0.122 | 0.110 | 0.090 | 0.066 | 0.048 |
| Jul | 0.109 | 0.109 | 0.108 | 0.107 | 0.104 | 0.098 | 0.088 | 0.072 | 0.051 | 0.036 |
| Aug | 0.085 | 0.085 | 0.084 | 0.083 | 0.080 | 0.075 | 0.067 | 0.053 | 0.037 | 0.025 |
| Sep | 0.072 | 0.072 | 0.071 | 0.070 | 0.067 | 0.063 | 0.055 | 0.044 | 0.030 | 0.019 |
| Natural Duration curves | | | | | | | | | | |
| Oct | 0.217 | 0.183 | 0.157 | 0.127 | 0.116 | 0.105 | 0.097 | 0.086 | 0.075 | 0.063 |
| Nov | 0.444 | 0.363 | 0.297 | 0.251 | 0.220 | 0.208 | 0.177 | 0.166 | 0.147 | 0.100 |
| Dec | 0.706 | 0.489 | 0.422 | 0.370 | 0.321 | 0.299 | 0.269 | 0.239 | 0.183 | 0.116 |
| Jan | 1.691 | 1.049 | 0.526 | 0.437 | 0.392 | 0.358 | 0.329 | 0.299 | 0.243 | 0.179 |
| Feb | 1.418 | 0.996 | 0.686 | 0.570 | 0.484 | 0.451 | 0.389 | 0.343 | 0.310 | 0.252 |
| Mar | 0.859 | 0.586 | 0.508 | 0.482 | 0.422 | 0.392 | 0.347 | 0.310 | 0.273 | 0.187 |
| Apr | 0.490 | 0.444 | 0.397 | 0.347 | 0.320 | 0.297 | 0.285 | 0.251 | 0.204 | 0.150 |
| May | 0.325 | 0.261 | 0.246 | 0.224 | 0.205 | 0.190 | 0.168 | 0.149 | 0.127 | 0.108 |
| Jun | 0.235 | 0.177 | 0.166 | 0.158 | 0.150 | 0.139 | 0.127 | 0.112 | 0.096 | 0.081 |
| Jul | 0.179 | 0.161 | 0.131 | 0.123 | 0.116 | 0.108 | 0.105 | 0.093 | 0.082 | 0.071 |
| Aug | 0.138 | 0.123 | 0.112 | 0.105 | 0.097 | 0.093 | 0.082 | 0.078 | 0.075 | 0.063 |
| Sep | 0.158 | 0.123 | 0.104 | 0.096 | 0.085 | 0.081 | 0.077 | 0.069 | 0.062 | 0.054 |

# APPENDIX A2: EWR2 (Crocodile)

Desktop Version 2, Printed on 2008/07/16

Summary of IFR rule curves for : CE2 Natural Flows

Determination based on defined BBM Table with site specific assurance rules.

Regional Type : E.Escarp ERC = B

Data are given in m^3/s mean monthly flow

% Points

| Month | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 99% |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 0.459 | 0.458 | 0.455 | 0.449 | 0.436 | 0.413 | 0.373 | 0.316 | 0.246 | 0.194 |
| Nov | 0.876 | 0.873 | 0.865 | 0.849 | 0.819 | 0.764 | 0.674 | 0.544 | 0.390 | 0.275 |
| Dec | 1.017 | 1.013 | 1.004 | 0.984 | 0.947 | 0.882 | 0.776 | 0.623 | 0.444 | 0.310 |
| Jan | 1.518 | 1.467 | 1.416 | 1.360 | 1.286 | 1.160 | 1.016 | 0.812 | 0.576 | 0.401 |
| Feb | 2.828 | 2.649 | 2.488 | 2.333 | 2.164 | 1.876 | 1.632 | 1.280 | 0.867 | 0.559 |
| Mar | 1.657 | 1.608 | 1.559 | 1.502 | 1.427 | 1.296 | 1.139 | 0.911 | 0.640 | 0.438 |
| Apr | 1.263 | 1.260 | 1.250 | 1.229 | 1.188 | 1.112 | 0.986 | 0.799 | 0.574 | 0.405 |
| May | 1.044 | 1.043 | 1.036 | 1.020 | 0.988 | 0.929 | 0.828 | 0.675 | 0.488 | 0.346 |
| Jun | 0.856 | 0.855 | 0.849 | 0.838 | 0.813 | 0.767 | 0.687 | 0.565 | 0.414 | 0.300 |
| Jul | 0.678 | 0.678 | 0.674 | 0.666 | 0.648 | 0.614 | 0.554 | 0.460 | 0.342 | 0.252 |
| Aug | 0.508 | 0.508 | 0.505 | 0.498 | 0.485 | 0.460 | 0.417 | 0.351 | 0.269 | 0.207 |
| Sep | 0.418 | 0.418 | 0.416 | 0.410 | 0.400 | 0.380 | 0.346 | 0.296 | 0.233 | 0.186 |

Reserve flows without High Flows

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 0.459 | 0.458 | 0.455 | 0.449 | 0.436 | 0.413 | 0.373 | 0.316 | 0.246 | 0.194 |
| Nov | 0.679 | 0.677 | 0.671 | 0.660 | 0.638 | 0.600 | 0.536 | 0.444 | 0.335 | 0.253 |
| Dec | 0.827 | 0.824 | 0.816 | 0.802 | 0.774 | 0.724 | 0.643 | 0.527 | 0.390 | 0.289 |
| Jan | 1.179 | 1.173 | 1.161 | 1.138 | 1.094 | 1.018 | 0.896 | 0.725 | 0.527 | 0.380 |
| Feb | 1.517 | 1.511 | 1.497 | 1.468 | 1.414 | 1.318 | 1.162 | 0.937 | 0.673 | 0.476 |
| Mar | 1.319 | 1.315 | 1.303 | 1.279 | 1.233 | 1.151 | 1.016 | 0.821 | 0.590 | 0.417 |
| Apr | 1.263 | 1.260 | 1.250 | 1.229 | 1.188 | 1.112 | 0.986 | 0.799 | 0.574 | 0.405 |
| May | 1.044 | 1.043 | 1.036 | 1.020 | 0.988 | 0.929 | 0.828 | 0.675 | 0.488 | 0.346 |
| Jun | 0.856 | 0.855 | 0.849 | 0.838 | 0.813 | 0.767 | 0.687 | 0.565 | 0.414 | 0.300 |
| Jul | 0.678 | 0.678 | 0.674 | 0.666 | 0.648 | 0.614 | 0.554 | 0.460 | 0.342 | 0.252 |
| Aug | 0.508 | 0.508 | 0.505 | 0.498 | 0.485 | 0.460 | 0.417 | 0.351 | 0.269 | 0.207 |
| Sep | 0.418 | 0.418 | 0.416 | 0.410 | 0.400 | 0.380 | 0.346 | 0.296 | 0.233 | 0.186 |

Natural Duration curves

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 1.254 | 1.060 | 0.915 | 0.739 | 0.668 | 0.616 | 0.571 | 0.504 | 0.433 | 0.377 |
| Nov | 2.550 | 2.076 | 1.705 | 1.435 | 1.269 | 1.208 | 1.011 | 0.949 | 0.833 | 0.583 |
| Dec | 3.995 | 2.808 | 2.371 | 2.091 | 1.833 | 1.699 | 1.516 | 1.359 | 1.042 | 0.668 |
| Jan | 8.651 | 5.529 | 2.964 | 2.546 | 2.210 | 2.031 | 1.841 | 1.691 | 1.366 | 1.012 |
| Feb | 7.358 | 5.622 | 3.943 | 3.286 | 2.716 | 2.542 | 2.290 | 1.930 | 1.740 | 1.422 |
| Mar | 4.925 | 3.386 | 2.923 | 2.785 | 2.375 | 2.244 | 1.956 | 1.751 | 1.527 | 1.064 |
| Apr | 2.828 | 2.550 | 2.249 | 2.006 | 1.840 | 1.686 | 1.613 | 1.408 | 1.181 | 0.868 |
| May | 1.878 | 1.501 | 1.411 | 1.277 | 1.184 | 1.109 | 0.967 | 0.859 | 0.721 | 0.612 |
| Jun | 1.393 | 1.046 | 0.965 | 0.922 | 0.868 | 0.806 | 0.748 | 0.660 | 0.579 | 0.475 |
| Jul | 1.053 | 0.948 | 0.784 | 0.724 | 0.683 | 0.642 | 0.612 | 0.553 | 0.493 | 0.422 |
| Aug | 0.818 | 0.736 | 0.661 | 0.609 | 0.568 | 0.541 | 0.497 | 0.474 | 0.429 | 0.381 |
| Sep | 0.922 | 0.721 | 0.613 | 0.559 | 0.509 | 0.475 | 0.451 | 0.413 | 0.367 | 0.313 |

## APPENDIX A3: EWR3 (Crocodile)

Desktop Version 2, Printed on 2008/07/16

Summary of IFR rule curves for : CE3 P.Day Flows

Determination based on defined BBM Table with site specific assurance rules.

Regional Type : E.Escarp     ERC = B/C

Data are given in m^3/s mean monthly flow

| | % Points | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Month | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 99% |
| Oct | 2.799 | 2.792 | 2.769 | 2.721 | 2.627 | 2.454 | 2.165 | 1.737 | 1.222 | 0.835 |
| Nov | 4.563 | 4.546 | 4.499 | 4.404 | 4.222 | 3.896 | 3.360 | 2.585 | 1.665 | 0.978 |
| Dec | 3.206 | 3.193 | 3.163 | 3.101 | 2.985 | 2.780 | 2.445 | 1.966 | 1.401 | 0.981 |
| Jan | 3.745 | 3.612 | 3.482 | 3.340 | 3.160 | 2.853 | 2.514 | 2.036 | 1.481 | 1.070 |
| Feb | 8.298 | 7.633 | 7.051 | 6.518 | 5.976 | 5.062 | 4.411 | 3.477 | 2.377 | 1.559 |
| Mar | 4.974 | 4.704 | 4.459 | 4.219 | 3.952 | 3.493 | 3.078 | 2.477 | 1.763 | 1.231 |
| Apr | 3.554 | 3.547 | 3.518 | 3.460 | 3.345 | 3.134 | 2.780 | 2.258 | 1.629 | 1.156 |
| May | 2.888 | 2.885 | 2.865 | 2.824 | 2.740 | 2.584 | 2.316 | 1.912 | 1.417 | 1.042 |
| Jun | 3.047 | 3.045 | 3.026 | 2.985 | 2.900 | 2.739 | 2.461 | 2.037 | 1.512 | 1.113 |
| Jul | 2.980 | 2.980 | 2.964 | 2.927 | 2.850 | 2.700 | 2.434 | 2.019 | 1.498 | 1.097 |
| Aug | 3.031 | 3.029 | 3.010 | 2.969 | 2.886 | 2.728 | 2.453 | 2.035 | 1.519 | 1.126 |
| Sep | 2.981 | 2.977 | 2.955 | 2.910 | 2.818 | 2.645 | 2.349 | 1.904 | 1.358 | 0.945 |

Reserve flows without High Flows

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 2.799 | 2.792 | 2.769 | 2.721 | 2.627 | 2.454 | 2.165 | 1.737 | 1.222 | 0.835 |
| Nov | 2.843 | 2.833 | 2.806 | 2.752 | 2.647 | 2.460 | 2.153 | 1.708 | 1.180 | 0.786 |
| Dec | 2.686 | 2.676 | 2.652 | 2.603 | 2.511 | 2.348 | 2.083 | 1.703 | 1.256 | 0.923 |
| Jan | 2.843 | 2.830 | 2.802 | 2.748 | 2.648 | 2.473 | 2.196 | 1.804 | 1.350 | 1.014 |
| Feb | 3.366 | 3.354 | 3.325 | 3.267 | 3.157 | 2.961 | 2.643 | 2.186 | 1.649 | 1.249 |
| Mar | 3.000 | 2.991 | 2.966 | 2.916 | 2.820 | 2.648 | 2.365 | 1.955 | 1.469 | 1.106 |
| Apr | 3.018 | 3.011 | 2.989 | 2.942 | 2.850 | 2.680 | 2.397 | 1.979 | 1.475 | 1.096 |
| May | 2.888 | 2.885 | 2.865 | 2.824 | 2.740 | 2.584 | 2.316 | 1.912 | 1.417 | 1.042 |
| Jun | 3.047 | 3.045 | 3.026 | 2.985 | 2.900 | 2.739 | 2.461 | 2.037 | 1.512 | 1.113 |
| Jul | 2.980 | 2.980 | 2.964 | 2.927 | 2.850 | 2.700 | 2.434 | 2.019 | 1.498 | 1.097 |
| Aug | 3.031 | 3.029 | 3.010 | 2.969 | 2.886 | 2.728 | 2.453 | 2.035 | 1.519 | 1.126 |
| Sep | 2.981 | 2.977 | 2.955 | 2.910 | 2.818 | 2.645 | 2.349 | 1.904 | 1.358 | 0.945 |

Natural Duration curves

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 6.213 | 5.544 | 5.137 | 4.536 | 3.622 | 3.039 | 2.277 | 1.762 | 1.266 | 0.922 |
| Nov | 6.381 | 5.401 | 4.074 | 3.557 | 3.152 | 2.415 | 2.041 | 1.821 | 1.335 | 0.934 |
| Dec | 10.204 | 5.470 | 4.219 | 3.569 | 2.684 | 2.270 | 1.956 | 1.714 | 1.538 | 1.131 |
| Jan | 16.207 | 8.367 | 5.839 | 4.749 | 4.055 | 3.304 | 2.591 | 1.882 | 1.639 | 1.075 |
| Feb | 23.690 | 14.964 | 7.858 | 6.138 | 4.936 | 3.782 | 3.026 | 2.116 | 1.852 | 1.389 |
| Mar | 13.150 | 9.756 | 7.743 | 5.548 | 4.275 | 3.577 | 2.714 | 2.117 | 1.747 | 1.232 |
| Apr | 8.318 | 7.230 | 5.941 | 5.382 | 4.541 | 3.781 | 3.148 | 2.137 | 1.667 | 1.269 |
| May | 7.773 | 6.392 | 5.529 | 4.917 | 4.275 | 3.973 | 3.327 | 2.871 | 2.024 | 1.232 |
| Jun | 8.376 | 7.184 | 6.798 | 6.111 | 5.478 | 4.834 | 4.302 | 3.762 | 2.944 | 1.466 |
| Jul | 8.076 | 7.142 | 6.814 | 6.388 | 5.888 | 5.391 | 4.421 | 3.610 | 2.841 | 1.740 |
| Aug | 7.672 | 7.299 | 6.859 | 6.631 | 6.392 | 6.033 | 5.447 | 4.219 | 2.733 | 1.594 |
| Sep | 6.019 | 5.552 | 5.127 | 4.969 | 4.576 | 3.889 | 3.499 | 2.693 | 1.366 | 0.945 |

## APPENDIX A4: EWR4 (Crocodile)

### Desktop Version 2, Printed on 2008/07/17

Summary of IFR rule curves for : CE4 Natural Flows

Determination based on defined BBM Table with site specific assurance rules.

Regional Type : E.Escarp     ERC = B

Data are given in m^3/s mean monthly flow

% Points

| Month | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 99% |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 4.998 | 4.987 | 4.944 | 4.854 | 4.679 | 4.358 | 3.819 | 3.025 | 2.067 | 1.347 |
| Nov | 8.183 | 8.153 | 8.073 | 7.909 | 7.596 | 7.035 | 6.114 | 4.781 | 3.198 | 2.017 |
| Dec | 9.435 | 9.396 | 9.300 | 9.110 | 8.749 | 8.108 | 7.068 | 5.576 | 3.818 | 2.510 |
| Jan | 23.306 | 21.438 | 19.797 | 18.273 | 16.700 | 14.064 | 12.133 | 9.411 | 6.251 | 3.914 |
| Feb | 18.940 | 18.119 | 17.344 | 16.540 | 15.570 | 13.905 | 12.186 | 9.720 | 6.816 | 4.654 |
| Mar | 17.379 | 16.646 | 15.951 | 15.230 | 14.360 | 12.855 | 11.286 | 9.015 | 6.319 | 4.307 |
| Apr | 13.086 | 13.057 | 12.947 | 12.721 | 12.277 | 11.463 | 10.098 | 8.084 | 5.657 | 3.831 |
| May | 9.275 | 9.263 | 9.196 | 9.054 | 8.767 | 8.229 | 7.308 | 5.920 | 4.220 | 2.930 |
| Jun | 7.948 | 7.941 | 7.886 | 7.768 | 7.526 | 7.067 | 6.271 | 5.060 | 3.564 | 2.424 |
| Jul | 6.404 | 6.404 | 6.364 | 6.276 | 6.091 | 5.730 | 5.088 | 4.091 | 2.836 | 1.871 |
| Aug | 5.339 | 5.335 | 5.296 | 5.213 | 5.044 | 4.723 | 4.167 | 3.320 | 2.273 | 1.476 |
| Sep | 4.903 | 4.896 | 4.858 | 4.777 | 4.614 | 4.309 | 3.785 | 2.996 | 2.029 | 1.296 |

Reserve flows without High Flows

| Month | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 99% |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 4.998 | 4.987 | 4.944 | 4.854 | 4.679 | 4.358 | 3.819 | 3.025 | 2.067 | 1.347 |
| Nov | 6.269 | 6.247 | 6.189 | 6.070 | 5.843 | 5.436 | 4.769 | 3.802 | 2.655 | 1.798 |
| Dec | 7.582 | 7.553 | 7.480 | 7.335 | 7.059 | 6.570 | 5.777 | 4.638 | 3.297 | 2.299 |
| Jan | 9.639 | 9.590 | 9.491 | 9.296 | 8.935 | 8.308 | 7.309 | 5.901 | 4.266 | 3.057 |
| Feb | 13.113 | 13.064 | 12.942 | 12.699 | 12.239 | 11.423 | 10.097 | 8.195 | 5.955 | 4.288 |
| Mar | 12.117 | 12.078 | 11.971 | 11.755 | 11.342 | 10.601 | 9.385 | 7.625 | 5.535 | 3.975 |
| Apr | 11.172 | 11.148 | 11.059 | 10.874 | 10.511 | 9.846 | 8.731 | 7.086 | 5.104 | 3.612 |
| May | 9.275 | 9.263 | 9.196 | 9.054 | 8.767 | 8.229 | 7.308 | 5.920 | 4.220 | 2.930 |
| Jun | 7.948 | 7.941 | 7.886 | 7.768 | 7.526 | 7.067 | 6.271 | 5.060 | 3.564 | 2.424 |
| Jul | 6.404 | 6.404 | 6.364 | 6.276 | 6.091 | 5.730 | 5.088 | 4.091 | 2.836 | 1.871 |
| Aug | 5.339 | 5.335 | 5.296 | 5.213 | 5.044 | 4.723 | 4.167 | 3.320 | 2.273 | 1.476 |
| Sep | 4.903 | 4.896 | 4.858 | 4.777 | 4.614 | 4.309 | 3.785 | 2.996 | 2.029 | 1.296 |

Natural Duration curves

| Month | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 99% |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 15.468 | 12.705 | 9.872 | 9.099 | 8.165 | 6.907 | 6.620 | 5.865 | 5.167 | 4.413 |
| Nov | 28.669 | 23.912 | 20.914 | 18.939 | 15.112 | 13.526 | 12.064 | 11.505 | 9.228 | 7.238 |
| Dec | 61.925 | 39.072 | 33.565 | 28.267 | 23.309 | 21.106 | 18.567 | 16.207 | 12.806 | 8.744 |
| Jan | 95.979 | 63.336 | 47.846 | 40.864 | 33.479 | 27.539 | 22.760 | 20.135 | 18.395 | 13.306 |
| Feb | 123.173 | 91.253 | 61.653 | 42.617 | 38.075 | 30.961 | 27.327 | 23.698 | 20.312 | 16.563 |
| Mar | 95.158 | 57.523 | 46.237 | 39.572 | 31.493 | 25.508 | 23.159 | 20.688 | 16.935 | 13.881 |
| Apr | 41.678 | 37.562 | 28.974 | 25.525 | 22.515 | 20.301 | 18.731 | 17.666 | 13.924 | 10.594 |
| May | 23.503 | 18.679 | 16.973 | 16.036 | 14.979 | 13.870 | 12.657 | 11.148 | 9.621 | 7.553 |
| Jun | 16.501 | 13.341 | 12.199 | 11.825 | 10.856 | 10.258 | 9.375 | 8.816 | 7.508 | 6.273 |
| Jul | 12.829 | 11.040 | 9.487 | 8.822 | 8.404 | 8.106 | 7.609 | 7.071 | 6.067 | 5.290 |
| Aug | 10.122 | 8.905 | 7.736 | 7.176 | 6.963 | 6.739 | 6.280 | 6.052 | 5.238 | 4.850 |
| Sep | 10.251 | 8.306 | 7.388 | 6.813 | 6.219 | 5.995 | 5.787 | 5.505 | 4.823 | 4.240 |

# APPENDIX A5: EWR5 (Crocodile)

Desktop Version 2, Printed on 2008/07/17

Summary of IFR rule curves for : CE5 Natural Flows

Determination based on defined BBM Table with site specific assurance rules.

Regional Type : E.Escarp ERC = C

Data are given in m^3/s mean monthly flow

% Points

| Month | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 99% |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 6.101 | 6.086 | 6.060 | 6.010 | 5.920 | 5.761 | 5.484 | 5.025 | 4.327 | 3.549 |
| Nov | 7.860 | 7.831 | 7.769 | 7.650 | 7.429 | 7.045 | 6.433 | 5.571 | 4.569 | 3.829 |
| Dec | 11.950 | 11.893 | 11.775 | 11.546 | 11.120 | 10.381 | 9.203 | 7.543 | 5.616 | 4.191 |
| Jan | 11.647 | 11.459 | 11.242 | 10.949 | 10.501 | 9.731 | 8.679 | 7.197 | 5.475 | 4.202 |
| Feb | 35.997 | 32.995 | 30.372 | 27.962 | 25.512 | 21.412 | 18.539 | 14.491 | 9.790 | 6.314 |
| Mar | 24.424 | 22.820 | 21.388 | 20.015 | 18.530 | 16.032 | 13.975 | 11.075 | 7.708 | 5.218 |
| Apr | 12.142 | 12.085 | 11.969 | 11.742 | 11.320 | 10.589 | 9.423 | 7.781 | 5.873 | 4.463 |
| May | 10.455 | 10.408 | 10.312 | 10.124 | 9.777 | 9.172 | 8.210 | 6.854 | 5.278 | 4.114 |
| Jun | 8.778 | 8.743 | 8.671 | 8.530 | 8.269 | 7.816 | 7.094 | 6.076 | 4.895 | 4.021 |
| Jul | 7.151 | 7.126 | 7.074 | 6.972 | 6.783 | 6.455 | 5.932 | 5.195 | 4.339 | 3.706 |
| Aug | 6.228 | 6.213 | 6.185 | 6.134 | 6.042 | 5.879 | 5.594 | 5.123 | 4.407 | 3.608 |
| Sep | 5.869 | 5.856 | 5.832 | 5.789 | 5.710 | 5.569 | 5.325 | 4.920 | 4.305 | 3.619 |

Reserve flows without High Flows

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 6.101 | 6.086 | 6.060 | 6.010 | 5.920 | 5.761 | 5.484 | 5.025 | 4.327 | 3.549 |
| Nov | 7.220 | 7.194 | 7.142 | 7.040 | 6.850 | 6.520 | 5.995 | 5.254 | 4.394 | 3.759 |
| Dec | 8.879 | 8.842 | 8.766 | 8.617 | 8.342 | 7.865 | 7.104 | 6.031 | 4.785 | 3.864 |
| Jan | 10.594 | 10.546 | 10.449 | 10.258 | 9.903 | 9.288 | 8.308 | 6.926 | 5.322 | 4.136 |
| Feb | 13.953 | 13.886 | 13.750 | 13.483 | 12.988 | 12.128 | 10.759 | 8.830 | 6.589 | 4.932 |
| Mar | 12.846 | 12.784 | 12.658 | 12.410 | 11.952 | 11.156 | 9.888 | 8.101 | 6.026 | 4.492 |
| Apr | 12.142 | 12.085 | 11.969 | 11.742 | 11.320 | 10.589 | 9.423 | 7.781 | 5.873 | 4.463 |
| May | 10.455 | 10.408 | 10.312 | 10.124 | 9.777 | 9.172 | 8.210 | 6.854 | 5.278 | 4.114 |
| Jun | 8.778 | 8.743 | 8.671 | 8.530 | 8.269 | 7.816 | 7.094 | 6.076 | 4.895 | 4.021 |
| Jul | 7.151 | 7.126 | 7.074 | 6.972 | 6.783 | 6.455 | 5.932 | 5.195 | 4.339 | 3.706 |
| Aug | 6.228 | 6.213 | 6.185 | 6.134 | 6.042 | 5.879 | 5.594 | 5.123 | 4.407 | 3.608 |
| Sep | 5.869 | 5.856 | 5.832 | 5.789 | 5.710 | 5.569 | 5.325 | 4.920 | 4.305 | 3.619 |

Natural Duration curves

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 21.666 | 17.712 | 13.489 | 12.616 | 11.402 | 9.577 | 9.237 | 8.438 | 7.643 | 6.429 |
| Nov | 39.545 | 34.093 | 28.904 | 24.985 | 21.069 | 18.403 | 17.018 | 15.687 | 11.825 | 10.123 |
| Dec | 78.666 | 55.201 | 43.018 | 37.605 | 30.376 | 28.390 | 25.246 | 22.177 | 17.156 | 11.932 |
| Jan | 120.942 | 77.752 | 58.124 | 52.464 | 43.631 | 36.746 | 29.996 | 26.800 | 24.194 | 16.417 |
| Feb | 159.164 | 113.980 | 75.723 | 54.320 | 46.152 | 41.419 | 35.156 | 30.928 | 25.769 | 22.028 |
| Mar | 121.767 | 67.600 | 57.042 | 49.220 | 40.965 | 33.897 | 29.652 | 26.243 | 21.938 | 17.622 |
| Apr | 59.626 | 45.980 | 39.691 | 33.557 | 29.934 | 27.029 | 24.174 | 23.191 | 17.770 | 13.889 |
| May | 30.623 | 25.706 | 22.861 | 21.517 | 20.359 | 18.784 | 17.309 | 16.118 | 13.232 | 10.181 |
| Jun | 22.531 | 19.402 | 17.164 | 16.397 | 15.525 | 14.776 | 13.476 | 12.616 | 10.594 | 9.286 |
| Jul | 18.735 | 15.506 | 13.975 | 12.907 | 12.563 | 11.955 | 11.104 | 10.215 | 9.024 | 7.732 |
| Aug | 15.367 | 13.239 | 11.268 | 10.529 | 10.353 | 9.946 | 9.274 | 8.774 | 7.755 | 6.806 |
| Sep | 14.672 | 11.890 | 10.910 | 9.877 | 9.267 | 8.862 | 8.337 | 7.859 | 6.906 | 6.103 |

# APPENDIX A6: EWR6 (Crocodile)

## Desktop Version 2, Printed on 2008/07/18

Summary of IFR rule curves for : CE6 Natural Flows

Determination based on defined BBM Table with site specific assurance rules.

Regional Type : E.Escarp ERC = C

Data are given in m^3/s mean monthly flow

% Points

| Month | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 99% |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 4.375 | 4.367 | 4.338 | 4.278 | 4.160 | 3.945 | 3.584 | 3.052 | 2.409 | 1.927 |
| Nov | 11.449 | 11.410 | 11.302 | 11.084 | 10.665 | 9.915 | 8.685 | 6.904 | 4.789 | 3.211 |
| Dec | 12.370 | 12.323 | 12.206 | 11.974 | 11.533 | 10.752 | 9.483 | 7.662 | 5.518 | 3.922 |
| Jan | 17.712 | 16.422 | 15.295 | 14.260 | 13.208 | 11.446 | 10.213 | 8.475 | 6.457 | 4.965 |
| Feb | 33.523 | 30.574 | 28.030 | 25.764 | 23.567 | 19.877 | 17.616 | 14.374 | 10.555 | 7.713 |
| Mar | 20.019 | 18.747 | 17.625 | 16.593 | 15.531 | 13.728 | 12.389 | 10.450 | 8.150 | 6.432 |
| Apr | 9.652 | 9.638 | 9.586 | 9.478 | 9.267 | 8.879 | 8.229 | 7.269 | 6.112 | 5.242 |
| May | 7.968 | 7.961 | 7.922 | 7.837 | 7.667 | 7.348 | 6.801 | 5.978 | 4.969 | 4.204 |
| Jun | 6.961 | 6.957 | 6.923 | 6.850 | 6.700 | 6.415 | 5.922 | 5.172 | 4.244 | 3.538 |
| Jul | 5.689 | 5.689 | 5.663 | 5.606 | 5.487 | 5.253 | 4.839 | 4.195 | 3.384 | 2.761 |
| Aug | 4.746 | 4.743 | 4.717 | 4.662 | 4.549 | 4.334 | 3.962 | 3.396 | 2.696 | 2.163 |
| Sep | 4.324 | 4.320 | 4.294 | 4.239 | 4.128 | 3.919 | 3.562 | 3.025 | 2.366 | 1.867 |

Reserve flows without High Flows

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 4.375 | 4.367 | 4.338 | 4.278 | 4.160 | 3.945 | 3.584 | 3.052 | 2.409 | 1.927 |
| Nov | 5.436 | 5.422 | 5.385 | 5.309 | 5.163 | 4.902 | 4.474 | 3.854 | 3.119 | 2.569 |
| Dec | 6.551 | 6.532 | 6.488 | 6.398 | 6.229 | 5.929 | 5.441 | 4.741 | 3.916 | 3.302 |
| Jan | 8.239 | 8.211 | 8.152 | 8.038 | 7.825 | 7.457 | 6.870 | 6.042 | 5.081 | 4.371 |
| Feb | 11.465 | 11.436 | 11.365 | 11.224 | 10.956 | 10.481 | 9.709 | 8.601 | 7.296 | 6.325 |
| Mar | 10.547 | 10.524 | 10.462 | 10.338 | 10.098 | 9.670 | 8.966 | 7.947 | 6.738 | 5.835 |
| Apr | 9.652 | 9.638 | 9.586 | 9.478 | 9.267 | 8.879 | 8.229 | 7.269 | 6.112 | 5.242 |
| May | 7.968 | 7.961 | 7.922 | 7.837 | 7.667 | 7.348 | 6.801 | 5.978 | 4.969 | 4.204 |
| Jun | 6.961 | 6.957 | 6.923 | 6.850 | 6.700 | 6.415 | 5.922 | 5.172 | 4.244 | 3.538 |
| Jul | 5.689 | 5.689 | 5.663 | 5.606 | 5.487 | 5.253 | 4.839 | 4.195 | 3.384 | 2.761 |
| Aug | 4.746 | 4.743 | 4.717 | 4.662 | 4.549 | 4.334 | 3.962 | 3.396 | 2.696 | 2.163 |
| Sep | 4.324 | 4.320 | 4.294 | 4.239 | 4.128 | 3.919 | 3.562 | 3.025 | 2.366 | 1.867 |

Natural Duration curves

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 22.050 | 17.992 | 14.147 | 13.068 | 11.667 | 9.950 | 9.506 | 8.617 | 7.788 | 6.709 |
| Nov | 41.597 | 35.799 | 29.398 | 25.204 | 21.508 | 18.646 | 17.365 | 15.984 | 12.068 | 10.255 |
| Dec | 83.318 | 56.720 | 43.533 | 38.937 | 31.112 | 28.726 | 25.646 | 22.450 | 17.346 | 12.056 |
| Jan | 131.414 | 78.091 | 60.040 | 53.080 | 44.011 | 37.321 | 31.373 | 27.718 | 25.239 | 16.532 |
| Feb | 174.115 | 124.921 | 77.005 | 54.741 | 46.631 | 41.803 | 35.615 | 31.105 | 26.066 | 22.264 |
| Mar | 135.189 | 68.679 | 60.667 | 51.934 | 41.144 | 34.155 | 30.048 | 26.493 | 22.133 | 17.749 |
| Apr | 60.035 | 46.481 | 40.394 | 33.962 | 30.262 | 27.427 | 24.441 | 23.376 | 17.998 | 14.016 |
| May | 30.907 | 26.202 | 23.171 | 21.980 | 20.527 | 18.993 | 17.671 | 16.543 | 13.366 | 10.282 |
| Jun | 22.994 | 19.796 | 17.523 | 16.991 | 15.999 | 15.085 | 14.005 | 12.809 | 10.737 | 9.487 |
| Jul | 19.194 | 15.797 | 14.277 | 13.292 | 12.911 | 12.186 | 11.268 | 10.413 | 9.185 | 7.874 |
| Aug | 15.853 | 13.504 | 11.634 | 10.962 | 10.652 | 10.279 | 9.521 | 8.987 | 7.878 | 6.937 |
| Sep | 15.123 | 12.203 | 11.269 | 10.019 | 9.525 | 9.163 | 8.584 | 8.052 | 7.014 | 6.223 |

## APPENDIX A7: EWR7 (Crocodile)

Desktop Version 2, Printed on 2008/07/18

Summary of IFR rule curves for : CE7 Natural Flows

Determination based on defined BBM Table with site specific assurance rules.

Regional Type : E.Escarp ERC = C

Data are given in m^3/s mean monthly flow

% Points

| Month | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 99% |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 0.521 | 0.520 | 0.515 | 0.504 | 0.484 | 0.447 | 0.385 | 0.294 | 0.184 | 0.101 |
| Nov | 1.126 | 1.122 | 1.110 | 1.087 | 1.043 | 0.963 | 0.833 | 0.644 | 0.420 | 0.252 |
| Dec | 1.371 | 1.365 | 1.352 | 1.324 | 1.272 | 1.180 | 1.030 | 0.816 | 0.563 | 0.374 |
| Jan | 2.754 | 2.553 | 2.375 | 2.207 | 2.032 | 1.736 | 1.509 | 1.189 | 0.818 | 0.543 |
| Feb | 5.665 | 5.139 | 4.683 | 4.275 | 3.874 | 3.201 | 2.772 | 2.158 | 1.434 | 0.895 |
| Mar | 2.243 | 2.163 | 2.087 | 2.005 | 1.903 | 1.726 | 1.533 | 1.253 | 0.920 | 0.672 |
| Apr | 1.591 | 1.588 | 1.576 | 1.551 | 1.503 | 1.415 | 1.266 | 1.048 | 0.784 | 0.586 |
| May | 1.382 | 1.380 | 1.371 | 1.351 | 1.311 | 1.235 | 1.106 | 0.912 | 0.674 | 0.493 |
| Jun | 1.259 | 1.258 | 1.250 | 1.232 | 1.196 | 1.127 | 1.008 | 0.827 | 0.603 | 0.432 |
| Jul | 0.991 | 0.991 | 0.985 | 0.972 | 0.945 | 0.891 | 0.796 | 0.648 | 0.461 | 0.318 |
| Aug | 0.705 | 0.704 | 0.699 | 0.688 | 0.664 | 0.620 | 0.544 | 0.427 | 0.284 | 0.174 |
| Sep | 0.510 | 0.509 | 0.504 | 0.495 | 0.475 | 0.439 | 0.377 | 0.283 | 0.168 | 0.081 |

Reserve flows without High Flows

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 0.521 | 0.520 | 0.515 | 0.504 | 0.484 | 0.447 | 0.385 | 0.294 | 0.184 | 0.101 |
| Nov | 0.768 | 0.765 | 0.758 | 0.743 | 0.715 | 0.665 | 0.582 | 0.462 | 0.320 | 0.214 |
| Dec | 1.025 | 1.021 | 1.011 | 0.992 | 0.957 | 0.893 | 0.790 | 0.642 | 0.467 | 0.337 |
| Jan | 1.288 | 1.282 | 1.269 | 1.245 | 1.199 | 1.119 | 0.992 | 0.813 | 0.605 | 0.451 |
| Feb | 1.736 | 1.730 | 1.715 | 1.685 | 1.628 | 1.528 | 1.364 | 1.129 | 0.853 | 0.648 |
| Mar | 1.679 | 1.674 | 1.660 | 1.633 | 1.580 | 1.485 | 1.329 | 1.104 | 0.836 | 0.637 |
| Apr | 1.591 | 1.588 | 1.576 | 1.551 | 1.503 | 1.415 | 1.266 | 1.048 | 0.784 | 0.586 |
| May | 1.382 | 1.380 | 1.371 | 1.351 | 1.311 | 1.235 | 1.106 | 0.912 | 0.674 | 0.493 |
| Jun | 1.259 | 1.258 | 1.250 | 1.232 | 1.196 | 1.127 | 1.008 | 0.827 | 0.603 | 0.432 |
| Jul | 0.991 | 0.991 | 0.985 | 0.972 | 0.945 | 0.891 | 0.796 | 0.648 | 0.461 | 0.318 |
| Aug | 0.705 | 0.704 | 0.699 | 0.688 | 0.664 | 0.620 | 0.544 | 0.427 | 0.284 | 0.174 |
| Sep | 0.510 | 0.509 | 0.504 | 0.495 | 0.475 | 0.439 | 0.377 | 0.283 | 0.168 | 0.081 |

Natural Duration curves

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 4.238 | 3.498 | 2.908 | 2.531 | 2.281 | 2.035 | 1.885 | 1.755 | 1.591 | 1.269 |
| Nov | 8.704 | 7.141 | 6.130 | 5.077 | 4.209 | 3.777 | 3.299 | 2.739 | 2.234 | 1.725 |
| Dec | 12.918 | 9.745 | 7.908 | 6.388 | 5.798 | 5.178 | 4.488 | 3.592 | 3.185 | 1.915 |
| Jan | 14.374 | 10.831 | 9.300 | 8.165 | 6.821 | 6.093 | 5.220 | 4.898 | 4.133 | 2.740 |
| Feb | 24.053 | 14.645 | 9.487 | 8.366 | 7.130 | 6.225 | 5.605 | 5.084 | 3.840 | 2.980 |
| Mar | 18.179 | 11.324 | 8.778 | 7.295 | 6.467 | 5.884 | 4.869 | 4.435 | 3.756 | 2.841 |
| Apr | 10.197 | 7.442 | 6.555 | 6.088 | 5.498 | 4.842 | 4.255 | 3.885 | 3.407 | 2.589 |
| May | 5.970 | 5.108 | 4.592 | 4.275 | 4.152 | 3.678 | 3.375 | 3.024 | 2.677 | 1.997 |
| Jun | 4.776 | 4.124 | 3.796 | 3.603 | 3.434 | 3.187 | 2.901 | 2.604 | 2.296 | 1.744 |
| Jul | 3.931 | 3.431 | 3.140 | 2.905 | 2.763 | 2.614 | 2.490 | 2.154 | 1.912 | 1.464 |
| Aug | 3.345 | 2.867 | 2.591 | 2.460 | 2.326 | 2.214 | 2.046 | 1.863 | 1.699 | 1.314 |
| Sep | 3.160 | 2.662 | 2.373 | 2.234 | 2.049 | 1.910 | 1.829 | 1.667 | 1.528 | 1.285 |

## APPENDIX B

## PRELIMINARY RULES CURVES FROM THE SABIE ECOLOGICAL RESERVE STUDY

# APPENDIX B1: EWR1 (Sabie)

Desktop Version 2, Printed on 2008/07/30
Summary of IFR rule curves for : SB1 Natural Flows
Determination based on defined BBM Table with site specific assurance rules.
Regional Type : E.Escarp     ERC = B/C

Data are given in m^3/s mean monthly flow

| | % Points | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Month | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 99% |
| Oct | 1.650 | 1.646 | 1.627 | 1.585 | 1.502 | 1.356 | 1.135 | 0.860 | 0.602 | 0.460 |
| Nov | 1.408 | 1.402 | 1.385 | 1.349 | 1.280 | 1.161 | 0.986 | 0.772 | 0.574 | 0.466 |
| Dec | 2.082 | 2.072 | 2.043 | 1.983 | 1.867 | 1.673 | 1.389 | 1.046 | 0.731 | 0.559 |
| Jan | 4.379 | 3.988 | 3.648 | 3.326 | 2.751 | 2.438 | 1.991 | 1.463 | 0.984 | 0.721 |
| Feb | 3.535 | 3.375 | 3.219 | 3.044 | 2.724 | 2.438 | 2.021 | 1.518 | 1.056 | 0.802 |
| Mar | 3.321 | 3.177 | 3.037 | 2.878 | 2.586 | 2.318 | 1.922 | 1.441 | 0.996 | 0.751 |
| Apr | 2.382 | 2.376 | 2.349 | 2.290 | 2.172 | 1.964 | 1.649 | 1.257 | 0.890 | 0.688 |
| May | 2.099 | 2.095 | 2.075 | 2.028 | 1.931 | 1.755 | 1.482 | 1.134 | 0.804 | 0.622 |
| Jun | 1.950 | 1.949 | 1.931 | 1.890 | 1.803 | 1.644 | 1.392 | 1.070 | 0.760 | 0.589 |
| Jul | 1.617 | 1.617 | 1.605 | 1.575 | 1.509 | 1.384 | 1.181 | 0.915 | 0.655 | 0.510 |
| Aug | 1.383 | 1.382 | 1.369 | 1.341 | 1.282 | 1.174 | 1.002 | 0.782 | 0.571 | 0.454 |
| Sep | 1.259 | 1.258 | 1.246 | 1.220 | 1.165 | 1.067 | 0.913 | 0.718 | 0.533 | 0.430 |

Reserve flows without High Flows

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 1.198 | 1.195 | 1.182 | 1.155 | 1.100 | 1.004 | 0.858 | 0.676 | 0.506 | 0.413 |
| Nov | 1.408 | 1.402 | 1.385 | 1.349 | 1.280 | 1.161 | 0.986 | 0.772 | 0.574 | 0.466 |
| Dec | 1.630 | 1.622 | 1.601 | 1.556 | 1.472 | 1.329 | 1.121 | 0.869 | 0.638 | 0.512 |
| Jan | 1.975 | 1.962 | 1.933 | 1.874 | 1.764 | 1.583 | 1.325 | 1.020 | 0.742 | 0.591 |
| Feb | 2.592 | 2.579 | 2.545 | 2.472 | 2.333 | 2.097 | 1.754 | 1.340 | 0.960 | 0.751 |
| Mar | 2.469 | 2.458 | 2.427 | 2.360 | 2.230 | 2.007 | 1.679 | 1.278 | 0.908 | 0.705 |
| Apr | 2.382 | 2.376 | 2.349 | 2.290 | 2.172 | 1.964 | 1.649 | 1.257 | 0.890 | 0.688 |
| May | 2.099 | 2.095 | 2.075 | 2.028 | 1.931 | 1.755 | 1.482 | 1.134 | 0.804 | 0.622 |
| Jun | 1.950 | 1.949 | 1.931 | 1.890 | 1.803 | 1.644 | 1.392 | 1.070 | 0.760 | 0.589 |
| Jul | 1.617 | 1.617 | 1.605 | 1.575 | 1.509 | 1.384 | 1.181 | 0.915 | 0.655 | 0.510 |
| Aug | 1.383 | 1.382 | 1.369 | 1.341 | 1.282 | 1.174 | 1.002 | 0.782 | 0.571 | 0.454 |
| Sep | 1.259 | 1.258 | 1.246 | 1.220 | 1.165 | 1.067 | 0.913 | 0.718 | 0.533 | 0.430 |

Natural Duration curves

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 2.599 | 2.266 | 1.971 | 1.732 | 1.534 | 1.456 | 1.359 | 1.273 | 1.116 | 0.971 |
| Nov | 5.694 | 4.001 | 3.576 | 3.171 | 2.805 | 2.485 | 2.157 | 1.825 | 1.470 | 1.138 |
| Dec | 8.714 | 7.116 | 5.727 | 4.966 | 4.085 | 3.562 | 3.147 | 2.789 | 2.431 | 1.665 |
| Jan | 14.363 | 10.488 | 8.020 | 6.369 | 5.608 | 5.141 | 4.096 | 3.726 | 3.091 | 2.767 |
| Feb | 20.685 | 16.100 | 11.760 | 7.688 | 6.758 | 6.114 | 4.952 | 4.415 | 3.191 | 2.501 |
| Mar | 16.831 | 10.895 | 8.621 | 8.094 | 6.160 | 4.884 | 4.238 | 3.775 | 3.338 | 2.263 |
| Apr | 8.931 | 7.222 | 6.046 | 5.285 | 4.699 | 4.109 | 3.789 | 3.383 | 3.090 | 2.153 |
| May | 4.540 | 4.088 | 3.864 | 3.539 | 3.442 | 3.017 | 2.722 | 2.550 | 2.296 | 1.725 |
| Jun | 3.546 | 3.079 | 2.859 | 2.735 | 2.689 | 2.600 | 2.265 | 2.068 | 1.867 | 1.454 |
| Jul | 2.819 | 2.483 | 2.352 | 2.147 | 2.050 | 1.968 | 1.826 | 1.669 | 1.508 | 1.292 |
| Aug | 2.236 | 2.087 | 1.874 | 1.807 | 1.688 | 1.620 | 1.512 | 1.441 | 1.325 | 1.094 |
| Sep | 2.211 | 2.060 | 1.690 | 1.609 | 1.520 | 1.447 | 1.366 | 1.300 | 1.188 | 1.003 |

# APPENDIX B2: EWR2 (Sabie)

Desktop Version 2, Printed on 2008/07/30
Summary of IFR rule curves for : SB2 Natural Flows
Determination based on defined BBM Table with site specific assurance rules.
Regional Type : E.Escarp ERC = C

Data are given in m^3/s mean monthly flow

| | % Points | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Month | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 99% |
| Oct | 1.747 | 1.743 | 1.732 | 1.708 | 1.661 | 1.576 | 1.432 | 1.220 | 0.964 | 0.772 |
| Nov | 2.777 | 2.768 | 2.744 | 2.695 | 2.601 | 2.433 | 2.158 | 1.759 | 1.286 | 0.932 |
| Dec | 2.919 | 2.908 | 2.881 | 2.828 | 2.726 | 2.547 | 2.255 | 1.837 | 1.345 | 0.978 |
| Jan | 3.716 | 3.530 | 3.361 | 3.191 | 2.997 | 2.669 | 2.364 | 1.936 | 1.438 | 1.070 |
| Feb | 6.314 | 5.869 | 5.475 | 5.109 | 4.727 | 4.080 | 3.586 | 2.878 | 2.044 | 1.423 |
| Mar | 4.165 | 3.983 | 3.813 | 3.642 | 3.441 | 3.094 | 2.750 | 2.252 | 1.661 | 1.220 |
| Apr | 2.792 | 2.787 | 2.767 | 2.726 | 2.646 | 2.500 | 2.254 | 1.891 | 1.454 | 1.125 |
| May | 2.527 | 2.524 | 2.509 | 2.475 | 2.408 | 2.281 | 2.063 | 1.736 | 1.335 | 1.031 |
| Jun | 2.417 | 2.415 | 2.401 | 2.371 | 2.309 | 2.191 | 1.987 | 1.677 | 1.294 | 1.002 |
| Jul | 2.115 | 2.115 | 2.104 | 2.080 | 2.030 | 1.933 | 1.761 | 1.493 | 1.155 | 0.896 |
| Aug | 1.910 | 1.908 | 1.898 | 1.874 | 1.827 | 1.737 | 1.581 | 1.344 | 1.050 | 0.827 |
| Sep | 1.826 | 1.824 | 1.813 | 1.790 | 1.744 | 1.658 | 1.510 | 1.287 | 1.013 | 0.806 |

Reserve flows without High Flows

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 1.747 | 1.743 | 1.732 | 1.708 | 1.661 | 1.576 | 1.432 | 1.220 | 0.964 | 0.772 |
| Nov | 1.942 | 1.936 | 1.922 | 1.893 | 1.837 | 1.737 | 1.573 | 1.336 | 1.054 | 0.843 |
| Dec | 2.110 | 2.104 | 2.087 | 2.053 | 1.990 | 1.877 | 1.694 | 1.431 | 1.122 | 0.892 |
| Jan | 2.400 | 2.390 | 2.368 | 2.327 | 2.249 | 2.115 | 1.900 | 1.598 | 1.247 | 0.987 |
| Feb | 3.026 | 3.016 | 2.991 | 2.941 | 2.847 | 2.680 | 2.408 | 2.017 | 1.558 | 1.216 |
| Mar | 2.849 | 2.841 | 2.819 | 2.773 | 2.686 | 2.530 | 2.275 | 1.904 | 1.465 | 1.137 |
| Apr | 2.792 | 2.787 | 2.767 | 2.726 | 2.646 | 2.500 | 2.254 | 1.891 | 1.454 | 1.125 |
| May | 2.527 | 2.524 | 2.509 | 2.475 | 2.408 | 2.281 | 2.063 | 1.736 | 1.335 | 1.031 |
| Jun | 2.417 | 2.415 | 2.401 | 2.371 | 2.309 | 2.191 | 1.987 | 1.677 | 1.294 | 1.002 |
| Jul | 2.115 | 2.115 | 2.104 | 2.080 | 2.030 | 1.933 | 1.761 | 1.493 | 1.155 | 0.896 |
| Aug | 1.910 | 1.908 | 1.898 | 1.874 | 1.827 | 1.737 | 1.581 | 1.344 | 1.050 | 0.827 |
| Sep | 1.826 | 1.824 | 1.813 | 1.790 | 1.744 | 1.658 | 1.510 | 1.287 | 1.013 | 0.806 |

Natural Duration curves

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 4.828 | 4.182 | 3.704 | 3.166 | 2.838 | 2.707 | 2.550 | 2.378 | 2.080 | 1.807 |
| Nov | 9.869 | 7.284 | 6.508 | 5.768 | 5.193 | 4.506 | 4.035 | 3.376 | 2.758 | 2.153 |
| Dec | 17.723 | 13.766 | 10.820 | 9.256 | 7.628 | 6.627 | 5.873 | 5.052 | 4.533 | 3.020 |
| Jan | 25.414 | 19.120 | 14.539 | 11.862 | 10.730 | 9.177 | 7.803 | 6.918 | 5.899 | 5.178 |
| Feb | 39.249 | 30.638 | 21.077 | 14.335 | 12.831 | 11.351 | 9.206 | 8.011 | 5.824 | 4.506 |
| Mar | 32.239 | 20.677 | 17.443 | 15.308 | 11.193 | 9.334 | 7.833 | 6.918 | 5.985 | 4.159 |
| Apr | 17.215 | 13.519 | 11.304 | 9.776 | 8.731 | 7.793 | 7.029 | 6.265 | 5.694 | 3.931 |
| May | 8.434 | 7.643 | 7.243 | 6.694 | 6.437 | 5.701 | 5.089 | 4.772 | 4.297 | 3.174 |
| Jun | 6.694 | 5.849 | 5.417 | 5.174 | 5.085 | 4.784 | 4.244 | 3.870 | 3.534 | 2.704 |
| Jul | 5.335 | 4.663 | 4.421 | 4.025 | 3.846 | 3.737 | 3.401 | 3.155 | 2.864 | 2.386 |
| Aug | 4.282 | 3.943 | 3.543 | 3.409 | 3.203 | 3.043 | 2.838 | 2.692 | 2.468 | 2.012 |
| Sep | 4.147 | 3.897 | 3.241 | 3.025 | 2.897 | 2.728 | 2.585 | 2.423 | 2.238 | 1.852 |

## APPENDIX B3: EWR3 (Sabie)

Desktop Version 2, Printed on 2008/07/31
Summary of IFR rule curves for : SB3 Natural Flows
Determination based on defined BBM Table with site specific assurance rules.
Regional Type : E.Escarp     ERC = A/B

Data are given in m^3/s mean monthly flow

| | % Points | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Month | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 99% |
| Oct | 3.230 | 3.223 | 3.199 | 3.148 | 3.048 | 2.864 | 2.557 | 2.103 | 1.556 | 1.144 |
| Nov | 6.082 | 6.060 | 6.001 | 5.880 | 5.650 | 5.236 | 4.558 | 3.575 | 2.409 | 1.539 |
| Dec | 7.104 | 7.073 | 6.999 | 6.851 | 6.569 | 6.070 | 5.259 | 4.096 | 2.725 | 1.706 |
| Jan | 10.172 | 9.664 | 9.190 | 8.700 | 8.118 | 7.132 | 6.150 | 4.766 | 3.159 | 1.971 |
| Feb | 20.234 | 18.756 | 17.440 | 16.198 | 14.880 | 12.642 | 10.847 | 8.273 | 5.241 | 2.984 |
| Mar | 11.597 | 11.217 | 10.834 | 10.402 | 9.828 | 8.828 | 7.636 | 5.911 | 3.863 | 2.334 |
| Apr | 8.289 | 8.269 | 8.196 | 8.044 | 7.745 | 7.198 | 6.281 | 4.928 | 3.296 | 2.069 |
| May | 6.920 | 6.911 | 6.857 | 6.742 | 6.511 | 6.078 | 5.335 | 4.217 | 2.847 | 1.808 |
| Jun | 6.115 | 6.110 | 6.066 | 5.971 | 5.777 | 5.409 | 4.770 | 3.798 | 2.597 | 1.683 |
| Jul | 4.881 | 4.881 | 4.851 | 4.784 | 4.643 | 4.370 | 3.883 | 3.127 | 2.175 | 1.444 |
| Aug | 3.974 | 3.971 | 3.944 | 3.886 | 3.768 | 3.544 | 3.156 | 2.566 | 1.835 | 1.280 |
| Sep | 3.443 | 3.439 | 3.415 | 3.365 | 3.264 | 3.074 | 2.748 | 2.258 | 1.657 | 1.202 |

Reserve flows without High Flows

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 3.230 | 3.223 | 3.199 | 3.148 | 3.048 | 2.864 | 2.557 | 2.103 | 1.556 | 1.144 |
| Nov | 4.017 | 4.004 | 3.968 | 3.897 | 3.759 | 3.512 | 3.106 | 2.520 | 1.823 | 1.303 |
| Dec | 5.105 | 5.085 | 5.035 | 4.935 | 4.746 | 4.411 | 3.866 | 3.084 | 2.163 | 1.478 |
| Jan | 6.624 | 6.588 | 6.514 | 6.370 | 6.102 | 5.638 | 4.898 | 3.855 | 2.644 | 1.748 |
| Feb | 9.366 | 9.326 | 9.229 | 9.035 | 8.666 | 8.013 | 6.951 | 5.429 | 3.635 | 2.300 |
| Mar | 8.966 | 8.933 | 8.844 | 8.664 | 8.319 | 7.700 | 6.685 | 5.215 | 3.471 | 2.169 |
| Apr | 8.289 | 8.269 | 8.196 | 8.044 | 7.745 | 7.198 | 6.281 | 4.928 | 3.296 | 2.069 |
| May | 6.920 | 6.911 | 6.857 | 6.742 | 6.511 | 6.078 | 5.335 | 4.217 | 2.847 | 1.808 |
| Jun | 6.115 | 6.110 | 6.066 | 5.971 | 5.777 | 5.409 | 4.770 | 3.798 | 2.597 | 1.683 |
| Jul | 4.881 | 4.881 | 4.851 | 4.784 | 4.643 | 4.370 | 3.883 | 3.127 | 2.175 | 1.444 |
| Aug | 3.974 | 3.971 | 3.944 | 3.886 | 3.768 | 3.544 | 3.156 | 2.566 | 1.835 | 1.280 |
| Sep | 3.443 | 3.439 | 3.415 | 3.365 | 3.264 | 3.074 | 2.748 | 2.258 | 1.657 | 1.202 |

Natural Duration curves

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 8.860 | 7.624 | 6.814 | 5.761 | 5.111 | 4.723 | 4.488 | 4.178 | 3.711 | 3.088 |
| Nov | 18.808 | 14.742 | 11.802 | 10.093 | 9.086 | 8.221 | 7.272 | 5.760 | 4.911 | 3.746 |
| Dec | 33.923 | 25.989 | 21.229 | 16.726 | 13.922 | 12.291 | 10.275 | 9.491 | 7.706 | 5.066 |
| Jan | 55.880 | 37.817 | 26.202 | 23.749 | 19.710 | 17.111 | 13.702 | 11.645 | 10.447 | 8.180 |
| Feb | 82.507 | 64.559 | 41.460 | 31.754 | 23.177 | 20.747 | 16.923 | 13.368 | 10.074 | 7.647 |
| Mar | 66.439 | 45.318 | 34.009 | 28.054 | 20.968 | 16.599 | 14.501 | 11.787 | 10.122 | 6.776 |
| Apr | 32.280 | 25.035 | 20.359 | 17.535 | 14.271 | 13.499 | 12.222 | 11.084 | 9.630 | 6.227 |
| May | 15.170 | 13.355 | 12.444 | 11.391 | 10.783 | 9.849 | 8.703 | 8.180 | 7.396 | 5.115 |
| Jun | 11.682 | 10.073 | 9.525 | 9.136 | 8.600 | 8.194 | 7.353 | 6.632 | 6.030 | 4.568 |
| Jul | 9.580 | 8.162 | 7.646 | 7.042 | 6.735 | 6.452 | 6.022 | 5.451 | 5.052 | 4.036 |
| Aug | 7.553 | 7.105 | 6.254 | 6.000 | 5.679 | 5.417 | 5.010 | 4.749 | 4.238 | 3.435 |
| Sep | 7.612 | 7.060 | 5.741 | 5.409 | 5.235 | 4.842 | 4.552 | 4.209 | 3.866 | 3.140 |

## APPENDIX B4: EWR4 (Sabie)

**Desktop Version 2, Printed on 2008/07/31**

Summary of IFR rule curves for : SB4 Natural Flows

Determination based on defined BBM Table with site specific assurance rules.

Regional Type : E.Escarp ERC = B

Data are given in m^3/s mean monthly flow

% Points

| Month | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 99% |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 0.561 | 0.560 | 0.556 | 0.546 | 0.527 | 0.493 | 0.435 | 0.350 | 0.247 | 0.170 |
| Nov | 0.933 | 0.929 | 0.920 | 0.902 | 0.867 | 0.804 | 0.701 | 0.551 | 0.374 | 0.242 |
| Dec | 1.061 | 1.056 | 1.046 | 1.025 | 0.985 | 0.914 | 0.799 | 0.635 | 0.441 | 0.297 |
| Jan | 1.450 | 1.385 | 1.324 | 1.261 | 1.185 | 1.057 | 0.927 | 0.744 | 0.531 | 0.374 |
| Feb | 3.539 | 3.245 | 2.988 | 2.753 | 2.517 | 2.118 | 1.839 | 1.439 | 0.969 | 0.619 |
| Mar | 1.763 | 1.700 | 1.638 | 1.573 | 1.491 | 1.349 | 1.193 | 0.967 | 0.699 | 0.499 |
| Apr | 1.258 | 1.256 | 1.246 | 1.226 | 1.187 | 1.116 | 0.997 | 0.820 | 0.608 | 0.448 |
| May | 1.093 | 1.092 | 1.085 | 1.069 | 1.037 | 0.976 | 0.873 | 0.718 | 0.528 | 0.384 |
| Jun | 1.004 | 1.003 | 0.996 | 0.982 | 0.954 | 0.899 | 0.804 | 0.660 | 0.482 | 0.346 |
| Jul | 0.815 | 0.815 | 0.810 | 0.800 | 0.777 | 0.734 | 0.658 | 0.538 | 0.388 | 0.273 |
| Aug | 0.675 | 0.675 | 0.670 | 0.660 | 0.640 | 0.602 | 0.536 | 0.435 | 0.311 | 0.216 |
| Sep | 0.597 | 0.597 | 0.592 | 0.583 | 0.564 | 0.529 | 0.469 | 0.378 | 0.267 | 0.183 |

Reserve flows without High Flows

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 0.561 | 0.560 | 0.556 | 0.546 | 0.527 | 0.493 | 0.435 | 0.350 | 0.247 | 0.170 |
| Nov | 0.670 | 0.668 | 0.662 | 0.650 | 0.627 | 0.585 | 0.516 | 0.417 | 0.300 | 0.212 |
| Dec | 0.807 | 0.803 | 0.796 | 0.781 | 0.753 | 0.703 | 0.622 | 0.506 | 0.369 | 0.268 |
| Jan | 0.999 | 0.994 | 0.984 | 0.965 | 0.929 | 0.867 | 0.768 | 0.628 | 0.465 | 0.345 |
| Feb | 1.354 | 1.349 | 1.337 | 1.313 | 1.268 | 1.187 | 1.056 | 0.868 | 0.646 | 0.481 |
| Mar | 1.312 | 1.308 | 1.297 | 1.275 | 1.232 | 1.155 | 1.030 | 0.848 | 0.632 | 0.471 |
| Apr | 1.258 | 1.256 | 1.246 | 1.226 | 1.187 | 1.116 | 0.997 | 0.820 | 0.608 | 0.448 |
| May | 1.093 | 1.092 | 1.085 | 1.069 | 1.037 | 0.976 | 0.873 | 0.718 | 0.528 | 0.384 |
| Jun | 1.004 | 1.003 | 0.996 | 0.982 | 0.954 | 0.899 | 0.804 | 0.660 | 0.482 | 0.346 |
| Jul | 0.815 | 0.815 | 0.810 | 0.800 | 0.777 | 0.734 | 0.658 | 0.538 | 0.388 | 0.273 |
| Aug | 0.675 | 0.675 | 0.670 | 0.660 | 0.640 | 0.602 | 0.536 | 0.435 | 0.311 | 0.216 |
| Sep | 0.597 | 0.597 | 0.592 | 0.583 | 0.564 | 0.529 | 0.469 | 0.378 | 0.267 | 0.183 |

Natural Duration curves

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 1.198 | 1.038 | 0.896 | 0.773 | 0.691 | 0.665 | 0.624 | 0.594 | 0.508 | 0.437 |
| Nov | 2.373 | 1.790 | 1.601 | 1.431 | 1.273 | 1.111 | 1.003 | 0.845 | 0.671 | 0.525 |
| Dec | 4.379 | 3.465 | 2.696 | 2.300 | 1.983 | 1.777 | 1.449 | 1.269 | 1.120 | 0.769 |
| Jan | 6.168 | 4.869 | 3.674 | 3.035 | 2.740 | 2.304 | 2.001 | 1.732 | 1.538 | 1.307 |
| Feb | 10.342 | 7.358 | 5.250 | 3.869 | 3.204 | 2.931 | 2.323 | 2.046 | 1.509 | 1.145 |
| Mar | 8.255 | 5.399 | 4.260 | 3.999 | 2.707 | 2.389 | 1.956 | 1.788 | 1.553 | 1.079 |
| Apr | 4.433 | 3.422 | 2.917 | 2.442 | 2.184 | 1.960 | 1.833 | 1.597 | 1.447 | 1.003 |
| May | 2.053 | 1.889 | 1.822 | 1.706 | 1.632 | 1.445 | 1.322 | 1.213 | 1.109 | 0.806 |
| Jun | 1.628 | 1.478 | 1.370 | 1.319 | 1.277 | 1.204 | 1.069 | 0.984 | 0.887 | 0.694 |
| Jul | 1.284 | 1.157 | 1.068 | 1.004 | 0.960 | 0.933 | 0.833 | 0.788 | 0.709 | 0.601 |
| Aug | 1.072 | 0.974 | 0.889 | 0.851 | 0.795 | 0.750 | 0.706 | 0.657 | 0.605 | 0.493 |
| Sep | 1.038 | 0.949 | 0.795 | 0.756 | 0.710 | 0.675 | 0.629 | 0.590 | 0.544 | 0.448 |

# APPENDIX B5: EWR5 (Sabie)

**Desktop Version 2, Printed on 2008/07/31**

Summary of IFR rule curves for : SB5 Natural Flows

Determination based on defined BBM Table with site specific assurance rules.

Regional Type : E.Escarp     ERC = B/C

Data are given in m^3/s mean monthly flow

| | % Points | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Month | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 99% |
| Oct | 0.612 | 0.611 | 0.607 | 0.599 | 0.583 | 0.554 | 0.506 | 0.435 | 0.350 | 0.285 |
| Nov | 1.078 | 1.074 | 1.065 | 1.046 | 1.010 | 0.944 | 0.837 | 0.681 | 0.497 | 0.359 |
| Dec | 1.996 | 1.987 | 1.966 | 1.925 | 1.846 | 1.706 | 1.478 | 1.152 | 0.768 | 0.482 |
| Jan | 2.604 | 2.456 | 2.321 | 2.187 | 2.034 | 1.776 | 1.539 | 1.206 | 0.819 | 0.533 |
| Feb | 6.912 | 6.293 | 5.752 | 5.262 | 4.772 | 3.945 | 3.383 | 2.576 | 1.626 | 0.919 |
| Mar | 2.669 | 2.602 | 2.530 | 2.444 | 2.323 | 2.110 | 1.837 | 1.443 | 0.974 | 0.625 |
| Apr | 1.932 | 1.928 | 1.911 | 1.878 | 1.811 | 1.689 | 1.485 | 1.184 | 0.820 | 0.547 |
| May | 1.447 | 1.445 | 1.435 | 1.413 | 1.367 | 1.283 | 1.138 | 0.919 | 0.651 | 0.448 |
| Jun | 1.207 | 1.206 | 1.198 | 1.181 | 1.146 | 1.080 | 0.965 | 0.789 | 0.572 | 0.407 |
| Jul | 0.936 | 0.936 | 0.931 | 0.920 | 0.896 | 0.849 | 0.766 | 0.636 | 0.474 | 0.349 |
| Aug | 0.757 | 0.757 | 0.752 | 0.743 | 0.723 | 0.686 | 0.623 | 0.525 | 0.405 | 0.314 |
| Sep | 0.649 | 0.648 | 0.645 | 0.637 | 0.621 | 0.591 | 0.541 | 0.464 | 0.370 | 0.299 |

Reserve flows without High Flows

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 0.612 | 0.611 | 0.607 | 0.599 | 0.583 | 0.554 | 0.506 | 0.435 | 0.350 | 0.285 |
| Nov | 0.809 | 0.807 | 0.801 | 0.788 | 0.764 | 0.720 | 0.648 | 0.544 | 0.421 | 0.329 |
| Dec | 1.125 | 1.121 | 1.111 | 1.091 | 1.052 | 0.983 | 0.872 | 0.713 | 0.525 | 0.385 |
| Jan | 1.552 | 1.544 | 1.527 | 1.495 | 1.436 | 1.332 | 1.168 | 0.936 | 0.666 | 0.467 |
| Feb | 2.300 | 2.291 | 2.268 | 2.222 | 2.135 | 1.980 | 1.729 | 1.369 | 0.945 | 0.629 |
| Mar | 2.218 | 2.211 | 2.189 | 2.146 | 2.064 | 1.916 | 1.674 | 1.323 | 0.907 | 0.596 |
| Apr | 1.932 | 1.928 | 1.911 | 1.878 | 1.811 | 1.689 | 1.485 | 1.184 | 0.820 | 0.547 |
| May | 1.447 | 1.445 | 1.435 | 1.413 | 1.367 | 1.283 | 1.138 | 0.919 | 0.651 | 0.448 |
| Jun | 1.207 | 1.206 | 1.198 | 1.181 | 1.146 | 1.080 | 0.965 | 0.789 | 0.572 | 0.407 |
| Jul | 0.936 | 0.936 | 0.931 | 0.920 | 0.896 | 0.849 | 0.766 | 0.636 | 0.474 | 0.349 |
| Aug | 0.757 | 0.757 | 0.752 | 0.743 | 0.723 | 0.686 | 0.623 | 0.525 | 0.405 | 0.314 |
| Sep | 0.649 | 0.648 | 0.645 | 0.637 | 0.621 | 0.591 | 0.541 | 0.464 | 0.370 | 0.299 |

Natural Duration curves

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 2.427 | 2.057 | 1.732 | 1.568 | 1.251 | 1.165 | 1.064 | 0.993 | 0.904 | 0.698 |
| Nov | 6.273 | 4.853 | 3.781 | 2.924 | 2.384 | 2.215 | 1.728 | 1.335 | 1.161 | 0.887 |
| Dec | 11.880 | 8.804 | 6.366 | 5.458 | 4.182 | 3.607 | 2.733 | 2.333 | 1.863 | 1.236 |
| Jan | 22.357 | 14.804 | 9.371 | 7.874 | 6.269 | 4.734 | 3.913 | 3.536 | 2.543 | 1.829 |
| Feb | 30.853 | 22.830 | 14.339 | 9.809 | 7.626 | 6.453 | 4.803 | 3.542 | 2.650 | 1.521 |
| Mar | 23.174 | 16.114 | 11.649 | 9.293 | 6.459 | 4.663 | 4.010 | 3.192 | 2.599 | 1.546 |
| Apr | 10.729 | 8.183 | 6.709 | 4.776 | 4.001 | 3.650 | 3.202 | 2.805 | 2.446 | 1.412 |
| May | 4.043 | 3.454 | 3.185 | 3.032 | 2.726 | 2.543 | 2.337 | 1.983 | 1.800 | 1.131 |
| Jun | 2.924 | 2.704 | 2.442 | 2.280 | 2.149 | 1.952 | 1.813 | 1.624 | 1.481 | 1.154 |
| Jul | 2.363 | 2.109 | 1.927 | 1.815 | 1.650 | 1.576 | 1.434 | 1.340 | 1.247 | 0.978 |
| Aug | 2.035 | 1.688 | 1.583 | 1.493 | 1.363 | 1.303 | 1.221 | 1.139 | 1.049 | 0.825 |
| Sep | 2.072 | 1.674 | 1.424 | 1.308 | 1.235 | 1.161 | 1.069 | 1.011 | 0.922 | 0.725 |

## APPENDIX B6: EWR6 (Sabie)

Desktop Version 2, Printed on 2008/08/01
Summary of IFR rule curves for : SB6 Natural Flows
Determination based on defined BBM Table with site specific assurance rules.
Regional Type : E.Escarp ERC = C

Data are given in m^3/s mean monthly flow

| % Points | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Month | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 99% |
| Oct | 0.279 | 0.278 | 0.276 | 0.271 | 0.262 | 0.245 | 0.217 | 0.175 | 0.125 | 0.087 |
| Nov | 0.430 | 0.428 | 0.424 | 0.415 | 0.399 | 0.371 | 0.323 | 0.255 | 0.173 | 0.113 |
| Dec | 0.501 | 0.499 | 0.494 | 0.485 | 0.466 | 0.433 | 0.380 | 0.303 | 0.213 | 0.145 |
| Jan | 0.696 | 0.670 | 0.644 | 0.617 | 0.583 | 0.525 | 0.463 | 0.374 | 0.272 | 0.197 |
| Feb | 2.217 | 2.021 | 1.851 | 1.698 | 1.546 | 1.289 | 1.112 | 0.876 | 0.589 | 0.372 |
| Mar | 0.932 | 0.906 | 0.880 | 0.850 | 0.810 | 0.742 | 0.660 | 0.541 | 0.400 | 0.294 |
| Apr | 0.682 | 0.680 | 0.675 | 0.665 | 0.644 | 0.607 | 0.544 | 0.451 | 0.338 | 0.254 |
| May | 0.535 | 0.535 | 0.531 | 0.524 | 0.508 | 0.479 | 0.430 | 0.355 | 0.263 | 0.194 |
| Jun | 0.484 | 0.483 | 0.480 | 0.474 | 0.460 | 0.434 | 0.389 | 0.320 | 0.236 | 0.171 |
| Jul | 0.410 | 0.410 | 0.408 | 0.402 | 0.391 | 0.370 | 0.332 | 0.273 | 0.198 | 0.141 |
| Aug | 0.351 | 0.351 | 0.349 | 0.344 | 0.333 | 0.314 | 0.280 | 0.229 | 0.166 | 0.117 |
| Sep | 0.309 | 0.309 | 0.307 | 0.302 | 0.293 | 0.275 | 0.244 | 0.198 | 0.141 | 0.099 |

Reserve flows without High Flows

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 0.279 | 0.278 | 0.276 | 0.271 | 0.262 | 0.245 | 0.217 | 0.175 | 0.125 | 0.087 |
| Nov | 0.315 | 0.314 | 0.311 | 0.305 | 0.295 | 0.275 | 0.243 | 0.197 | 0.142 | 0.100 |
| Dec | 0.390 | 0.389 | 0.385 | 0.378 | 0.365 | 0.341 | 0.303 | 0.247 | 0.182 | 0.134 |
| Jan | 0.516 | 0.513 | 0.508 | 0.499 | 0.481 | 0.449 | 0.399 | 0.328 | 0.246 | 0.185 |
| Feb | 0.760 | 0.757 | 0.751 | 0.738 | 0.713 | 0.669 | 0.597 | 0.495 | 0.374 | 0.284 |
| Mar | 0.752 | 0.749 | 0.743 | 0.731 | 0.707 | 0.664 | 0.594 | 0.493 | 0.373 | 0.283 |
| Apr | 0.682 | 0.680 | 0.675 | 0.665 | 0.644 | 0.607 | 0.544 | 0.451 | 0.338 | 0.254 |
| May | 0.535 | 0.535 | 0.531 | 0.524 | 0.508 | 0.479 | 0.430 | 0.355 | 0.263 | 0.194 |
| Jun | 0.484 | 0.483 | 0.480 | 0.474 | 0.460 | 0.434 | 0.389 | 0.320 | 0.236 | 0.171 |
| Jul | 0.410 | 0.410 | 0.408 | 0.402 | 0.391 | 0.370 | 0.332 | 0.273 | 0.198 | 0.141 |
| Aug | 0.351 | 0.351 | 0.349 | 0.344 | 0.333 | 0.314 | 0.280 | 0.229 | 0.166 | 0.117 |
| Sep | 0.309 | 0.309 | 0.307 | 0.302 | 0.293 | 0.275 | 0.244 | 0.198 | 0.141 | 0.099 |

Natural Duration curves

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 0.653 | 0.579 | 0.511 | 0.470 | 0.399 | 0.381 | 0.362 | 0.351 | 0.299 | 0.202 |
| Nov | 1.269 | 0.984 | 0.795 | 0.664 | 0.594 | 0.552 | 0.471 | 0.382 | 0.324 | 0.212 |
| Dec | 2.856 | 1.919 | 1.449 | 1.157 | 0.870 | 0.717 | 0.609 | 0.564 | 0.429 | 0.280 |
| Jan | 5.638 | 3.663 | 2.188 | 1.520 | 1.262 | 1.064 | 0.904 | 0.747 | 0.605 | 0.381 |
| Feb | 11.615 | 5.824 | 3.125 | 1.914 | 1.554 | 1.343 | 1.112 | 0.889 | 0.744 | 0.372 |
| Mar | 7.389 | 4.338 | 3.342 | 2.091 | 1.396 | 1.184 | 1.008 | 0.825 | 0.706 | 0.321 |
| Apr | 3.985 | 2.658 | 1.551 | 1.389 | 1.161 | 1.011 | 0.914 | 0.799 | 0.710 | 0.370 |
| May | 1.359 | 1.191 | 1.086 | 0.997 | 0.851 | 0.806 | 0.717 | 0.687 | 0.586 | 0.310 |
| Jun | 1.042 | 0.934 | 0.880 | 0.810 | 0.706 | 0.675 | 0.606 | 0.583 | 0.505 | 0.285 |
| Jul | 0.818 | 0.728 | 0.683 | 0.642 | 0.605 | 0.553 | 0.515 | 0.467 | 0.429 | 0.269 |
| Aug | 0.709 | 0.642 | 0.579 | 0.549 | 0.523 | 0.474 | 0.437 | 0.418 | 0.366 | 0.243 |
| Sep | 0.644 | 0.583 | 0.532 | 0.486 | 0.448 | 0.428 | 0.394 | 0.370 | 0.328 | 0.224 |

## APPENDIX B7: EWR7 (Sabie)

**Desktop Version 2, Printed on 2008/07/31**

Summary of IFR rule curves for : SB7 Natural Flows

Determination based on defined BBM Table with site specific assurance rules.

Regional Type : E.Escarp     ERC = B

Data are given in m^3/s mean monthly flow

| | % Points | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Month | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 99% |
| Oct | 0.227 | 0.227 | 0.225 | 0.221 | 0.215 | 0.202 | 0.181 | 0.150 | 0.112 | 0.084 |
| Nov | 0.346 | 0.345 | 0.341 | 0.335 | 0.323 | 0.300 | 0.264 | 0.211 | 0.149 | 0.102 |
| Dec | 0.631 | 0.629 | 0.622 | 0.608 | 0.553 | 0.459 | 0.388 | 0.358 | 0.236 | 0.143 |
| Jan | 0.963 | 0.879 | 0.806 | 0.739 | 0.672 | 0.560 | 0.485 | 0.379 | 0.255 | 0.164 |
| Feb | 1.781 | 1.605 | 1.454 | 1.232 | 1.000 | 0.860 | 0.719 | 0.575 | 0.422 | 0.236 |
| Mar | 0.627 | 0.603 | 0.580 | 0.557 | 0.527 | 0.476 | 0.421 | 0.342 | 0.248 | 0.178 |
| Apr | 0.427 | 0.426 | 0.423 | 0.416 | 0.403 | 0.379 | 0.340 | 0.281 | 0.210 | 0.157 |
| May | 0.350 | 0.350 | 0.347 | 0.342 | 0.332 | 0.314 | 0.282 | 0.233 | 0.174 | 0.129 |
| Jun | 0.329 | 0.328 | 0.326 | 0.322 | 0.313 | 0.295 | 0.265 | 0.220 | 0.163 | 0.121 |
| Jul | 0.290 | 0.290 | 0.289 | 0.285 | 0.278 | 0.263 | 0.237 | 0.197 | 0.146 | 0.107 |
| Aug | 0.262 | 0.262 | 0.260 | 0.256 | 0.249 | 0.235 | 0.212 | 0.175 | 0.131 | 0.096 |
| Sep | 0.244 | 0.244 | 0.242 | 0.238 | 0.232 | 0.218 | 0.196 | 0.163 | 0.121 | 0.090 |

Reserve flows without High Flows

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 0.227 | 0.227 | 0.225 | 0.221 | 0.215 | 0.202 | 0.181 | 0.150 | 0.112 | 0.084 |
| Nov | 0.247 | 0.247 | 0.245 | 0.240 | 0.233 | 0.218 | 0.195 | 0.161 | 0.121 | 0.091 |
| Dec | 0.282 | 0.281 | 0.279 | 0.274 | 0.264 | 0.248 | 0.221 | 0.183 | 0.137 | 0.104 |
| Jan | 0.343 | 0.341 | 0.338 | 0.332 | 0.320 | 0.299 | 0.266 | 0.219 | 0.165 | 0.125 |
| Feb | 0.470 | 0.468 | 0.464 | 0.456 | 0.440 | 0.413 | 0.368 | 0.304 | 0.229 | 0.173 |
| Mar | 0.458 | 0.456 | 0.453 | 0.445 | 0.430 | 0.404 | 0.360 | 0.298 | 0.223 | 0.167 |
| Apr | 0.427 | 0.426 | 0.423 | 0.416 | 0.403 | 0.379 | 0.340 | 0.281 | 0.210 | 0.157 |
| May | 0.350 | 0.350 | 0.347 | 0.342 | 0.332 | 0.314 | 0.282 | 0.233 | 0.174 | 0.129 |
| Jun | 0.329 | 0.328 | 0.326 | 0.322 | 0.313 | 0.295 | 0.265 | 0.220 | 0.163 | 0.121 |
| Jul | 0.290 | 0.290 | 0.289 | 0.285 | 0.278 | 0.263 | 0.237 | 0.197 | 0.146 | 0.107 |
| Aug | 0.262 | 0.262 | 0.260 | 0.256 | 0.249 | 0.235 | 0.212 | 0.175 | 0.131 | 0.096 |
| Sep | 0.244 | 0.244 | 0.242 | 0.238 | 0.232 | 0.218 | 0.196 | 0.163 | 0.121 | 0.090 |

Natural Duration curves

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 0.418 | 0.370 | 0.325 | 0.302 | 0.258 | 0.246 | 0.235 | 0.220 | 0.194 | 0.131 |
| Nov | 0.822 | 0.625 | 0.502 | 0.421 | 0.378 | 0.355 | 0.301 | 0.247 | 0.208 | 0.135 |
| Dec | 1.856 | 1.232 | 0.933 | 0.739 | 0.553 | 0.459 | 0.388 | 0.358 | 0.276 | 0.175 |
| Jan | 3.786 | 2.333 | 1.523 | 0.982 | 0.821 | 0.687 | 0.590 | 0.478 | 0.381 | 0.246 |
| Feb | 7.374 | 3.592 | 2.001 | 1.232 | 1.000 | 0.860 | 0.719 | 0.575 | 0.471 | 0.236 |
| Mar | 4.831 | 2.916 | 2.136 | 1.296 | 0.889 | 0.754 | 0.653 | 0.526 | 0.455 | 0.213 |
| Apr | 2.515 | 1.690 | 0.988 | 0.876 | 0.752 | 0.644 | 0.586 | 0.517 | 0.459 | 0.243 |
| May | 0.889 | 0.777 | 0.694 | 0.624 | 0.556 | 0.515 | 0.463 | 0.444 | 0.377 | 0.202 |
| Jun | 0.667 | 0.602 | 0.556 | 0.521 | 0.455 | 0.440 | 0.394 | 0.370 | 0.324 | 0.193 |
| Jul | 0.523 | 0.467 | 0.437 | 0.414 | 0.388 | 0.358 | 0.336 | 0.306 | 0.280 | 0.179 |
| Aug | 0.455 | 0.411 | 0.370 | 0.351 | 0.336 | 0.302 | 0.284 | 0.269 | 0.235 | 0.153 |
| Sep | 0.409 | 0.374 | 0.340 | 0.313 | 0.289 | 0.270 | 0.251 | 0.243 | 0.208 | 0.143 |

# APPENDIX B8: EWR8 (Sabie)

**Desktop Version 2, Printed on 2008/08/01**

Summary of IFR rule curves for : SB8 Natural Flows

Determination based on defined BBM Table with site specific assurance rules.

Regional Type : E.Escarp ERC = B

Data are given in m^3/s mean monthly flow

% Points

| Month | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 99% |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 0.800 | 0.794 | 0.782 | 0.759 | 0.716 | 0.642 | 0.524 | 0.357 | 0.163 | 0.020 |
| Nov | 1.315 | 1.306 | 1.288 | 1.253 | 1.187 | 1.073 | 0.890 | 0.634 | 0.335 | 0.115 |
| Dec | 1.514 | 1.501 | 1.472 | 1.414 | 1.307 | 1.129 | 0.876 | 0.576 | 0.304 | 0.155 |
| Jan | 2.171 | 2.051 | 1.936 | 1.810 | 1.580 | 1.384 | 1.097 | 0.750 | 0.433 | 0.258 |
| Feb | 7.677 | 6.844 | 6.135 | 4.551 | 3.509 | 3.038 | 2.381 | 2.030 | 1.130 | 0.622 |
| Mar | 2.889 | 2.772 | 2.652 | 2.512 | 2.249 | 1.985 | 1.586 | 1.089 | 0.624 | 0.368 |
| Apr | 1.757 | 1.747 | 1.719 | 1.660 | 1.548 | 1.359 | 1.082 | 0.748 | 0.442 | 0.273 |
| May | 1.280 | 1.270 | 1.248 | 1.202 | 1.118 | 0.979 | 0.781 | 0.546 | 0.333 | 0.217 |
| Jun | 1.190 | 1.181 | 1.159 | 1.116 | 1.034 | 0.901 | 0.710 | 0.483 | 0.278 | 0.166 |
| Jul | 1.044 | 1.037 | 1.023 | 0.996 | 0.946 | 0.858 | 0.718 | 0.521 | 0.292 | 0.123 |
| Aug | 0.934 | 0.927 | 0.914 | 0.889 | 0.842 | 0.759 | 0.629 | 0.444 | 0.230 | 0.072 |
| Sep | 0.865 | 0.859 | 0.847 | 0.823 | 0.777 | 0.699 | 0.573 | 0.397 | 0.192 | 0.041 |

Reserve flows without High Flows

| Month | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 99% |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 0.800 | 0.794 | 0.782 | 0.759 | 0.716 | 0.642 | 0.524 | 0.357 | 0.163 | 0.020 |
| Nov | 0.898 | 0.892 | 0.879 | 0.855 | 0.809 | 0.730 | 0.605 | 0.428 | 0.223 | 0.071 |
| Dec | 1.109 | 1.100 | 1.079 | 1.037 | 0.958 | 0.828 | 0.643 | 0.423 | 0.225 | 0.115 |
| Jan | 1.461 | 1.452 | 1.429 | 1.379 | 1.286 | 1.127 | 0.896 | 0.616 | 0.360 | 0.220 |
| Feb | 2.355 | 2.347 | 2.315 | 2.244 | 2.103 | 1.855 | 1.479 | 1.011 | 0.574 | 0.332 |
| Mar | 2.179 | 2.172 | 2.143 | 2.078 | 1.949 | 1.722 | 1.378 | 0.951 | 0.550 | 0.330 |
| Apr | 1.757 | 1.747 | 1.719 | 1.660 | 1.548 | 1.359 | 1.082 | 0.748 | 0.442 | 0.273 |
| May | 1.280 | 1.270 | 1.248 | 1.202 | 1.118 | 0.979 | 0.781 | 0.546 | 0.333 | 0.217 |
| Jun | 1.190 | 1.181 | 1.159 | 1.116 | 1.034 | 0.901 | 0.710 | 0.483 | 0.278 | 0.166 |
| Jul | 1.044 | 1.037 | 1.023 | 0.996 | 0.946 | 0.858 | 0.718 | 0.521 | 0.292 | 0.123 |
| Aug | 0.934 | 0.927 | 0.914 | 0.889 | 0.842 | 0.759 | 0.629 | 0.444 | 0.230 | 0.072 |
| Sep | 0.865 | 0.859 | 0.847 | 0.823 | 0.777 | 0.699 | 0.573 | 0.397 | 0.192 | 0.041 |

Natural Duration curves

| Month | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 99% |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 1.620 | 1.456 | 1.299 | 1.180 | 1.012 | 0.915 | 0.866 | 0.818 | 0.694 | 0.459 |
| Nov | 3.549 | 2.859 | 1.971 | 1.686 | 1.447 | 1.289 | 1.165 | 0.930 | 0.806 | 0.521 |
| Dec | 10.450 | 5.462 | 3.573 | 2.655 | 2.363 | 1.695 | 1.441 | 1.310 | 0.967 | 0.635 |
| Jan | 18.089 | 9.558 | 5.395 | 3.655 | 3.300 | 2.729 | 2.173 | 1.770 | 1.370 | 0.829 |
| Feb | 38.538 | 16.286 | 9.077 | 4.551 | 3.509 | 3.038 | 2.381 | 2.030 | 1.674 | 0.798 |
| Mar | 26.430 | 10.570 | 7.486 | 4.958 | 2.987 | 2.714 | 2.195 | 1.792 | 1.512 | 0.691 |
| Apr | 9.267 | 5.127 | 3.573 | 2.998 | 2.500 | 2.215 | 1.941 | 1.779 | 1.535 | 0.795 |
| May | 3.177 | 2.815 | 2.520 | 2.184 | 1.923 | 1.729 | 1.602 | 1.497 | 1.262 | 0.683 |
| Jun | 2.442 | 2.230 | 2.091 | 1.806 | 1.663 | 1.505 | 1.381 | 1.292 | 1.111 | 0.648 |
| Jul | 2.046 | 1.807 | 1.676 | 1.520 | 1.404 | 1.296 | 1.180 | 1.079 | 0.978 | 0.609 |
| Aug | 1.759 | 1.557 | 1.411 | 1.333 | 1.213 | 1.113 | 1.045 | 0.960 | 0.833 | 0.538 |
| Sep | 1.601 | 1.489 | 1.350 | 1.223 | 1.115 | 1.026 | 0.941 | 0.876 | 0.772 | 0.494 |

# APPENDIX C

## Approved Reserves in the Komati River catchment

## KOMATI RIVER: RU B, SITE K1

### Table B 3.1. EWR rule table for REC: B/C

Desktop Version 2, Printed on 31/01/2005

Summary of EWR rule curves for : EWR K1 Monthly Nat EWR K1

Determination based on defined BBM Table with site specific assurance rules.

Regional Type : E.Escarp REC = B/C

Data are given in m^3/s mean monthly flow

This EWR rule table can be used in combination with the natural duration curves below for implementation.

| | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 99% |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 0.55 | 0.55 | 0.54 | 0.53 | 0.52 | 0.48 | 0.43 | 0.35 | 0.25 | 0.18 |
| Nov | 0.89 | 0.89 | 0.88 | 0.85 | 0.83 | 0.77 | 0.67 | 0.53 | 0.36 | 0.23 |
| Dec | 1.72 | 1.71 | 1.69 | 1.64 | 1.58 | 1.45 | 1.25 | 0.95 | 0.60 | 0.34 |
| Jan | 3.64 | 3.29 | 3.11 | 2.86 | 2.64 | 2.21 | 1.88 | 1.40 | 0.85 | 0.44 |
| Feb | 10.02 | 8.85 | 7.81 | 6.46 | 4.74 | 4.09 | 3.72 | 3.04 | 1.87 | 0.90 |
| Mar | 1.74 | 1.73 | 1.71 | 1.67 | 1.61 | 1.48 | 1.28 | 0.98 | 0.62 | 0.36 |
| Apr | 1.98 | 1.98 | 1.95 | 1.90 | 1.84 | 1.70 | 1.46 | 1.11 | 0.68 | 0.36 |
| May | 1.27 | 1.27 | 1.26 | 1.24 | 1.19 | 1.11 | 0.96 | 0.74 | 0.47 | 0.27 |
| Jun | 0.84 | 0.84 | 0.83 | 0.82 | 0.79 | 0.74 | 0.65 | 0.52 | 0.35 | 0.23 |
| Jul | 0.74 | 0.74 | 0.73 | 0.72 | 0.70 | 0.66 | 0.59 | 0.47 | 0.32 | 0.21 |
| Aug | 0.47 | 0.47 | 0.47 | 0.46 | 0.45 | 0.43 | 0.38 | 0.32 | 0.24 | 0.18 |
| Sep | 0.63 | 0.63 | 0.63 | 0.62 | 0.60 | 0.56 | 0.50 | 0.40 | 0.28 | 0.19 |

### Natural Duration curves

| | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 99% |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 3.663 | 2.823 | 2.180 | 1.822 | 1.534 | 1.378 | 1.131 | 1.004 | 0.855 | 0.631 |
| Nov | 15.174 | 9.282 | 5.069 | 3.839 | 3.295 | 2.982 | 2.608 | 2.346 | 1.574 | 0.849 |
| Dec | 21.599 | 16.708 | 13.575 | 7.284 | 5.653 | 4.865 | 4.510 | 3.543 | 2.561 | 1.501 |
| Jan | 29.279 | 19.052 | 16.588 | 9.285 | 7.523 | 6.276 | 5.234 | 4.719 | 3.584 | 2.434 |
| Feb | 36.611 | 21.036 | 14.261 | 9.268 | 6.184 | 5.671 | 5.204 | 4.588 | 4.088 | 2.732 |
| Mar | 19.355 | 10.588 | 7.150 | 5.570 | 4.895 | 4.208 | 3.883 | 3.551 | 3.002 | 2.386 |
| Apr | 8.322 | 5.868 | 4.950 | 4.394 | 4.062 | 3.808 | 3.472 | 2.870 | 2.404 | 1.779 |
| May | 5.074 | 4.170 | 3.476 | 3.230 | 2.983 | 2.647 | 2.292 | 2.109 | 1.680 | 1.023 |
| Jun | 3.461 | 3.063 | 2.623 | 2.269 | 2.033 | 1.836 | 1.725 | 1.451 | 1.258 | 0.903 |
| Jul | 2.614 | 1.983 | 1.800 | 1.613 | 1.508 | 1.378 | 1.146 | 1.019 | 0.922 | 0.709 |
| Aug | 2.009 | 1.613 | 1.437 | 1.277 | 1.142 | 1.075 | 0.986 | 0.896 | 0.810 | 0.676 |
| Sep | 1.879 | 1.636 | 1.377 | 1.196 | 1.146 | 1.038 | 0.930 | 0.860 | 0.752 | 0.637 |

## KOMATI RIVER: RU C, SITE K2

### Table B3.2 . EWR rule table for recommended REC: C

Desktop Version 2, Printed on 31/01/2005

Summary of EWR rule curves for : EWR K2 Generic Name

Determination based on defined BBM Table with site specific assurance rules.

Regional Type : E.Escarp REC = C

Data are given in m^3/s mean monthly flow

This EWR rule table can be used in combination with the natural duration curves below for implementation

| | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 99% |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 1.99 | 1.98 | 1.96 | 1.75 | 1.51 | 1.38 | 0.96 | 0.75 | 0.51 | 0.28 |
| Nov | 3.13 | 3.12 | 3.06 | 3.00 | 2.88 | 2.64 | 2.25 | 1.67 | 1.02 | 0.37 |
| Dec | 3.36 | 3.35 | 3.31 | 3.18 | 3.10 | 2.85 | 2.44 | 1.86 | 1.17 | 0.66 |
| Jan | 6.45 | 5.93 | 5.46 | 4.94 | 4.55 | 3.78 | 3.24 | 2.48 | 1.60 | 0.95 |
| Feb | 14.65 | 13.36 | 11.68 | 10.18 | 9.52 | 7.54 | 6.44 | 4.87 | 3.01 | 1.63 |
| Mar | 11.19 | 10.26 | 9.16 | 7.82 | 6.96 | 5.70 | 5.05 | 3.88 | 2.41 | 1.32 |
| Apr | 2.63 | 2.63 | 2.61 | 2.53 | 2.47 | 2.29 | 2.01 | 1.58 | 1.07 | 0.69 |
| May | 2.09 | 2.09 | 2.07 | 2.03 | 1.97 | 1.84 | 1.61 | 1.27 | 0.86 | 0.54 |
| Jun | 1.95 | 1.95 | 1.93 | 1.89 | 1.84 | 1.71 | 1.49 | 1.16 | 0.75 | 0.44 |
| Jul | 1.81 | 1.81 | 1.79 | 1.77 | 1.71 | 1.58 | 1.36 | 1.00 | 0.68 | 0.39 |
| Aug | 1.67 | 1.67 | 1.63 | 1.46 | 1.27 | 1.00 | 0.95 | 0.81 | 0.58 | 0.34 |
| Sep | 1.85 | 1.84 | 1.74 | 1.62 | 1.21 | 0.99 | 0.90 | 0.80 | 0.63 | 0.28 |

### Natural Duration curves

| | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 99% |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 11.499 | 8.766 | 6.463 | 5.462 | 4.831 | 4.320 | 3.622 | 3.248 | 2.830 | 2.158 |
| Nov | 44.826 | 19.687 | 15.069 | 10.829 | 9.753 | 8.816 | 8.021 | 6.470 | 5.243 | 2.766 |
| Dec | 54.099 | 48.073 | 30.724 | 21.229 | 17.425 | 14.602 | 12.784 | 10.786 | 8.083 | 4.346 |
| Jan | 83.102 | 59.633 | 49.683 | 30.249 | 23.156 | 17.174 | 15.464 | 13.833 | 10.588 | 8.009 |
| Feb | 117.026 | 63.951 | 45.606 | 29.183 | 18.395 | 17.324 | 16.055 | 14.120 | 12.430 | 9.057 |
| Mar | 56.649 | 35.036 | 24.037 | 16.383 | 14.796 | 13.404 | 12.168 | 11.078 | 9.394 | 7.975 |
| Apr | 26.339 | 17.187 | 15.444 | 13.777 | 12.905 | 12.118 | 10.818 | 9.263 | 7.940 | 6.227 |
| May | 15.218 | 12.690 | 11.302 | 10.652 | 9.543 | 8.625 | 7.669 | 6.769 | 5.821 | 3.659 |
| Jun | 10.829 | 9.726 | 8.457 | 7.423 | 6.694 | 6.026 | 5.687 | 4.830 | 4.321 | 3.029 |
| Jul | 8.322 | 6.321 | 5.768 | 5.354 | 4.895 | 4.506 | 3.797 | 3.371 | 3.106 | 2.371 |
| Aug | 6.362 | 5.354 | 4.559 | 4.211 | 3.831 | 3.521 | 3.252 | 2.976 | 2.707 | 2.296 |
| Sep | 6.111 | 5.320 | 4.468 | 3.904 | 3.773 | 3.353 | 3.079 | 2.894 | 2.485 | 2.095 |

## KOMATI RIVER: RU D, SITE K3

### Table B3.3. EWR rule table for REC: D

Desktop Version 2, Printed on 28/11/2004

Summary of EWR rule curves for : EWR K3 Monthly Nat EWR K3

Determination based on defined BBM Table with site specific assurance rules.

Regional Type : E.Escarp REC = D

Data are given in m^3/s mean monthly flow

This EWR rule table can be used in combination with the natural duration curves below for implementation.

| | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 99% |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 3.84 | 3.69 | 3.62 | 3.59 | 3.54 | 3.41 | 2.81 | 2.14 | 1.18 | 0.50 |
| Nov | 4.92 | 3.77 | 3.74 | 3.64 | 3.53 | 3.20 | 2.87 | 2.34 | 1.42 | 0.53 |
| Dec | 6.43 | 5.29 | 4.77 | 4.18 | 4.15 | 4.06 | 3.55 | 2.55 | 1.44 | 0.74 |
| Jan | 12.02 | 7.24 | 6.14 | 5.31 | 5.14 | 5.07 | 4.43 | 2.98 | 2.01 | 0.71 |
| Feb | 13.84 | 12.65 | 6.06 | 5.84 | 5.60 | 5.08 | 4.83 | 3.35 | 2.28 | 1.34 |
| Mar | 34.99 | 27.78 | 5.76 | 5.68 | 5.41 | 5.22 | 4.84 | 4.07 | 3.02 | 1.33 |
| Apr | 6.18 | 5.37 | 5.33 | 5.24 | 5.04 | 4.68 | 4.12 | 2.55 | 1.79 | 0.82 |
| May | 4.87 | 4.85 | 4.78 | 4.69 | 4.51 | 3.84 | 3.32 | 2.34 | 1.47 | 0.65 |
| Jun | 4.38 | 4.37 | 4.30 | 4.20 | 4.04 | 3.55 | 2.92 | 2.03 | 1.37 | 0.59 |
| Jul | 3.88 | 3.87 | 3.82 | 3.72 | 3.56 | 3.36 | 2.79 | 1.73 | 1.22 | 0.50 |
| Aug | 3.72 | 3.71 | 3.65 | 3.56 | 3.40 | 3.10 | 2.44 | 1.99 | 1.07 | 0.45 |
| Sep | 3.64 | 3.64 | 3.60 | 3.54 | 3.43 | 3.20 | 2.77 | 2.33 | 1.18 | 0.43 |

**Natural Duration curves**

| | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 99% |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 22.435 | 17.992 | 13.430 | 11.264 | 10.140 | 8.643 | 7.941 | 7.269 | 6.261 | 4.954 |
| Nov | 59.313 | 39.063 | 29.444 | 23.677 | 19.564 | 17.940 | 16.574 | 14.788 | 9.306 | 6.327 |
| Dec | 86.526 | 69.598 | 57.400 | 40.961 | 33.942 | 29.204 | 25.258 | 21.244 | 16.805 | 7.228 |
| Jan | 132.098 | 92.047 | 73.723 | 60.357 | 46.924 | 35.850 | 31.829 | 27.225 | 22.555 | 18.399 |
| Feb | 246.532 | 134.970 | 76.120 | 55.915 | 44.267 | 34.487 | 31.130 | 26.939 | 23.822 | 19.610 |
| Mar | 129.600 | 71.024 | 52.737 | 39.397 | 31.892 | 29.794 | 26.449 | 22.185 | 17.955 | 15.252 |
| Apr | 60.544 | 38.873 | 32.971 | 29.672 | 27.832 | 25.829 | 23.681 | 19.267 | 15.694 | 12.018 |
| May | 29.686 | 24.854 | 22.390 | 21.050 | 20.288 | 18.160 | 16.566 | 14.303 | 12.593 | 8.695 |
| Jun | 23.472 | 19.583 | 16.682 | 15.961 | 15.251 | 13.978 | 12.647 | 11.134 | 9.468 | 6.501 |
| Jul | 18.705 | 14.755 | 13.381 | 11.884 | 11.126 | 10.559 | 9.468 | 8.580 | 7.389 | 5.190 |
| Aug | 14.397 | 12.254 | 10.977 | 9.845 | 9.353 | 8.531 | 7.796 | 7.247 | 6.470 | 4.887 |
| Sep | 15.448 | 11.335 | 9.857 | 9.182 | 8.850 | 7.982 | 7.438 | 6.686 | 5.826 | 5.150 |

## GLADDESPRUIT RIVER: RU G, SITE G1

### Table B3.4. EWR rule table for REC: D.

Desktop Version 2, Printed on 31/01/2005

Summary of EWR rule curves for : EWR G1 Generic Name

Determination based on defined BBM Table with site specific assurance rules.

Regional Type : E.Escarp REC = D

Data are given in m^3/s mean monthly flow

This EWR rule table can be used in combination with the natural duration curves below for

implementation.

| | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 99% |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 0.22 | 0.22 | 0.22 | 0.21 | 0.2 | 0.19 | 0.17 | 0.14 | 0.1 | 0.07 |
| Nov | 0.31 | 0.31 | 0.3 | 0.3 | 0.29 | 0.27 | 0.23 | 0.18 | 0.12 | 0.08 |
| Dec | 0.36 | 0.36 | 0.35 | 0.34 | 0.33 | 0.3 | 0.26 | 0.21 | 0.14 | 0.09 |
| Jan | 0.57 | 0.53 | 0.51 | 0.48 | 0.45 | 0.39 | 0.34 | 0.26 | 0.17 | 0.11 |
| Feb | 1.46 | 1.33 | 1.2 | 1.06 | 0.99 | 0.81 | 0.69 | 0.52 | 0.32 | 0.17 |
| Mar | 0.38 | 0.38 | 0.37 | 0.36 | 0.35 | 0.33 | 0.28 | 0.22 | 0.15 | 0.09 |
| Apr | 0.39 | 0.39 | 0.38 | 0.37 | 0.36 | 0.34 | 0.29 | 0.23 | 0.15 | 0.09 |
| May | 0.32 | 0.32 | 0.32 | 0.31 | 0.3 | 0.28 | 0.25 | 0.19 | 0.13 | 0.08 |
| Jun | 0.29 | 0.28 | 0.28 | 0.28 | 0.27 | 0.25 | 0.22 | 0.18 | 0.12 | 0.08 |
| Jul | 0.24 | 0.24 | 0.24 | 0.23 | 0.23 | 0.21 | 0.19 | 0.16 | 0.11 | 0.07 |
| Aug | 0.22 | 0.22 | 0.22 | 0.21 | 0.21 | 0.2 | 0.17 | 0.14 | 0.1 | 0.07 |
| Sep | 0.25 | 0.25 | 0.23 | 0.21 | 0.2 | 0.18 | 0.17 | 0.15 | 0.11 | 0.07 |

**Natural Duration curves**

| | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 99% |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 0.762 | 0.560 | 0.474 | 0.396 | 0.355 | 0.291 | 0.269 | 0.239 | 0.202 | 0.168 |
| Nov | 2.735 | 1.308 | 0.868 | 0.768 | 0.718 | 0.625 | 0.567 | 0.463 | 0.382 | 0.212 |
| Dec | 3.887 | 3.412 | 2.479 | 1.456 | 1.262 | 1.027 | 0.833 | 0.784 | 0.586 | 0.310 |
| Jan | 6.366 | 4.264 | 3.539 | 2.326 | 1.699 | 1.232 | 1.086 | 0.844 | 0.765 | 0.594 |
| Feb | 8.647 | 4.592 | 3.476 | 2.025 | 1.397 | 1.257 | 1.124 | 1.004 | 0.831 | 0.508 |
| Mar | 4.387 | 2.744 | 1.785 | 1.232 | 1.094 | 0.974 | 0.885 | 0.840 | 0.668 | 0.437 |
| Apr | 2.025 | 1.208 | 1.157 | 1.030 | 0.957 | 0.876 | 0.802 | 0.702 | 0.602 | 0.343 |
| May | 1.045 | 0.892 | 0.825 | 0.769 | 0.698 | 0.605 | 0.553 | 0.508 | 0.441 | 0.273 |
| Jun | 0.806 | 0.710 | 0.598 | 0.559 | 0.509 | 0.444 | 0.405 | 0.351 | 0.309 | 0.204 |
| Jul | 0.624 | 0.467 | 0.426 | 0.392 | 0.370 | 0.343 | 0.287 | 0.258 | 0.220 | 0.149 |
| Aug | 0.482 | 0.399 | 0.340 | 0.302 | 0.287 | 0.265 | 0.235 | 0.228 | 0.194 | 0.146 |
| Sep | 0.463 | 0.374 | 0.316 | 0.293 | 0.274 | 0.247 | 0.224 | 0.204 | 0.177 | 0.158 |

## TEESPRUIT RIVER, RU T, SITE T1

### Table B3.5: EWR rule table for REC: C

Desktop Version 2, Printed on 06/12/2004

Summary of EWR rule curves for : EWR T1 Monthly Nat EWR T1

Determination based on defined BBM Table with site specific assurance rules.

Regional Type : E.Escarp REC = C

Data are given in m^3/s mean monthly flow

This EWR rule table can be used in combination with the natural duration curves below for implementation.

| | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 99% |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 0.42 | 0.42 | 0.42 | 0.41 | 0.40 | 0.37 | 0.32 | 0.26 | 0.18 | 0.12 |
| Nov | 0.68 | 0.68 | 0.67 | 0.66 | 0.64 | 0.59 | 0.51 | 0.40 | 0.27 | 0.17 |
| Dec | 0.79 | 0.79 | 0.78 | 0.76 | 0.74 | 0.68 | 0.59 | 0.46 | 0.31 | 0.20 |
| Jan | 1.75 | 1.60 | 1.48 | 1.33 | 1.24 | 1.03 | 0.89 | 0.69 | 0.45 | 0.28 |
| Feb | 5.51 | 4.92 | 3.80 | 2.19 | 1.84 | 1.71 | 1.56 | 1.37 | 1.07 | 0.57 |
| Mar | 0.70 | 0.69 | 0.69 | 0.67 | 0.65 | 0.61 | 0.54 | 0.44 | 0.32 | 0.23 |
| Apr | 0.73 | 0.72 | 0.72 | 0.70 | 0.68 | 0.64 | 0.56 | 0.45 | 0.32 | 0.22 |
| May | 0.56 | 0.56 | 0.55 | 0.54 | 0.53 | 0.50 | 0.44 | 0.36 | 0.26 | 0.18 |
| Jun | 0.49 | 0.49 | 0.48 | 0.48 | 0.46 | 0.44 | 0.39 | 0.32 | 0.23 | 0.16 |
| Jul | 0.39 | 0.39 | 0.39 | 0.38 | 0.37 | 0.35 | 0.31 | 0.26 | 0.18 | 0.13 |
| Aug | 0.34 | 0.33 | 0.33 | 0.32 | 0.32 | 0.30 | 0.27 | 0.22 | 0.16 | 0.12 |
| Sep | 0.41 | 0.41 | 0.40 | 0.39 | 0.38 | 0.36 | 0.32 | 0.25 | 0.18 | 0.12 |

**Natural Duration curves**

| | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 99% |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 1.221 | 0.978 | 0.762 | 0.653 | 0.582 | 0.478 | 0.444 | 0.392 | 0.336 | 0.265 |
| Nov | 4.379 | 2.064 | 1.566 | 1.254 | 1.150 | 1.003 | 0.938 | 0.795 | 0.613 | 0.340 |
| Dec | 6.078 | 4.954 | 3.405 | 2.292 | 1.781 | 1.632 | 1.404 | 1.269 | 0.952 | 0.497 |
| Jan | 9.648 | 6.825 | 5.414 | 3.592 | 2.714 | 1.975 | 1.800 | 1.635 | 1.232 | 0.952 |
| Feb | 13.835 | 7.350 | 5.564 | 3.245 | 2.125 | 2.013 | 1.823 | 1.666 | 1.447 | 1.124 |
| Mar | 6.116 | 4.391 | 2.852 | 1.934 | 1.729 | 1.557 | 1.415 | 1.344 | 1.098 | 0.963 |
| Apr | 3.241 | 1.933 | 1.813 | 1.644 | 1.543 | 1.474 | 1.285 | 1.123 | 0.965 | 0.745 |
| May | 1.755 | 1.542 | 1.340 | 1.273 | 1.154 | 1.023 | 0.915 | 0.814 | 0.717 | 0.478 |
| Jun | 1.319 | 1.154 | 1.019 | 0.899 | 0.814 | 0.725 | 0.667 | 0.598 | 0.536 | 0.378 |
| Jul | 0.997 | 0.777 | 0.706 | 0.653 | 0.601 | 0.556 | 0.459 | 0.429 | 0.392 | 0.299 |
| Aug | 0.773 | 0.661 | 0.553 | 0.515 | 0.467 | 0.426 | 0.399 | 0.362 | 0.336 | 0.284 |
| Sep | 0.752 | 0.644 | 0.521 | 0.471 | 0.455 | 0.417 | 0.378 | 0.355 | 0.313 | 0.255 |

## LOMATI RIVER, RU M, SITE L1

### Table B3.6. EWR rule table for REC: C/D

Desktop Version 2, Printed on 31/01/2005

Summary of EWR rule curves for : EWR L1 Monthly Nat EWR L1

Determination based on defined BBM Table with site specific assurance rules.

Regional Type : E.Escarp REC = C/D

Data are given in m^3/s mean monthly flow

This EWR rule table can be used in combination with the natural duration curves below for

implementation.

| | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 99% |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 0.54 | 0.54 | 0.54 | 0.53 | 0.51 | 0.48 | 0.44 | 0.36 | 0.27 | 0.21 |
| Nov | 1.05 | 1.05 | 1.03 | 1.01 | 0.97 | 0.89 | 0.80 | 0.63 | 0.43 | 0.28 |
| Dec | 1.29 | 1.28 | 1.27 | 1.23 | 1.20 | 1.11 | 0.97 | 0.76 | 0.53 | 0.35 |
| Jan | 2.34 | 2.20 | 2.03 | 1.91 | 1.78 | 1.53 | 1.32 | 1.00 | 0.67 | 0.41 |
| Feb | 3.12 | 2.97 | 2.73 | 2.59 | 2.32 | 2.08 | 1.82 | 1.42 | 0.90 | 0.52 |
| Mar | 5.08 | 4.76 | 4.15 | 3.55 | 3.04 | 2.75 | 2.36 | 1.95 | 1.20 | 0.63 |
| Apr | 1.56 | 1.56 | 1.54 | 1.51 | 1.46 | 1.36 | 1.18 | 0.93 | 0.62 | 0.39 |
| May | 1.31 | 1.31 | 1.30 | 1.28 | 1.24 | 1.15 | 1.01 | 0.80 | 0.54 | 0.34 |
| Jun | 1.12 | 1.11 | 1.11 | 1.09 | 1.06 | 0.99 | 0.87 | 0.70 | 0.48 | 0.31 |
| Jul | 0.82 | 0.82 | 0.82 | 0.81 | 0.78 | 0.74 | 0.66 | 0.54 | 0.38 | 0.27 |
| Aug | 0.60 | 0.60 | 0.59 | 0.59 | 0.57 | 0.54 | 0.49 | 0.41 | 0.31 | 0.23 |
| Sep | 0.68 | 0.67 | 0.67 | 0.66 | 0.64 | 0.60 | 0.54 | 0.44 | 0.32 | 0.23 |

**Natural Duration curves**

| | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 99% |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 7.217 | 5.276 | 4.529 | 3.573 | 3.300 | 3.073 | 2.740 | 2.457 | 2.244 | 1.941 |
| Nov | 14.900 | 11.497 | 8.985 | 7.419 | 6.235 | 5.000 | 4.441 | 3.526 | 2.967 | 2.056 |
| Dec | 24.313 | 18.436 | 14.053 | 11.932 | 10.013 | 8.707 | 7.542 | 5.996 | 4.559 | 2.561 |
| Jan | 37.563 | 26.225 | 18.067 | 15.401 | 13.004 | 10.842 | 9.349 | 8.408 | 6.392 | 3.547 |
| Feb | 68.477 | 38.389 | 23.103 | 16.700 | 13.174 | 11.020 | 9.950 | 8.213 | 7.081 | 4.696 |
| Mar | 42.413 | 28.286 | 16.850 | 14.953 | 11.063 | 9.595 | 8.218 | 7.587 | 5.974 | 3.771 |
| Apr | 19.128 | 15.448 | 12.542 | 10.829 | 9.340 | 8.657 | 7.596 | 6.860 | 5.058 | 3.326 |
| May | 10.443 | 8.225 | 7.538 | 7.198 | 6.948 | 6.481 | 5.746 | 5.029 | 4.066 | 2.475 |
| Jun | 8.117 | 6.759 | 6.096 | 5.876 | 5.382 | 5.177 | 4.853 | 4.120 | 3.472 | 2.114 |
| Jul | 6.026 | 5.119 | 4.869 | 4.566 | 4.275 | 4.085 | 3.681 | 3.136 | 2.733 | 1.803 |
| Aug | 5.037 | 4.506 | 4.002 | 3.749 | 3.663 | 3.353 | 3.084 | 2.737 | 2.393 | 1.773 |
| Sep | 4.815 | 4.101 | 3.731 | 3.414 | 3.167 | 3.052 | 2.685 | 2.527 | 2.218 | 1.624 |

## KOMATI RIVER IN SWAZILAND: RU MAGUGA, SITE M1

### Table B3.7. EWR rule table for REC: C

Desktop Version 2, Printed on 01/02/2005

Summary of EWR rule curves for : EWR M1 Generic Name

Determination based on defined BBM Table with site specific assurance rules.

Regional Type : E.Escarp REC = C

Data are given in m^3/s mean monthly flow

This EWR rule table can be used in combination with the natural duration curves below for implementation.

| | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 99% |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 5.53 | 5.48 | 5.39 | 5.18 | 4.82 | 4.21 | 3.71 | 2.99 | 2.08 | 1.44 |
| Nov | 10.29 | 9.83 | 8.93 | 7.52 | 6.06 | 5.57 | 4.39 | 3.98 | 3.34 | 2.05 |
| Dec | 10.18 | 9.97 | 9.60 | 9.05 | 8.58 | 7.65 | 6.50 | 5.58 | 4.38 | 2.67 |
| Jan | 13.13 | 12.33 | 11.13 | 9.90 | 9.28 | 8.43 | 7.48 | 5.96 | 4.59 | 3.44 |
| Feb | 27.53 | 25.27 | 18.02 | 15.26 | 13.29 | 11.22 | 9.73 | 7.72 | 6.78 | 4.75 |
| Mar | 14.31 | 13.43 | 12.32 | 10.76 | 9.37 | 8.18 | 7.41 | 6.54 | 5.20 | 3.73 |
| Apr | 9.45 | 9.40 | 9.26 | 8.60 | 8.36 | 7.48 | 6.77 | 5.84 | 4.33 | 3.20 |
| May | 8.08 | 8.05 | 7.90 | 7.71 | 7.36 | 6.63 | 5.90 | 4.95 | 3.75 | 2.64 |
| Jun | 7.25 | 7.23 | 7.12 | 6.83 | 6.44 | 5.94 | 4.84 | 4.37 | 3.35 | 2.33 |
| Jul | 6.27 | 6.24 | 6.17 | 5.95 | 5.62 | 4.90 | 4.38 | 3.85 | 2.85 | 1.89 |
| Aug | 5.57 | 5.55 | 5.49 | 5.33 | 4.98 | 4.50 | 3.95 | 3.44 | 2.43 | 1.54 |
| Sep | 5.55 | 5.53 | 5.45 | 5.25 | 4.95 | 4.29 | 3.75 | 3.24 | 2.10 | 1.34 |

**Natural Duration curves**

| | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 99% |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct | 18.884 | 15.379 | 11.193 | 10.002 | 8.822 | 7.616 | 6.806 | 6.261 | 5.395 | 4.219 |
| Nov | 54.414 | 32.377 | 24.190 | 19.541 | 16.755 | 15.193 | 13.611 | 12.388 | 8.144 | 5.421 |
| Dec | 74.485 | 60.372 | 51.643 | 35.667 | 29.040 | 24.194 | 20.755 | 18.851 | 14.434 | 6.549 |
| Jan | 112.003 | 80.070 | 63.885 | 51.867 | 37.549 | 31.235 | 27.012 | 23.488 | 18.298 | 15.177 |
| Feb | 192.717 | 108.565 | 65.348 | 48.950 | 38.496 | 29.353 | 25.686 | 23.458 | 20.230 | 16.328 |
| Mar | 107.344 | 57.687 | 41.211 | 32.415 | 26.400 | 24.619 | 22.092 | 19.243 | 16.136 | 13.232 |
| Apr | 47.955 | 31.011 | 27.928 | 24.850 | 23.391 | 21.863 | 20.096 | 17.203 | 13.696 | 10.853 |
| May | 24.630 | 21.005 | 19.579 | 18.209 | 17.342 | 15.744 | 13.949 | 12.179 | 11.115 | 7.616 |
| Jun | 20.096 | 17.014 | 14.433 | 13.723 | 13.175 | 11.964 | 10.922 | 9.167 | 8.468 | 5.706 |
| Jul | 14.848 | 12.743 | 11.320 | 10.181 | 9.427 | 8.927 | 8.236 | 7.288 | 6.440 | 4.477 |
| Aug | 12.089 | 10.529 | 9.554 | 8.259 | 7.803 | 7.213 | 6.709 | 6.201 | 5.556 | 4.219 |
| Sep | 12.836 | 9.838 | 8.245 | 7.832 | 7.523 | 6.782 | 6.335 | 5.895 | 5.042 | 4.464 |

# APPENDIX D

## Extrapolated Reserves in the Komati River catchment

| Hydro Node | MAR | | EWR | % MAR |
|---|---|---|---|---|
| | Incremetal | Cumulative | | |
| | million m3/a | million m3/a | million m3/a | |
| NodeX11A1 | 15.21 | 25.80 | 8.99 | 34.9 |
| NodeX11B1 | 9.42 | 15.70 | 4.10 | 26.1 |
| NodeX11B2 | 7.06 | 29.20 | 8.16 | 27.9 |
| NodeX11C1 | 5.43 | 9.00 | 3.60 | 40.0 |
| NooitgedachtDam | 0.00 | 64.00 | 14.19 | 22.2 |
| NodeX11D1 | 11.63 | 22.40 | 7.32 | 32.7 |
| NodeX11D2 | 4.14 | 70.90 | 15.67 | 22.1 |
| Node | 12.90 | 114.80 | 25.42 | 22.1 |
| EWRX11E1 | 9.22 | 15.40 | 6.47 | 42.0 |
| NodeX11E2 | 7.26 | 137.40 | 35.03 | 25.5 |
| NodeX11G1 | 31.48 | 213.00 | 46.81 | 22.0 |
| VygeboomDam | 36.16 | 273.20 | 60.49 | 22.1 |
| NodeX11J1 | 51.48 | 55.40 | 9.58 | 17.3 |
| NodeX11K1 | 5.95 | 15.30 | 5.99 | 39.1 |
| NodeX11K2 | 7.39 | 80.50 | 31.10 | 38.6 |
| NodeX11K3 | 7.81 | 281.80 | 64.20 | 22.8 |
| NodeX11K4 | 4.04 | 368.60 | 84.06 | 22.8 |
| EWRX12B1 | 21.09 | 27.90 | 7.25 | 26.0 |
| NodeX12A1 | 4.54 | 32.40 | 9.41 | 29.0 |
| NodeX12B1 | 16.17 | 22.10 | 7.26 | 32.8 |
| NodeX12C1 | 6.47 | 6.50 | 3.84 | 59.1 |
| NodeX12C2 | 18.41 | 83.20 | 32.26 | 38.8 |
| NodeX12D1 | 6.63 | 12.10 | 5.17 | 42.7 |
| NodeX12D2 | 4.23 | 100.50 | 38.85 | 38.7 |
| NodeX12E1 | 27.85 | 32.00 | 10.39 | 32.5 |
| NodeX12F1 | 10.66 | 12.00 | 5.28 | 44.0 |
| NodeX12F2 | 4.23 | 5.30 | 3.05 | 57.5 |
| NodeX12F3 | 6.39 | 57.30 | 34.40 | 60.0 |
| EWRX12G1 | 7.68 | 9.90 | 6.91 | 69.7 |
| NodeX12G2 | 0.53 | 5.30 | 2.86 | 54.0 |
| NodeX12G3 | 4.58 | 481.10 | 113.68 | 23.6 |
| NodeX12H1 | 8.77 | 11.00 | 5.18 | 47.1 |
| EWRX12H2 | 7.74 | 10.50 | 5.78 | 55.0 |
| NodeX12H2 | 3.32 | 13.80 | 5.78 | 41.9 |
| NodeX12H3 | 3.16 | 567.10 | 93.34 | 16.5 |
| NodeX12J1 | 27.77 | 34.70 | 13.21 | 38.1 |
| NodeX12J2 | 13.42 | 16.80 | 7.52 | 44.7 |
| NodeX12J3 | 8.95 | 62.70 | 29.38 | 46.9 |
| NodeX12K1 | 2.62 | 26.20 | 7.32 | 28.0 |
| NodeX12K2 | 3.08 | 597.10 | 113.42 | 19.0 |
| NodeX13A1 | 51.54 | 719.10 | 195.57 | 27.2 |
| Magugu | 4.97 | 753.20 | 235.10 | 31.2 |
| NodeX13B2 | 13.23 | 770.10 | 240.44 | 31.2 |
| NodeX13C1 | 56.82 | 56.80 | 15.45 | 27.2 |
| NodeX13D1 | 39.89 | 866.80 | 225.67 | 26.0 |
| NodeX13E1 | 38.28 | 905.10 | 282.72 | 31.2 |
| NodeX13F1 | 27.87 | 31.80 | 8.27 | 26.0 |

| | | | | |
|---|---|---|---|---|
| NodeX13F2 | 3.53 | 908.60 | 189.42 | 20.8 |
| NodeX13G1 | 4.72 | 945.10 | 197.13 | 20.9 |
| NodeX13G2 | 17.13 | 19.70 | 4.27 | 21.7 |
| NodeX13G3 | 1.87 | 947.00 | 197.13 | 20.8 |
| NodeX13H1 | 4.64 | 5.20 | 1.85 | 35.5 |
| NodeX13H2 | 8.03 | 982.40 | 205.29 | 20.9 |
| NodeX13J1 | 2.50 | 2.80 | 0.74 | 26.6 |
| NodeX13J2 | 3.52 | 6.40 | 1.40 | 21.8 |
| NodeX13J3 | 13.79 | 1000.80 | 143.18 | 14.3 |
| NodeX13J4 | 0.65 | 1007.90 | 173.26 | 17.2 |
| NodeX14B1 | 13.25 | 13.20 | 7.40 | 56.0 |
| Shiyalongube | 9.32 | 22.60 | 7.36 | 32.6 |
| NodeX14B2 | 37.29 | 104.50 | 23.85 | 22.8 |
| NodeX14C1 | 33.40 | 41.80 | 10.75 | 25.7 |
| NodeX14D1 | 16.08 | 120.60 | 27.56 | 22.9 |
| NodeX14D2 | 16.40 | 178.70 | 41.00 | 22.9 |
| NodeX14E1 | 22.98 | 202.90 | 51.08 | 25.2 |
| NodeX14F1 | 37.89 | 37.90 | 9.65 | 25.4 |
| Driekoppies | 1.15 | 214.40 | 24.80 | 11.6 |
| NodeX14G1 | 4.99 | 259.50 | 25.76 | 9.9 |
| NodeX14G3 | 0.94 | 260.60 | 38.98 | 15.0 |
| NodeX14H1 | 11.88 | 281.40 | 42.31 | 15.0 |

DEPARTMENT OF WATER AFFAIRS & FORESTRY

# INKOMATI WATER AVAILABILITY ASSESSMENT

## WATER QUALITY SITUATION



Report No. PWMA 05/X22/00/1108

June 2009

Water for Africa
Environmental, Engineering & Management Consultants (Pty) Ltd

WfA

CPH2O

SRK Consulting
Engineers and Scientists

| | |
|---|---|
| **PROJECT NAME:** | INKOMATI WATER AVAILABILITY ASSESSMENT |
| **REPORT TITLE:** | Water Quality Situation |
| **AUTHORS:** | T Coleman |
| | R Heath |
| **REPORT STATUS:** | FINAL |
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**SJL Mallory** (Date)

Project Leader

**DEPARTMENT OF WATER AFFAIRS AND FORESTRY**

Directorate of Water resource Planning Systems

Approved for Department of Water Affairs and Forestry by:

22/10/2009 29/10/2009

N J van Wyk (Date) J A van Rooyen (Date)

Chief Engineer: Water Resource Planning (East) Director: Water Resource Planning

## SCHEDULE OF REPORTS

| | | |
|---|---|---|
| | PWMA 05/X22/00/0808 | Main Report |
| | PWMA 05/X22/00/0908 | Water Requirements Volume 1<br>Water Requirements Volume 2: Assessment of Alien Vegetation |
| | PWMA 05/X22/00/1008 | Ecological Water Requirements |
| **This Report** ☞ | PWMA 05/X22/00/1108 | Water Quality |
| | PWMA 05/X22/00/1208 | Infrastructure and Operating Rules Volume 1<br>Infrastructure and Operating Rules Volume 2: Appendices |
| | PWMA 05/X22/00/1308 | Rainfall Volume !: Report<br>Rainfall Volume 2: Appendices |
| | PWMA 05/X22/00/1408 | Hydrology of Komati River Volume 1<br>Hydrology of Komati River Volume 2: Appendices |
| | PWMA 05/X22/00/1508 | Hydrology of Crocodile River Volume 1<br>Hydrology of Crocodile River Volume 2 Appendices |
| | PWMA 05/X22/00/1608 | Hydrology of Sabie River Volume 1<br>Hydrology of Sabie River Volume 2 Appendices |
| | PWMA 05/X22/00/1708 | Yield Modelling Volume 1<br>Yield Modelling Volume 2: Appendices |

# EXECUTIVE SUMMARY

*This report is intended to provide an overview of the water quality status of the water resources of the major river catchments in the Inkomati Water Management Area (WMA) (X drainage region). It forms part of a Department of Water Affairs and Forestry study on the Water Availability Assessment of the WMA. The information derived from the status assessment will provide a water quality perspective to the development of a water allocation plan for the WMA.*

*Currently the major stresses facing the WMA are the high water demands by Eskom, irrigation, afforestation and industry and rapidly increasing domestic water demands. The water shortages experienced in the area have led to intense competition for the available water resources among user sectors. In addition, a substantial portion of the population in the WMA does not have access to basic level of services. Furthermore the large number of dams in the study area not only changes the flow regime but also impacts the water quality.*

*The National Water Resources Planning Directorate of DWAF thus identified the need for this study to address effective water resource planning and allocation in the WMA. The water quality assessment was initiated as a sub-task in support of the larger study.*

*The study area for the assessment comprised the X drainage area, which includes the Komati, Crocodile and Sabie River catchments. Key monitoring points were identified for each river system based on the availability of reliable data sets. The points selected were located on the main stem of the rivers and on the major tributaries. The assessment was limited to historical water quality data obtained from the Department of Water Affairs and Forestry. A large number of water quality variables were found to be monitored in these catchments. However, the data used for the analysis has different time scales, different sampling frequencies, different laboratories and different analytical methods used.*

*The lack of an integrated holistic monitoring programme for the different water resources has made the identification of water quality trends difficult. Taking these limitations into account, the data obtained has been used to determine the water quality status and to correlate these with activities in the area. Water quality was assessed based on the trends identified and on the basis of compliance to selected water quality guidelines in terms of the South African Water Quality Guidelines (SAWQGs).*

*The results of the assessment are presented in a series of graphs (box and whisker plots).*

*The water quality of the Inkomati WMA appears to be in a good to fair condition. The main water quality issues are related to nutrients and in certain catchments elevated salt levels. These issues are related mainly to the land based activities such as urbanisation, industrial activity and agricultural activity such as intensive irrigation. The control of these sources will contribute to maintaining the quality at current day levels and prevent any further deterioration.*

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# 1 INTRODUCTION

## 1.1 Background

The water resources of the Inkomati Water Management Area (WMA) are an important asset to the country and its people, supporting major economic activities and eco-tourism. The Inkomati WMA in **Figure 1** is situated in the north-eastern part of South Africa within the Mpumalanga province and borders on Mozambique and Swaziland. Its main rivers include the Sabie, Crocodile and Komati Rivers. The Komati River first flows into Swaziland and re-enters South Africa before flowing into Mozambique to form the Inkomati River in Mozambique. The WMA comprises the primary drainage region X within the water management drainage regions of South Africa.

Currently the major stresses facing the WMA are the high water demands for Eskom, irrigation, afforestation and industry and rapidly increasing domestic water demands. The water shortages experienced in the area have led to competition for the available water resources among user sectors. A substantial portion of the population in the catchment does not have access to a basic level of services and a number of planned expansions to water uses have been put on hold. Furthermore the major dams in the study area change the flow regime and impact on the water quality. Having water of the right quality is just as important as having enough water. It is therefore vital that the water resources of this WMA are managed in an integrated manner to achieve a balance between meeting water demands (quality and quantity) and what is available.

To achieve the above, a holistic assessment is required in order to inform development planning that will ensure a balance between environmental sustainability and different forms of developmental initiatives. According to the National Water Resource Strategy, the central objective of managing water resources is to ensure that water is used to support equitable social and economic transformation and development. Key to this is also balancing the need for sustainability. The overarching Inkomai Water Availability Study (WAS) aims to achieve these objectives in terms of planning for the needs of water users without comprising the quality of the water resources and aquatic biota. This study forms a component of the WAS and describes the current situation in the Inkomati WMA with respect to water quality and related issues. This information aims to provide a water quality perspective to the development of a water allocation plan for the Inkomati WMA.

## 1.2 Description of the Study Area

The Inkomati WMA is one of nineteen WMAs in the country. It is situated in the Mpumalanga Province, in the north-eastern part of South Africa and borders on Mozambique and Swaziland. Population in the WMA is estimated at 1 462 000 people, of which 64% is estimated to be urban and semi-urban. It covers an area of 28 757 $km^2$. Important urban centres are Nelspruit, White River, Komatipoort, Carolina, Badplaas, Barberton, Sabie, Bushbuckridge, Kanyamazane and Matsulu. The WMA borders with Mozambique on the east and Swaziland on the south east. In the south, it also borders on the Usuthu to Umhlatuze WMA and Upper Vaal WMAs.

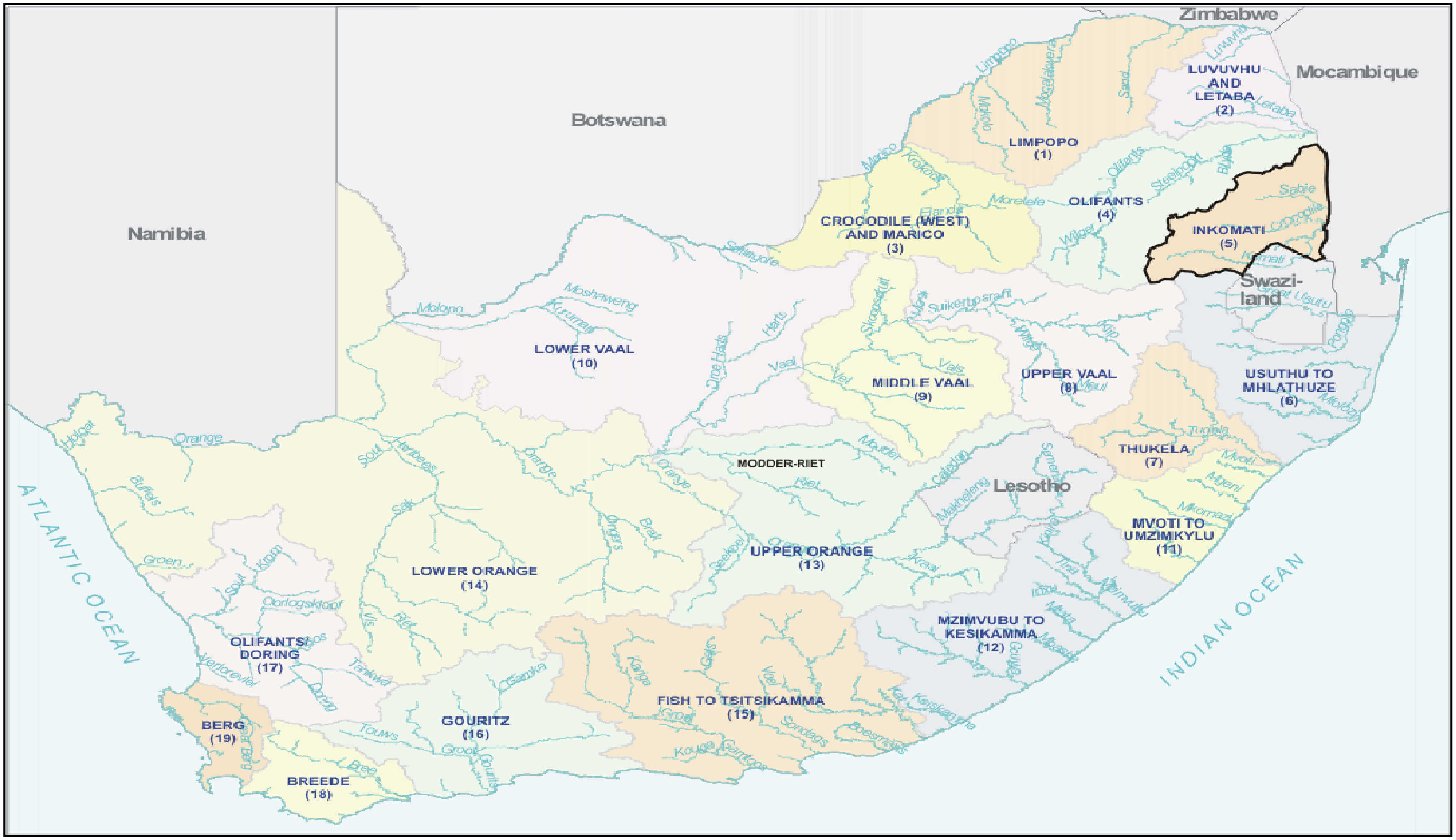



**Figure 1: Location of the Inkomati WMA (WMA 5) within South Africa**

The whole of the eastern and north eastern boundary of the WMA borders on the Olifants WMA. The famous eco-tourism haven, the Kruger National Park occupies almost 35% of the WMA.

The mean annual runoff (MAR) from the entire WMA is estimated at 3 022 million $m^3$/annum (DWAF, 2003). This excludes the MAR from Swaziland (517 million $m^3$/annum), which is not part of the WMA, although it is part of the catchment.

From a water resources management point of view the WMA includes three major catchments, *viz.* the Sabie, Crocodile and Komati catchments that are shown in **Figure 2**.

### 1.2.1 Komati River catchment

The Komati River falls within the X1 drainage region of South Africa has a catchment area of about 11 200 $km^2$. The river is bordered by towns such as Carolina, Eerstehoek, Machadodorp, Waterval Boven, Ekulindeni, Mbojane, Barberton, Emangweni, Sibayeni and Komatipoort. The river is a shared watercourse, and crosses the South African border into Swaziland, and back into South Africa, to the north of Swaziland, and eventually flows into Mozambique. The major water requirements in the catchment are power generation demands in the Olifants WMA met by water transferred from the Komati, irrigation, afforestation, industrial activities and an increasing domestic water demand (**AfriDev, 2006**).

The Komati River catchment consists of three sections: Komati West or upper Komati, which comprises the area upstream of Swaziland, Swaziland and lastly Komati North or lower Komati, which is the area downstream of Swaziland (AfriDev, 2006). The main tributaries in the catchment include Lomati, Gladdespruit, Teespruit and Seekoeispruit. Water management in the Upper Komati region is controlled by two major dams, namely Nooitgedacht and Vygeboom Dams, which are both located on the Komati River. In the lower Komati region the major dams are Maguga Dam situated on the Komati River in Swaziland and Driekoppies Dam which is situated on the Lomati River in South Africa as shown in **Figure 3**.

### 1.2.2 Crocodile River catchment

The Crocodile River catchment in **Figure 4** falls in the X2 drainage region of South Africa and covers an area of about 10 450 $km^2$. The river rises in the Steenkampsberg Mountains and flows in an easterly direction past the towns of Elandshoek and Nelspruit and along the border of the Kruger National Park towards the Komati River confluence at Komatipoort. The major water uses include domestic, irrigation, afforestation as well as industrial and mining activities.

The Crocodile River can be divided into the Crocodile West and Crocodile East regions. The major tributaries in the catchment are the Elands River, Nelspruit, White River and the Kaap River and the only major dam in the catchment is the Kwena Dam located in the Upper Crocodile or Crocodile West region of the river.

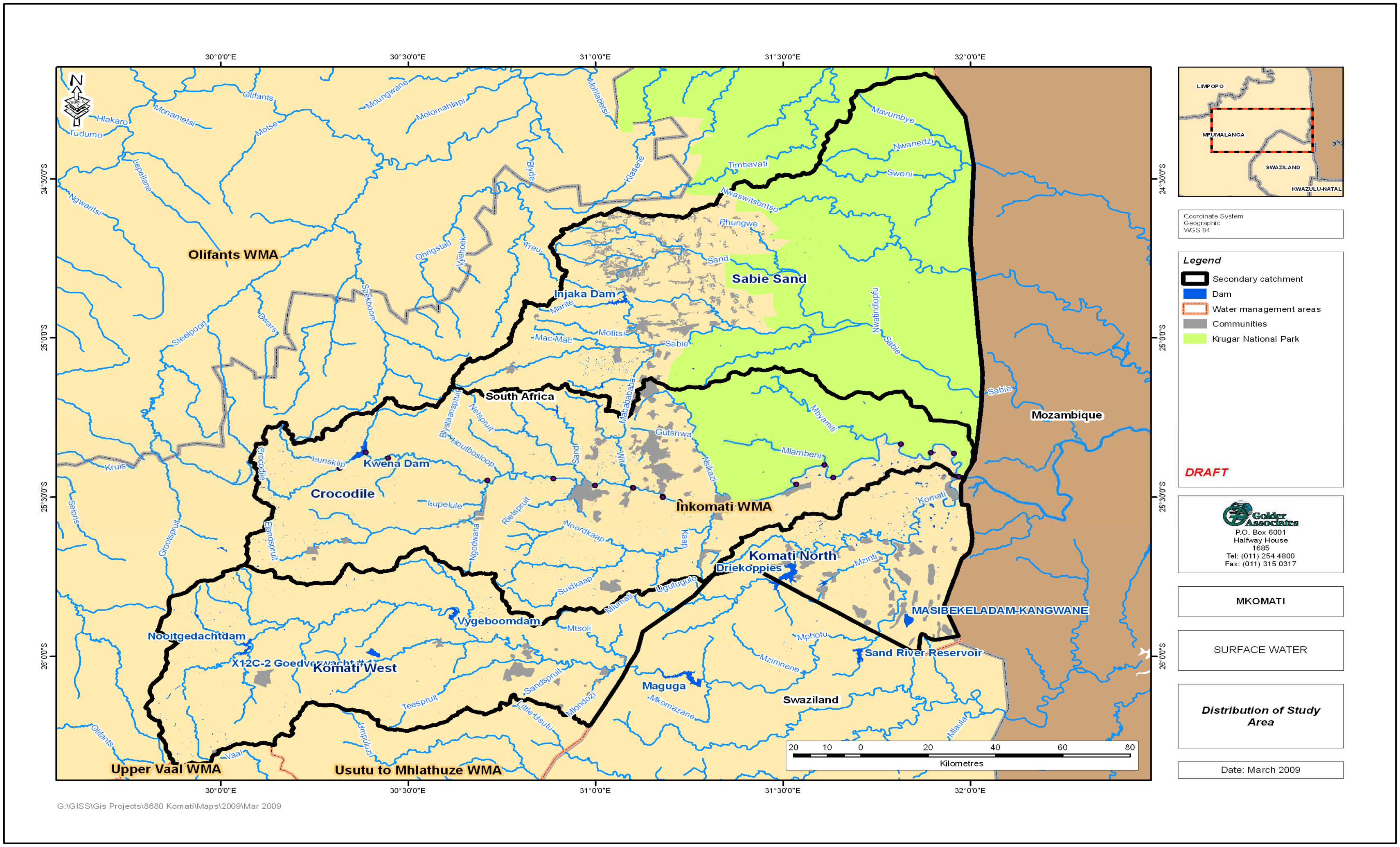



**Figure 2: Komati River, Crocodile River and Sabie River catchments**

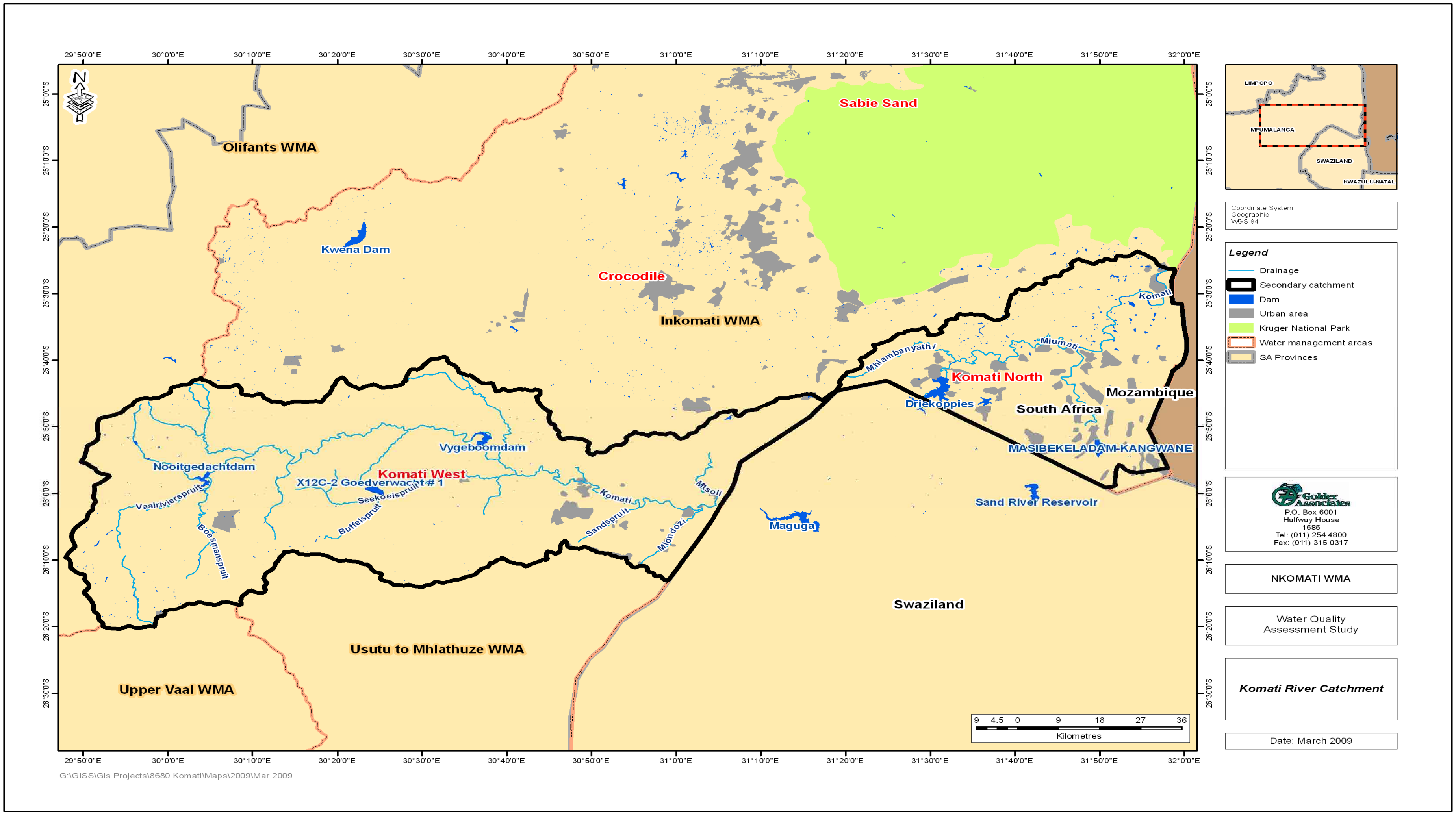



Figure 3: Komati River catchment

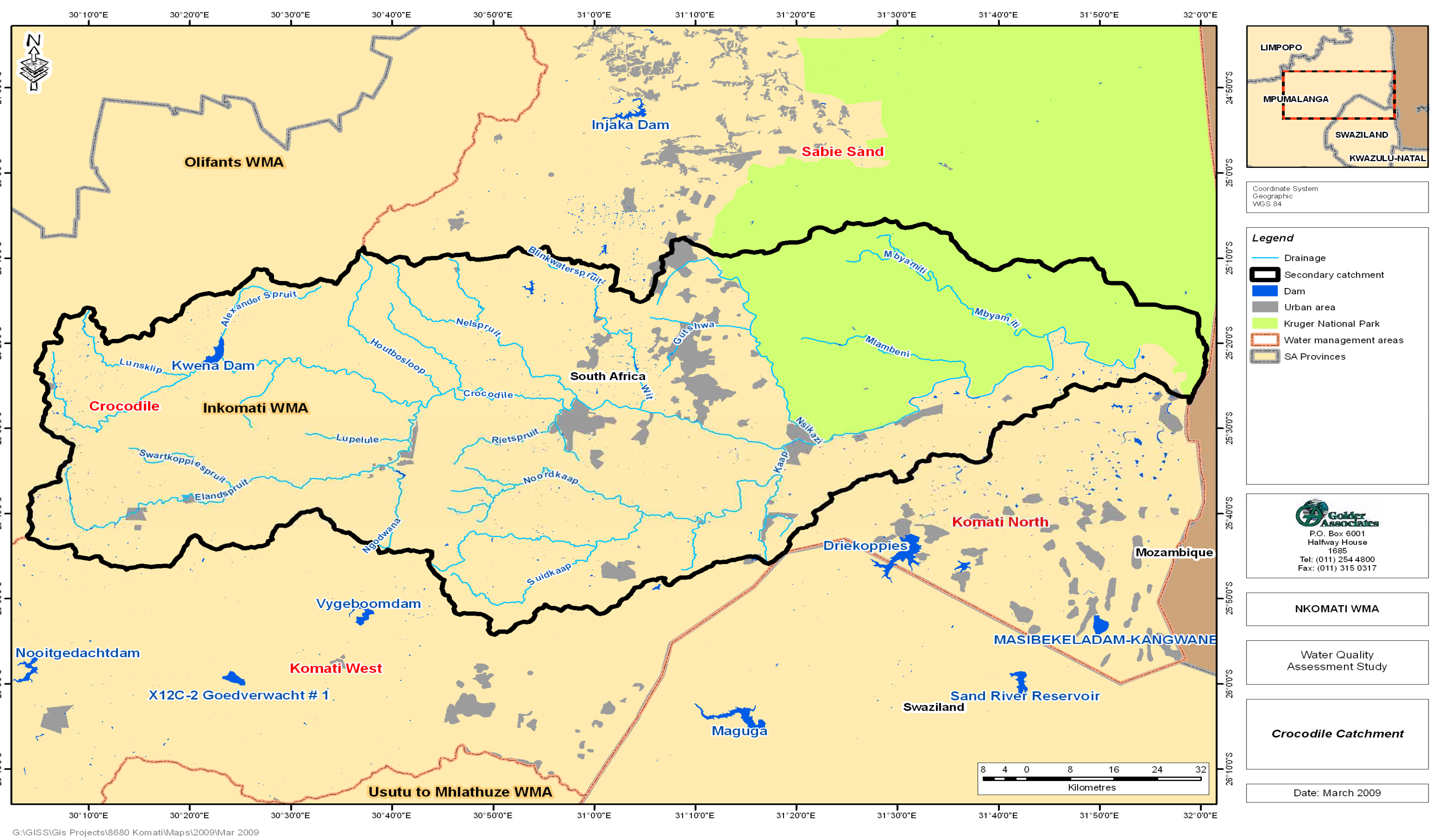



**Figure 4: Crocodile River catchment**

The Crocodile River originates near Dullstroom, from where it flows eastwards. The Elands River originates near Belfast, and joins the Crocodile River upstream of Nelspruit. The Kaap and Crocodile Rivers confluence is near Kaapmuiden in eastern Mpumalanga. The confluence of the Komati and the Crocodile occurs just upstream of the border with Mozambique. After the confluence, the river is called the Inkomati and flows into Mozambique.

### 1.2.3 Sabie River catchment

The Sabie River catchment forms the X3 drainage region and covers an area of approximately 6 315 $km^2$. The source of the Sabie River is high up in the Drakensberg escarpment. The major water uses in the catchment include domestic, irrigation, afforestation and industrial activities.

In the Sabie River catchment, the Sabie River forms the main river of the catchment with the Sand, Mac-Mac and Marite Rivers acting as the major tributaries. There are no major dams on the Sabie River itself with the only major dams located in the Marite River tributary (Inyaka Dam) and the White Waters River tributary (Da Gama Dam) as shown in **Figure 5**.

The Sabie River originates in the northern part of Mpumalanga, and the Sand River in Bushbuckridge. The two rivers join near Skukuza, in the Kruger National Park and becomes the Sabie River which then flows southeast into Mozambique, where it joins the Inkomati River. The Upper Rio Uanetze catchment comprises the Uanetse and Massintonto Rivers. The two rivers flow eastwards through the dry central parts of the Kruger National Park into Mozambique. They join the Inkomati River in Mozambique.

### 1.2.4 Spatial extent of study

The spatial extent for the water quality assessment is the X drainage region (Inkomati WMA), which includes the Komati River catchments (X1), the Crocodile River catchments (X2) and the Sabie River catchments (X3) and shown in **Figures 3, 4** and **5**.

### 1.2.5 Objective of the study

This water quality assessment aims to provide a reconnaissance level analysis of the available information of the current water quality situation of the X1, X2 and X3 catchment areas and in doing so identify the water quality issues or aspects that have an impact on the water resource management of the Inkomati WMA.

The water quality information provided in this report will inform the water resource allocation plan for the Inkomati WMA as part of the water availability assessment study.

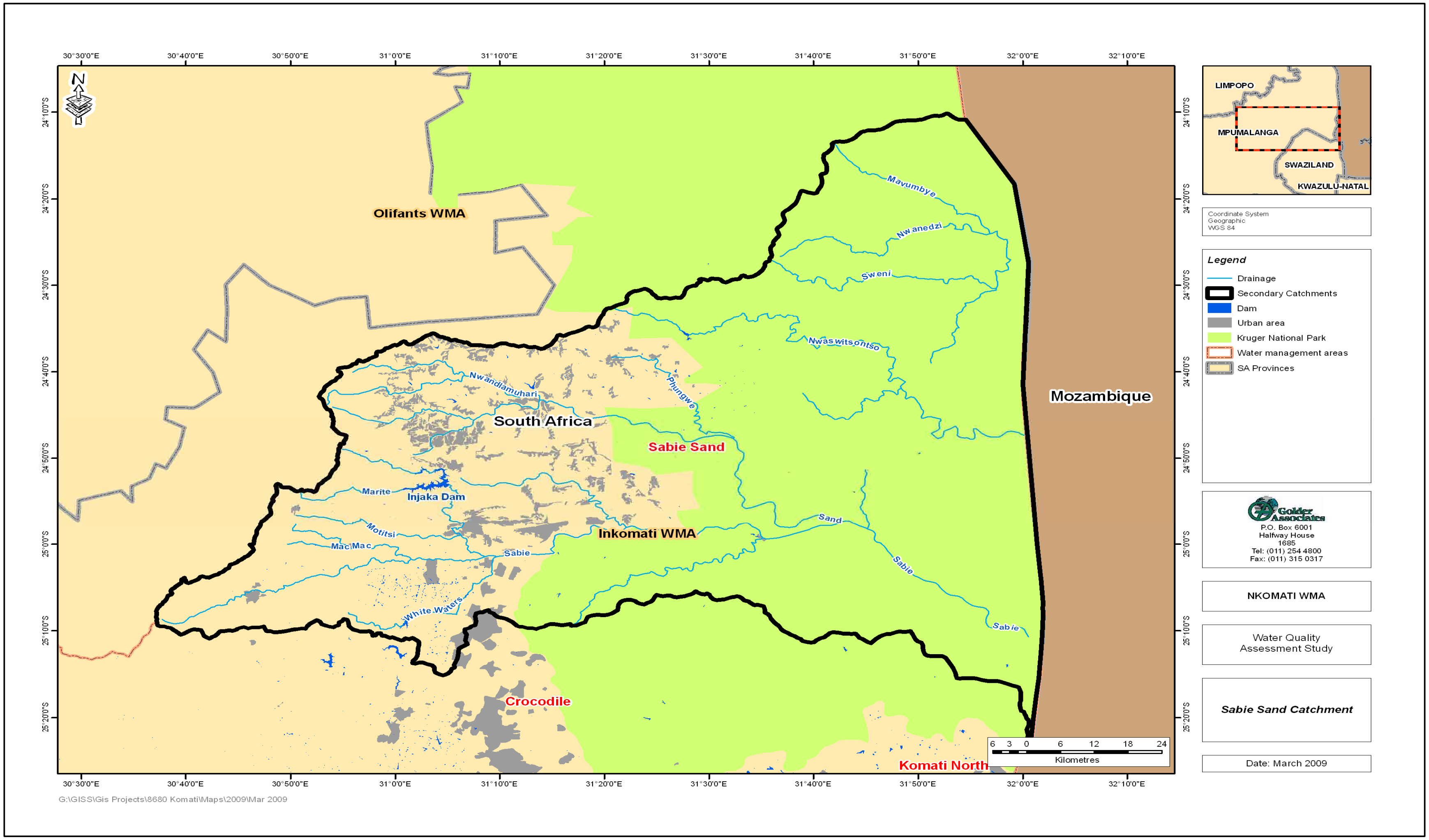



**Figure 5: Sabie River catchment**

## 1.3 Summary of Findings from Previous Studies Conducted

A number of studies that were previously carried out for the Komati, Crocodile and Sabie catchments are of relevance and have been consulted in this study.

The Komati River Catchment study detailed in a report by AfriDev Consultants was of particular relevance to this water quality assessment (**AfriDev, 2006**). The results of the AfriDev study report indicated that there was insufficient long term data on the water quality status of the Komati River and this restricted certain investigations such as flow-concentration modelling. Overall the study revealed that the water in the headwaters of the Komati River was generally of good quality with no major water quality problems being experienced. Some water quality impact is experienced in terms of dry land farming and forestry in the Upper Komati River between Nooitgedacht and Vygeboom Dams, however the catchment is in good ecological condition (**AfriDev, 2006**). The two main dams in the Upper Komati catchment are operated to ensure the maximum yield. The volumes of water abstracted are based on the water available through the inter-basin transfers from the Vaal-Eastern Sub-system. The water is abstracted by Eskom for power generation. Eskom power stations receiving water from the Komati catchment were designed for use of this high quality (low sulphate) water. The continued supply of good quality water to Eskom is of strategic national importance and a key factor for the management of the catchment water resources. Due to the abstraction and rigid operating rules, the low flows of the Komati River between the dams have been impacted upon. This has resulted in an increase of nutrients in this reach of the river due to trout dams and tourism activities (**AfriDev, 2006**). The low flow reduction coupled with trout dams, agricultural and tourism activities has resulted in increased nutrient concentrations in the river.

The main water quality impacts within the Gladdespruit were attributed to acid mine drainage from old gold mining activities, high afforestation, invasion of alien vegetation and trout farming. The flow in the Gladdespruit is also altered due to abstractions for gold mining and a diversion weir at Vriesland that transfers water to Vygeboom dam (**AfriDev, 2006**). Two poorly functioning sewage works at Badplaas and several informal settlements along the banks of the river leading to organic pollution in the rivers were presumed to be the main water quality influences in the Seekoeispruit tributary. Typical water quality issues of concern are microbiological, nutrient enrichment and high turbidity. In the Teespruit tributary, there is a greenstone mine in close proximity to the water course. However the impacts thereof were presumed to be very limited. The water quality is mainly affected by sewage works in the Tjakastad and Eerstehoek towns and their associated organic pollution.

The lower Komati River catchment has been found to be in a poor ecological condition mainly due to the large number of weirs associated with irrigation in the area. The main water quality issues in the area were nutrients, bacterial contamination, increased water temperatures and slight salinity problems (**AfriDev, 2006**).

The South African River Health Programme (SARHP) was initiated by the Department of Water Affairs and Forestry (DWAF) in 1994 for the purpose of assessing the ecological status of the major rivers in South Africa. As part of the SARHP, the Crocodile, Sabie and Olifants River Systems were assessed to determine their ecological health (**WRC, 2001**). In terms of the assessment undertaken the overall status of the Crocodile River has been reported as being in a good to fair condition with the exception of the area near Nelspruit where the water quality was described as being significantly impacted upon (**WRC, 2001**). This was attributed to the increased urban development which has lead to organic pollution in the river, intensive agricultural and industrial activities and the invasion of alien vegetation. The lower Crocodile River has found to experience eutrophication problems due to irrigation run-off enriched with nutrients. Large abstractions for irrigation purposes has resulted in a lower than desired river flows that has also had a negative impact on water quality.

The water quality impacts identified in the upper Crocodile catchment were related to the invasion of alien vegetation, impacts from agricultural activities, afforestation, trout farming and impacts from waste discharges and urban development. The Verlorenvallei Nature Reserve outside Dullstroom is an important conservation area which has been proposed as a ‘Ramsar’ site. The main issues identified in the Elands River tributary catchment are impacts related to irrigated agriculture, forestry plantations, alien vegetation and infrastructure development. A major impact is increased erosion which has increased sedimentation in the river (**WRC, 2001**). The Kwena Dam has resulted in flow modification of the river which has caused ecological changes and impacts on water quality.

The water quality of Sabie River system was described as being in a good condition mainly due to the influence of the conservation laws implemented by the Kruger National Park in the lower reaches of the catchment. However, in some of the smaller tributaries the quality of water was found to be in an unacceptable state mainly due to the invasion of alien vegetation coupled with sedimentation problems in these areas. The river is under threat due to urbanisation, trout farming, forestry and alien vegetation (**WRC, 2001**).

# 2 WATER QUALITY ASSESSMENT

Significant catchment development, including industrial growth, widespread mining activities, afforestation, agricultural activity and formal and informal urbanisation has impacted on the surface water resources of the Komati, Crocodile and Sabie catchment areas. The water quality assessment was undertaken to present the current chemical water quality status of the three major river systems in the Inkomati WMA in order to determine the extent of the impacts and to identify the most significant water quality issues of concern.

The water quality status is provided here at an overview level, with the key water quality variables of concern being identified. This overview provides an indication of the fitness for use of the water resources in the system and the key areas where intervention is required within the catchment.

## 2.1 Methodology and Materials

### 2.1.1 Collection of historical data

The historical data on physico-chemical parameters as were obtained from Resource Quality Services (RQS), Department of Water Affairs and Forestry (DWAF) for the monitoring sites on the Komati, Crocodile and Sabie Rivers and some major tributaries registered in the National Chemical Monitoring Programme.

The data used for the analysis has different time scales, different sampling frequencies, variation in the water quality variables monitored and different laboratories and analytical methods used. There were gaps in the available data.

### 2.1.2 Water Quality Data Analysis

The water quality status is presented in this section in graphical form. Software used for data manipulation included Microsoft Office Excel for basic statistical analyses and graphical presentation. The data has been plotted from the most upstream monitoring station to the downstream station, providing an indication of status along the river length.

The data sets obtained have been represented in these plots in the form of box and whisker diagrams, which depicts the data distribution as:

- $5^{th}$, $25^{th}$, $50^{th}$, $75^{th}$ and $95^{th}$ percentile values.

The water quality status along the river was than compared to the most stringent user Target Water Quality Ranges (TWQR) as specified in the South African Water Quality Guidelines (**DWAF, 1996**) for the identified water quality variables. Currently no Resource Water Quality Objectives (RWQOs) have been set for the water resources in the Inkomati WMA.

The water quality status assessment has been based on the routine monitoring conducted by the Department in recent years and it must be borne in mind that this is a high level qualitative assessment of historical water quality in the Inkomati WMA making use of the data available to the study team.

### 2.1.3 Identification of Key Variables

The original data obtained from the DWAF included a comprehensive list of variables that are monitored within the X-drainage region of South Africa. This study focussed on the following water quality variables which were selected based on the major land use activities (agriculture, urban development, settlements, industrial activity), current water quality issues in the catchment (eutrophication, salinisation) and water user requirements (power generation, industry, domestic, agriculture).

- Chloride (Cl)
- Electrical Conductivity (EC)
- Ammonia ($NH_4$)
- Nitrate and nitrite ($NO_3$ and $NO_2$)
- Sodium (Na)
- Phosphorus ($PO_4$) (Inorganic)
- Sulphate ($SO_4$)
- pH
- Magnesium (Mg)
- Total Alkalinity

### 2.1.4 Water Quality Guidelines

RWQOs for the Komati, Crocodile and Sabie Rivers had not been determined at the start of this study. Thus it was necessary for the purposes of this assessment that there are benchmarks against which water quality could be measured to identify the issues or concerns regarding water quality. The South African Water Quality Guidelines (**DWAF, 1996**) were used as the target guideline criteria. These serve as the primary source of information for determining the water quality requirements of different users and for the protection and maintenance of the health of aquatic ecosystems.

The most stringent applicable target water quality range (TWQR) amongst the user groups (most stringent user requirement) per identified variable was selected as the target concentration against which the current water quality status was compared to. The water quality guidelines used for the assessment are listed in

**Table** 1 (**DWAF, 1996**).

**Table 1: Water Quality Guidelines used to assess water quality status**

| Water Quality Variable | Most Stringent user Requirement | Water Quality Guideline Concentration (TWQR) |
|---|---|---|
| Chloride | Industrial: Category 1 | 20 mg/l |
| Ammonia | Aquatic ecosystem | ≤0.007 mg/l N |
| Electrical conductivity | Industrial: Category 1 | 15 mS/m |
| Nitrate | Domestic: Class 0 | 6 mg/l N |
| pH | Domestic: Class 0 | 6 – 9 pH units |
| Phosphorus (inorganic) | Aquatic ecosystem | <0.005 mg/l |
| Sodium | Irrigation | ≤70 mg/l |
| Sulphate | Industrial: Category 1 | 30 mg/l |
| Magnesium | Domestic: Class 0 | 30 mg/l |
| Alkalinity | Industrial: Category 1 | 50 mg $CaCO_3$/l |

## 2.2 Water Quality Assessment of the Komati River

### 2.2.1 Identification of the Key Monitoring Points

From the information received from the DWAF's Resource Quality Service (RQS) Directorate, 58 monitoring stations were identified along the length of the Komati River. These stations are located from the Upper Komati, starting at Nooitgedacht Dam, to the Lower Komati where the Komati River flows into Mozambique. Data for monitoring stations in Swaziland was not obtained from the DWAF.

The water quality data received was not very comprehensive as monitoring at some of the stations ceased several years ago whilst at other stations monitoring is inconsistent resulting in scattered data that is not representative of the entire monitoring period. Therefore, of the 58 monitoring stations along the Komati River only 10 stations with reliable data, that was compiled from monitoring over long periods, were selected for this study and are tabulated in **Table 2** and depicted in **Figure 6.**

**Table 2: Monitoring points selected for water quality assessment along the Komati River**

| Monitoring ID | Monitoring Point Name | Location Feature | No. of samples | Duration of Monitoring |
|---|---|---|---|---|
| 102931 | X1H001 – at Hooggenoeg | Komati River | 507 | Oct 1977 – Feb 2007 |
| 102933 | X1H003 – at Tonga | Komati River | 1272 | March 1977 – March 2007 |
| 102937 | X1H017 – at Waterval | Komati River | 20 | Dec 1979 – April 2002 |
| 102938 | X1H018 – at Gemsbokhoek | Komati River | 323 | April 1977 – Feb 2007 |
| 102947 | X1H033 – Nooitgedacht Dam at d/s weir | Komati River | 96 | March 1983 – July 2004 |
| 102948 | X1H036 – Vygeboom Dam at d/s weir | Komati River | 147 | March 1982 – Jan 2007 |
| 102949 | X1H042 – at Komatipoort | Komati River | 343 | Jan 1993 – Feb 2007 |
| 102950 | X1R001 – Nooitgedacht Dam | Dam/Barrage | 233 | March 1968 – Sept 2006 |
| 102951 | X1R003 – Vygeboom Dam | Dam/Barrage | 129 | March 1975 – Dec 2006 |
| 102979 | X2H036 – at Komatipoort | Komati River | 973 | Oct 1982 – Jan 2007 |

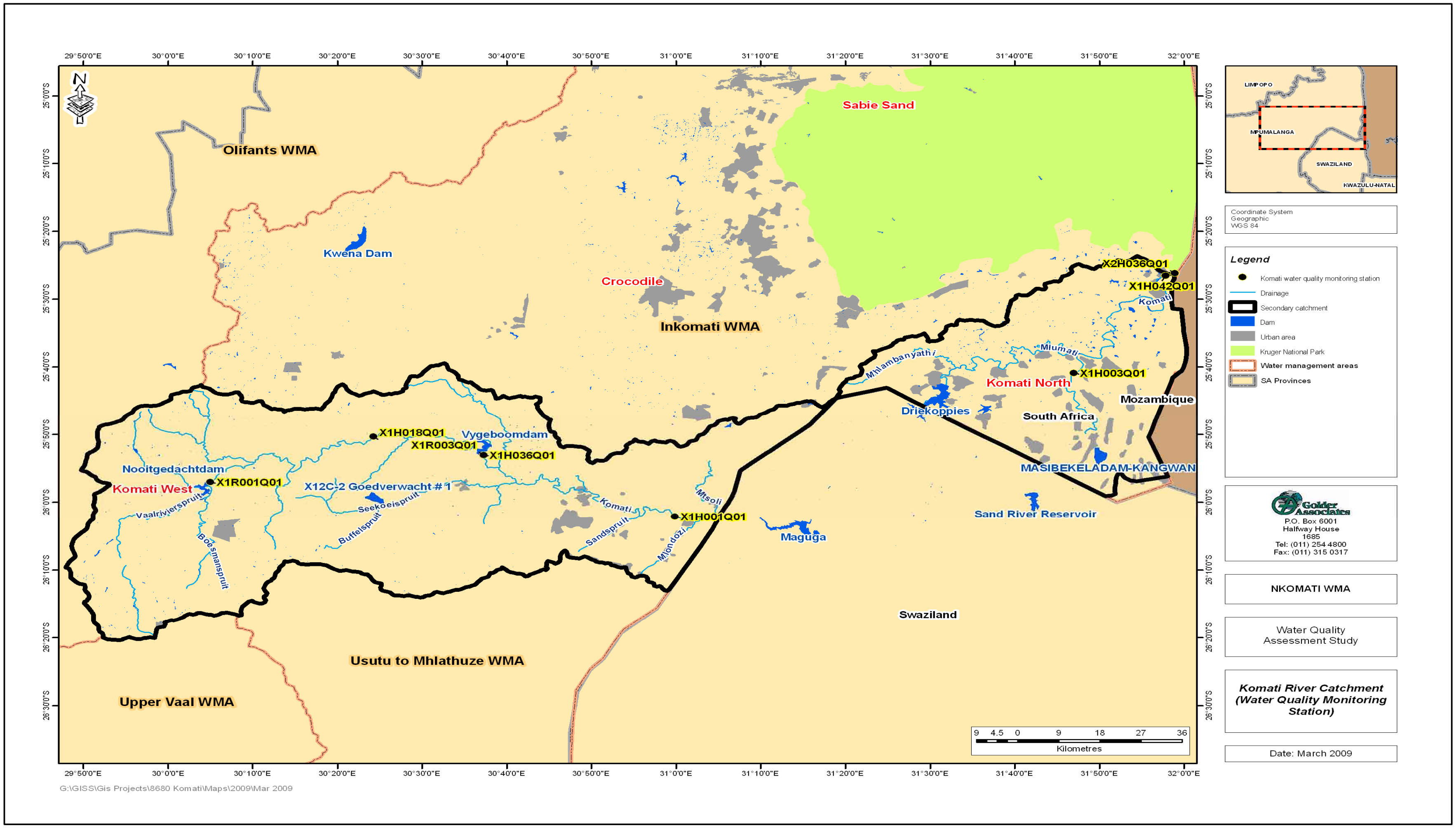



**Figure 6: Location of the monitoring points on the Komati River used in the assessment**

The water quality status assessment of the river at these stations was compiled by using the data from the last five monitoring years (from 2002 to early 2007) with the exception of monitoring stations X1H017 and X1H033. At these two monitoring stations the data analysis was done for the entire monitoring period, as monitoring was not as frequent as was the case with the other eight stations. The sampling period varies from annually to daily with monthly being the most typical interval.

### 2.2.2 Results of the Water Quality Analysis

The $5^{th}$, $25^{th}$, $50^{th}$, $75^{th}$ and $95^{th}$ percentiles of each of the identified water quality variables were calculated using the data sets obtained from DWAF. The tabulated results per water quality variable per monitoring station are included in **Appendix A**.

The observed concentrations for each variable was then compared to the most stringent TWQR guideline selected as per the SAWQGs in **Table 1** in **Section 2.1.4**. Reference was also made to the ecological specifications (EcoSpecs) for water quality as outlined in the **AfriDev** (2006).

The following were observed for each variable along the Komati River:

**Chloride:**

The mean chloride concentration in the Komati River was found to be 28.23 mg/l and ranged between 2.0 and 158 mg/l. The chloride concentration observed in the upper Komati River catchment (to Hooggenoeg) is very close to natural concentrations of chloride in rivers, and is within the TWQR of 20 mg/l (**Figure 7**). This concentration appears to be fairly stable over the last 10 years. Exceptionally high chloride concentrations are however observed in the lower Komati catchment as the river flows from Swaziland towards Komatipoort, which reflects a deteriorating quality as the river flows downstream (**Figure 7**). This observation is indicative that certain land use activities that exist in this part of the catchment are impacting on the resource fairly significantly. The chloride concentrations at these stations in the lower Komati, X1H003, X1H042 and X2H036 also show an increasing trend over recent years, as can be seen in the time series graphs in

Figure 8. The plots in **Figure 8** show a rapid increase in chloride concentrations over the low flow winter periods with the concentration dropping with the onset of the rainy season. The increasing concentration during the low flow period could be attributed to evaporation from the river, diffuses sources such as irrigation return flows or point source discharge into reduced flows.

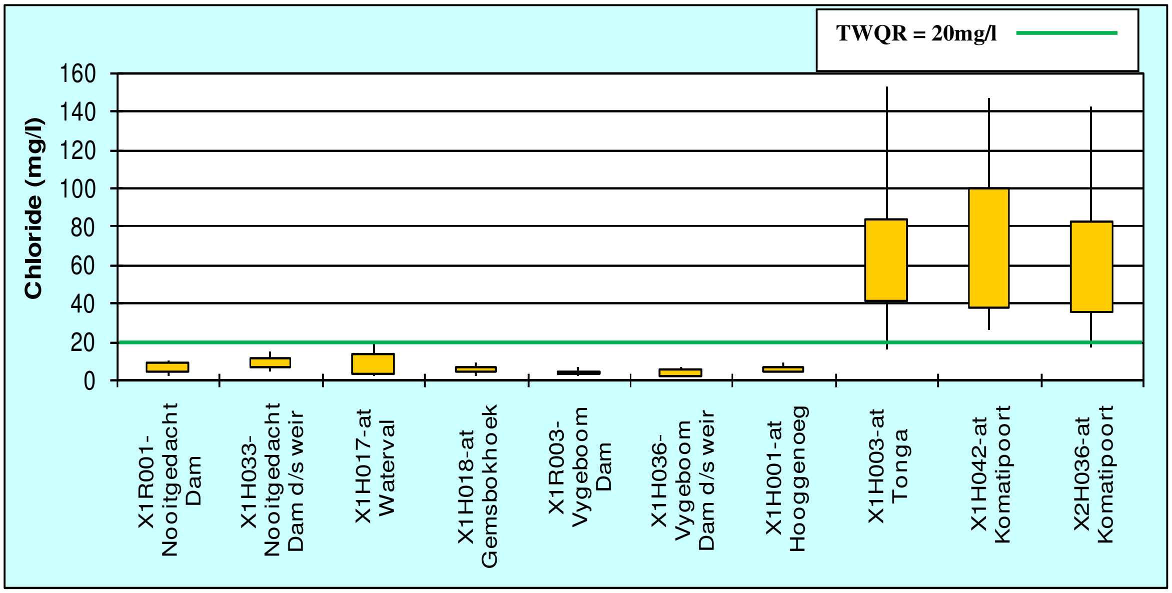
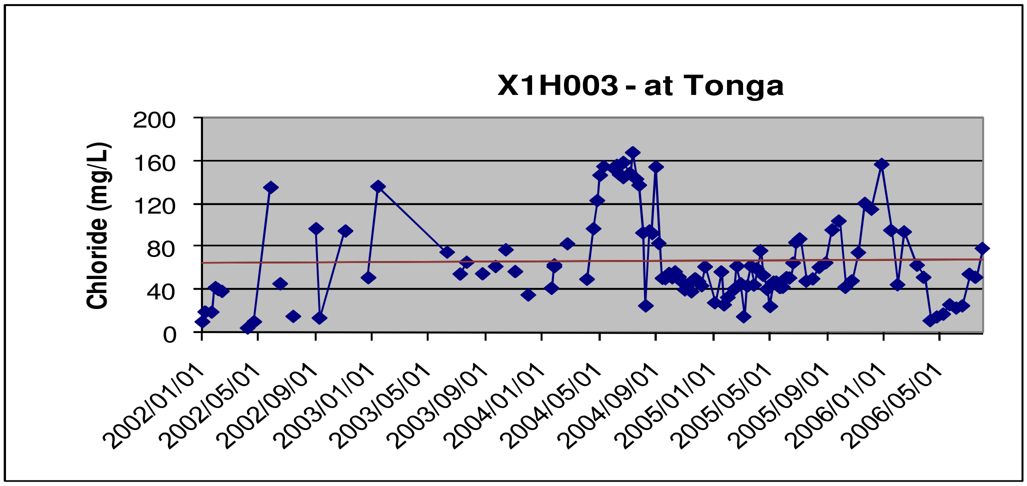
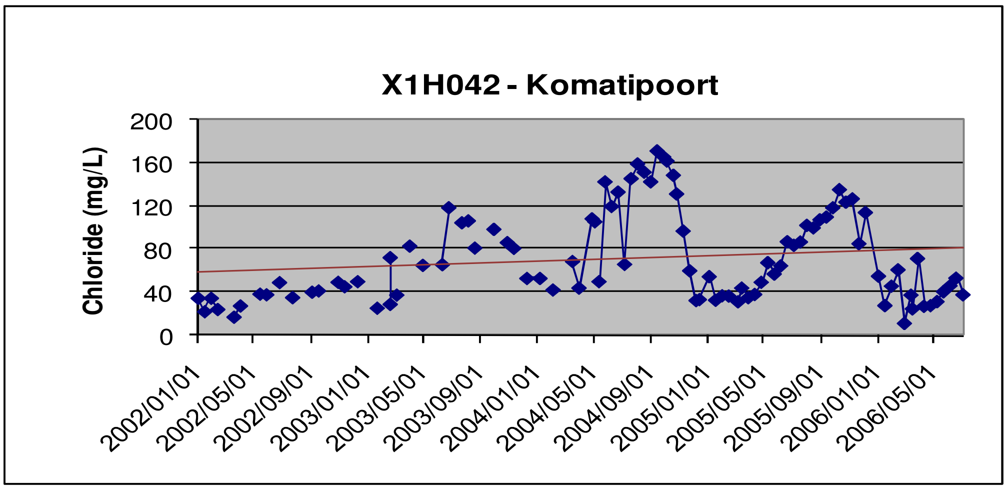



**Figure 7: Spatial variation in Chloride (mg/l) concentrations along the Komati River**

(a)




(b)




(c)

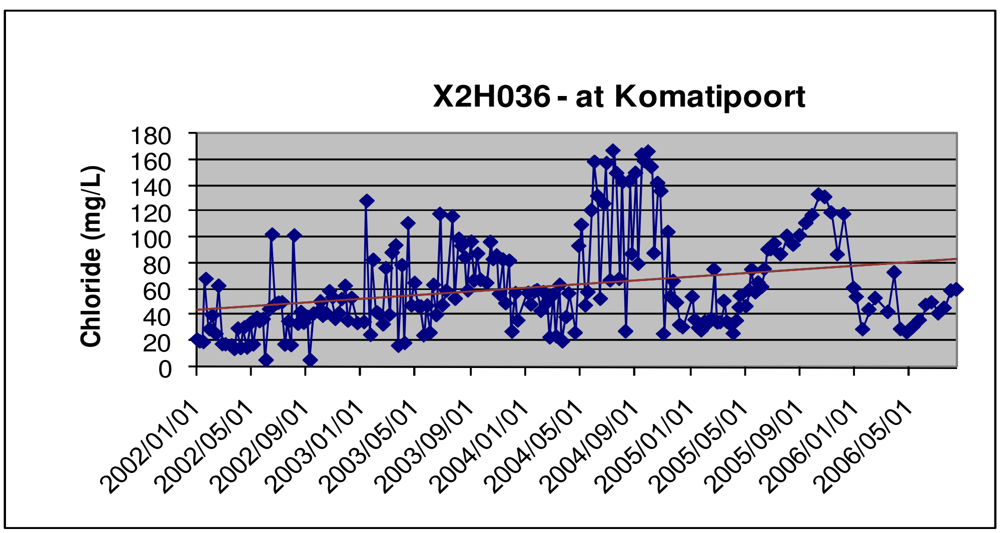



**Figure 8: Temporal variation in chloride (mg/l) at monitoring stations (a) X1H003 at Tonga (b) X1H042 and (c) X2H036 at Komatipoort (2002 – 2006) indicating an increasing trend.**

## Electrical Conductivity:

Salinity is an indication of the concentration of total dissolved salts (TDS) in a body of water. The level of salinity in aquatic systems is important to the aquatic biota and vegetation as species survive within certain ranges. The TDS concentration is proportional to the electrical conductivity (EC) of water. Since EC is much easier to measure, it is routinely used as an estimate of the TDS concentration (**DWAF, 1996**).

A similar trend to chloride is observed for electrical conductivity (EC) in **Figure 9**, along the Komati River. There is a general increase in electrical conductivity with over a doubling in concentration from Nooitgedacht Dam (mean of 18.05 mS/m) to Komatipoort (52.0 mS/m). This could be attributed to return flows and intensive irrigation in the middle to lower part of the catchment. The mean EC concentration in the Komati River was found to be 29.04 mS/m (189 mg/l TDS). The middle Komati River in the vicinity of the Vygeboom Dam catchment area shows fairly low concentrations of EC falling below the industrial guideline TWQR of 15 mS/m. The concentrations in the upper Komati in the Nooitgedacht Dam catchment are above the TWQR, which indicates a potential threat to the quality of water supplied to Eskom power stations. **Figure 9** shows a major increase in TDS concentration observed for the lower Komati catchments indicating a deterioration in water quality due to the impact of salts. The concentration of salts at Komatipoort reflects an increasing trend over time with the current state also exceeding the TWQR for irrigation and drinking water in **Figure 10**.

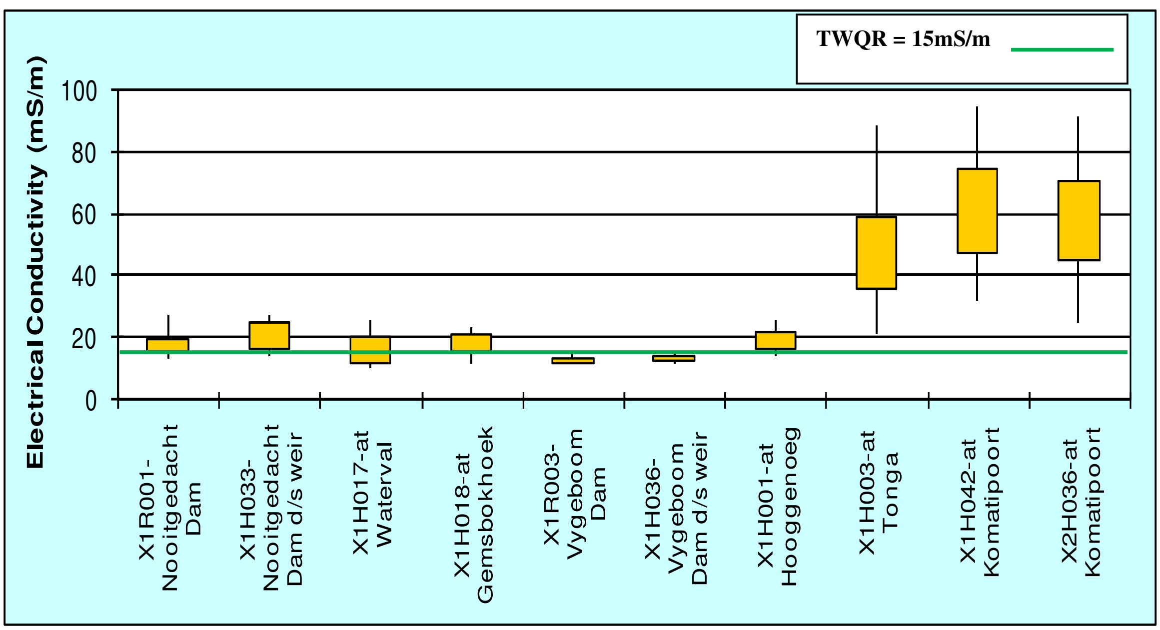
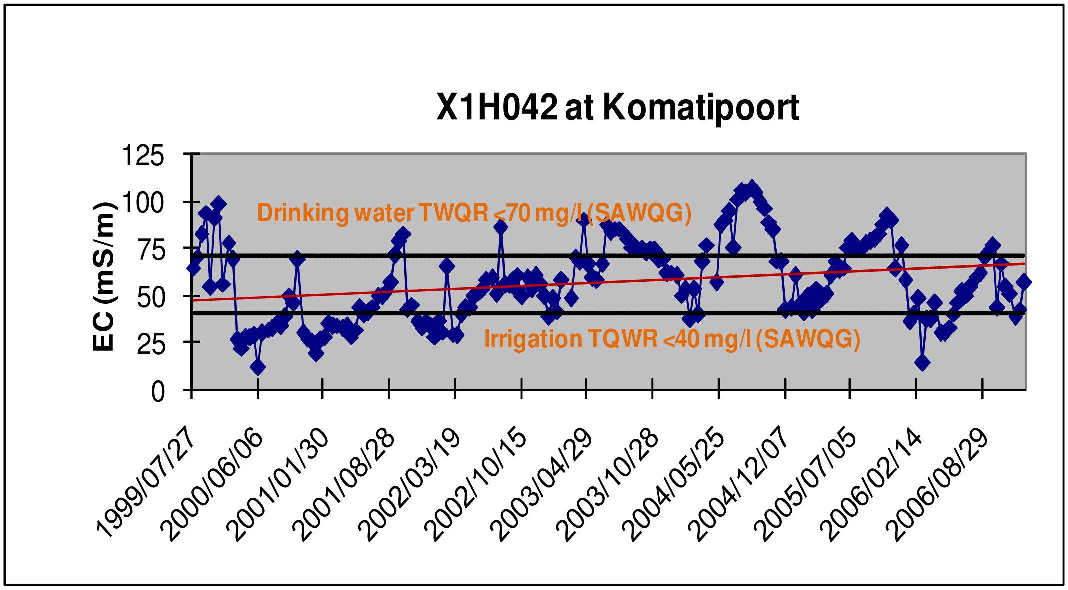



**Figure 9: Spatial variation in EC(mS/m) along the Komati River**

**(a)**




**(b)**

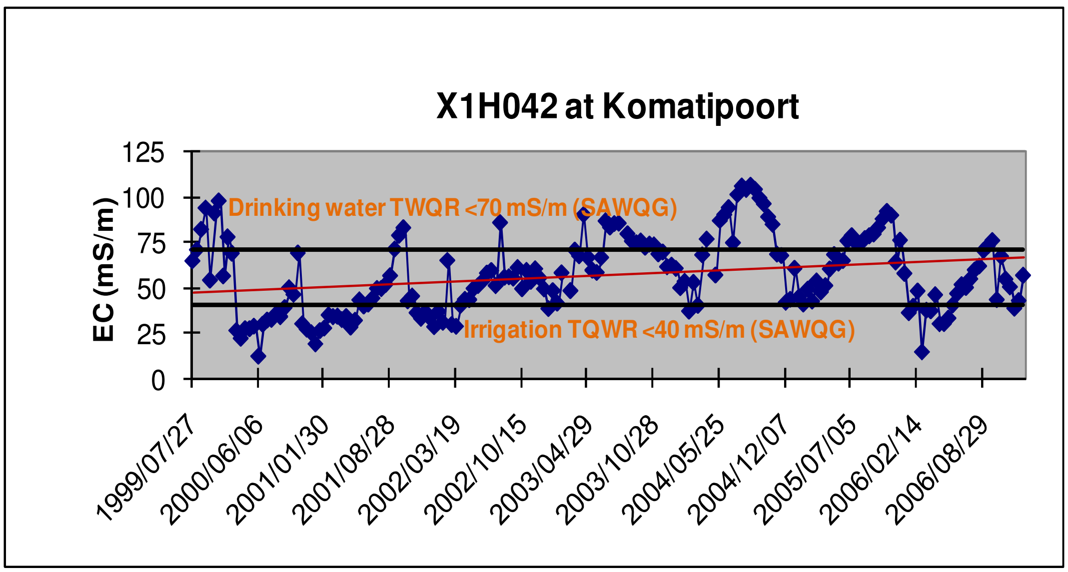



**Figure 10: Temporal variation in EC (mS/m) at monitoring stations (a) X1H042 and (b) X2H036 at Komatipoort indicating an increasing trend**

The same upward trend observed in the chloride concentration is evident in the EC. The reasons for the increase in EC during the dry periods are the same as for chloride.

**Ammonia:**

Ammonium ($NH_4$) occurs naturally in water bodies arising from the breakdown of nitrogenous organic and inorganic matter in soil and water, excretion by biota, reduction of nitrogen gas in water by microorganisms and from gas exchange with the atmosphere. Unpolluted waters contain small amounts of ammonium, usually < 0.1 mg/l as nitrogen. The mean concentration of $NH_4$-N in the Komati River was generally low (0.05 mg/l) and ranged between 0.02 and 0.18 mg/l. The $NH_4$-N concentrations in **Figure 11** do not show a significant trend along the length of the Komati River.

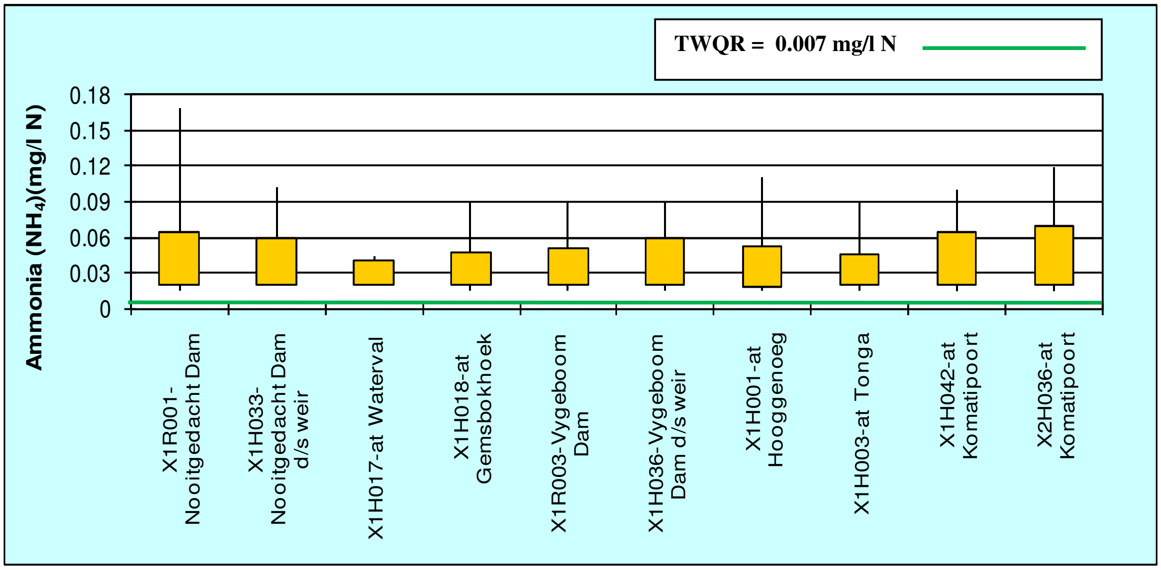



**Figure 11: Spatial variation in Ammonia concentrations (mg/l N) along the Komati River**

There is no significant difference between the downstream concentrations and most upstream point (mean of 0.045 mg/l N). However the concentrations observed along the length of the river exceed the TWQR for ammonia for the aquatic ecosystem as a user (≤ 0.007 mg/l N) and also exceeds the ecological specifications of 0.015 mg/l set for the Reserve (**AfriDev, 2006**). However it must be emphasised that the TWQR for ammonia of 0.007mg/l N is for ammonia, $NH_3$ and not total ammonia as reflected by the $NH_4$ concentration plotted in **Figure 11**.

**Nitrates and nitrites:**

Nitrogen occurs in water in a variety of inorganic and organic forms and the concentration of each form is primarily mediated by biological activity. Aerobic bacteria convert $NH_4^+$, to nitrate ($NO_3^-$) and nitrite ($NO_2^-$) through nitrification, and anaerobic and facultative bacteria convert $NO_3^-$ and $NO_2^-$ to $N_2$ gas through denitrification.

The concentrations of nitrate and nitrite in the Komati were generally low (mean of 0.21 mg/l). There is however a general increase in nitrates and nitrites along the length of the river as it flows downstream. There is a more than doubling in concentration from a mean of 0.11 mg/l at Nooitgedacht Dam to mean of 0.38 mg/l at Komatipoort as shown in **Figure 12**. While the concentrations in the lower Komati region are higher than in the upper catchments, the nitrate and nitrite concentrations at Komatipoort in

**Figure** 13 display a downward trend over time. The reasons for this downward trend are unclear. The concentration of the nitrate and nitrite are within the TWQR guideline limit of 6 mg/l N.

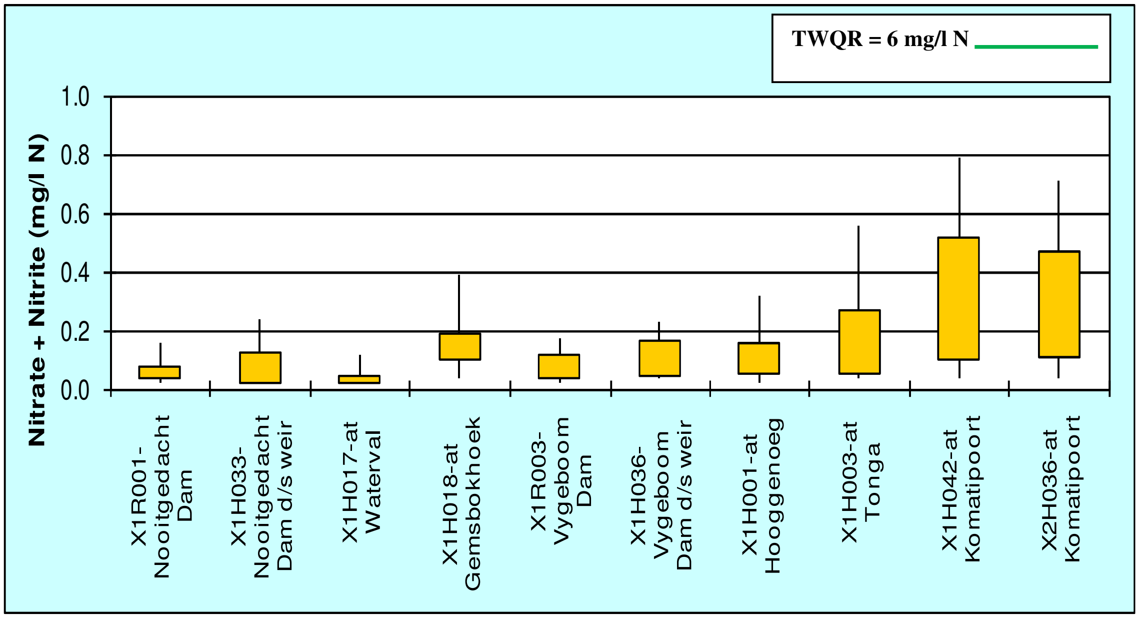



**Figure 12: Spatial variation in nitrate / nitrite concentrations (mg/l N) along the Komati River**

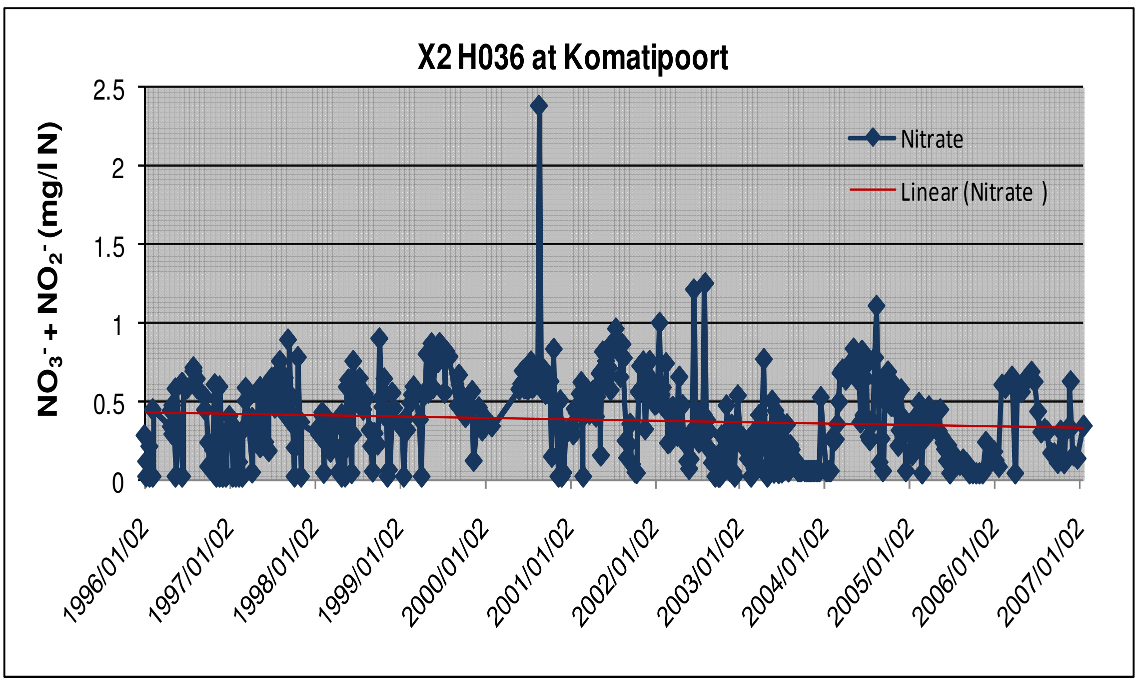



**Figure 13: Temporal variation in nitrate and nitrite concentrations at Komatipoort (X2H036)**

**Sodium:**

Sodium is one of the most abundant elements on earth. All natural waters contain some sodium as sodium salts are highly soluble in water. Increased concentrations in surface waters may arise from sewage and industrial effluents.

The sodium concentrations are fairly conservative from Nooitgedacht Dam to Hoogegenoeg (mean 6.94 mg/l), however further downstream in the lower Komati concentrations increase significantly (from Tonga to Komatipoort – mean of 38.2 mg/l ) as shown in **Figure 14**.This could be attributed to irrigation activities and return flows. The concentration of sodium in the Komati River with a few exceptions (in the lower Komati) complies to the applicable TWQR for sodium for all the major users.

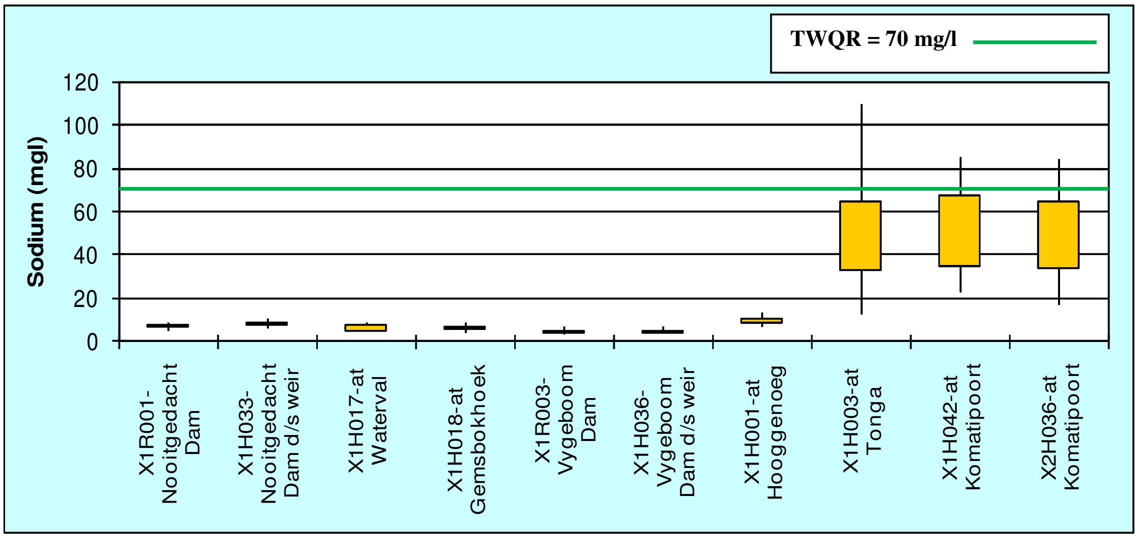



**Figure 14: Spatial variation in Sodium concentrations (mg/l) along the Komati River**

**Phosphates:**

The mean concentration of ortho-phosphate in the Komati River is 0.02 mg/l. The concentration is fairly constant along the length of the river with slight increases observed at Gemsbokhoek (mean 0.022 mg/l) and downstream in the lower Komati from Tonga (mean 0.024 mg/l) to Komatipoort (mean 0.03 mg/l) and shown in **Figure 15**. The levels of ortho-phosphate in the river exceeds the South African Water Quality TWQR of <0.005 mg/l. The ecological specification for phosphate for the Reserve is 0.017 mg/l (**AfriDev, 2006)** and currently this limit is being exceeded along the length of the river. Agricultural activity, urban development and sewage treatment plant discharges are the probable contributing factors to the concentrations observed.

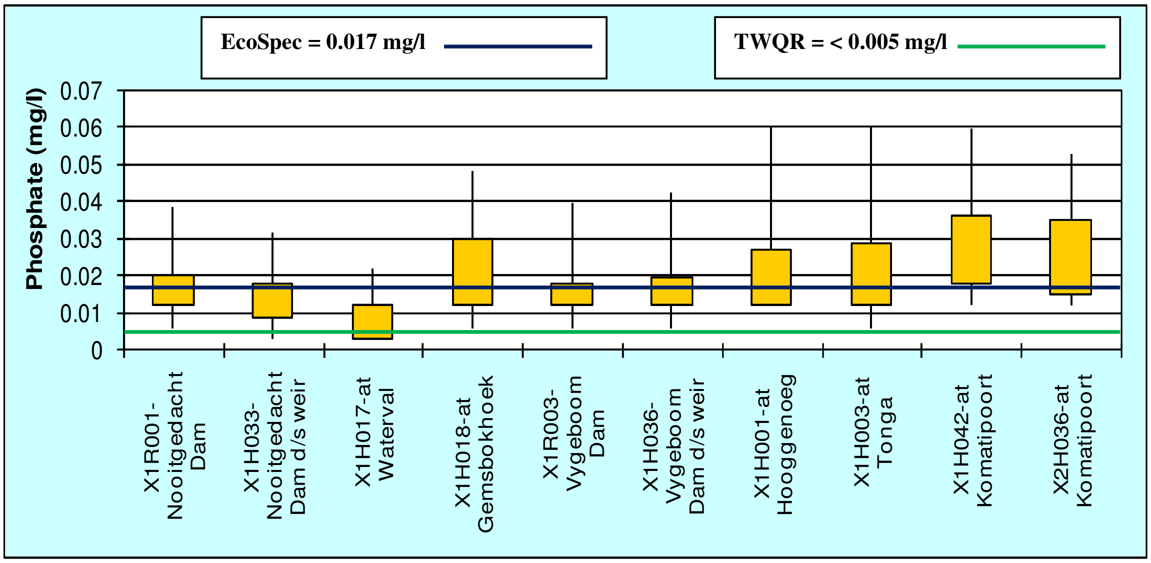



**Figure 15: Spatial variation in phosphate concentrations (mg/l) along the Komati River**

**Sulphates:**

The sulphate anion ($SO_4^{2-}$) is the most frequent form of sulphur encountered in freshwaters. The most common natural concentration in rivers is 4.8mg/l. The mean concentration of sulphate in the Komati River is 12.75 mg/l. The sulphate concentrations along the length of the river reflect a slight elevation in the upper Komati at Nooitgedacht Dam (mean 18.6 mg/l), a fairly low concentration between the dam and Tonga (7.45 mg/l), and once again increased concentrations in the lower Komati Komatipoort (mean 22.8 mg/l) and shown in

**Figure** 16. The concentration of sulphate in the Komati River is within the TWQR guideline limit of 30 mg/l with the exception of a slight exceedance at Komatipoort for 5% of values.

The slightly elevated sulphate concentration in Nooitgedacht Dam and downstream weir is a cause for concern and must be monitored. Eskom power stations receiving water from the Komati catchment were designed for use of this high quality (low sulphate) water. Based on the historical data, the concentrations of sulphate at Nooitgedacht Dam indicate a decreasing trend, while the concentration at the downstream weir reflects an increasing trend shown in **Figure 17**. The impact of atmospheric deposition on the water quality in the catchment must be monitored. There is also the expansion of coal mining in the upper reaches of the Nooitgedacht Dam catchment which will threaten the water quality of the dam in the future.

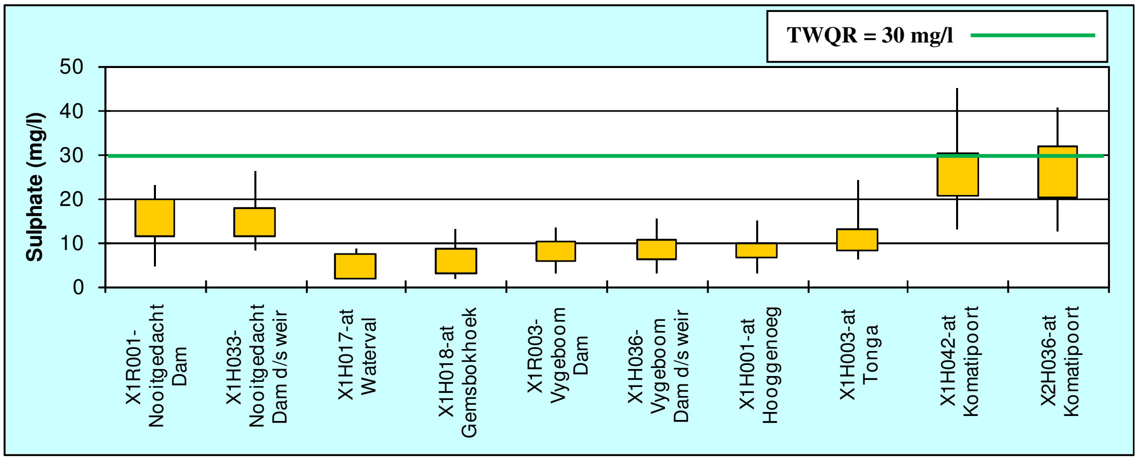
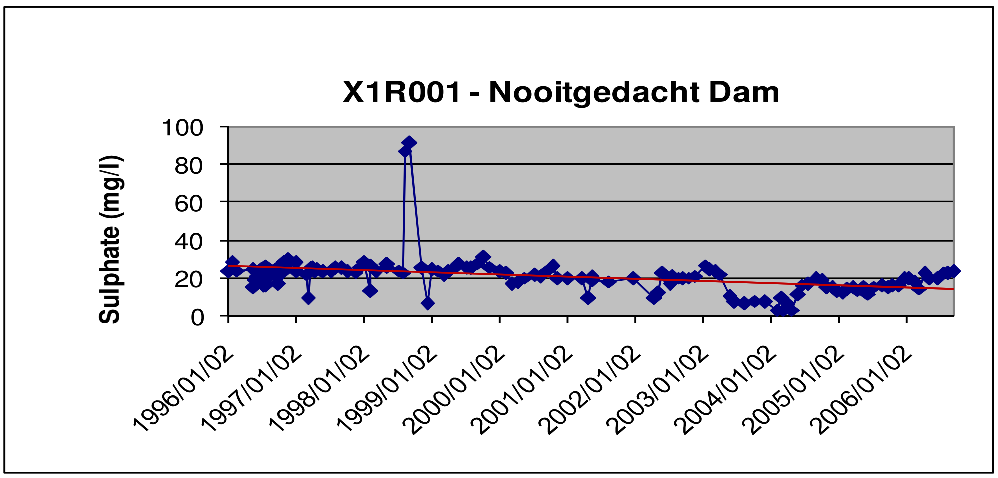



**Figure 16: Spatial variation in sulphate concentrations (mg/l) along the Komati River**

(a)




(b)

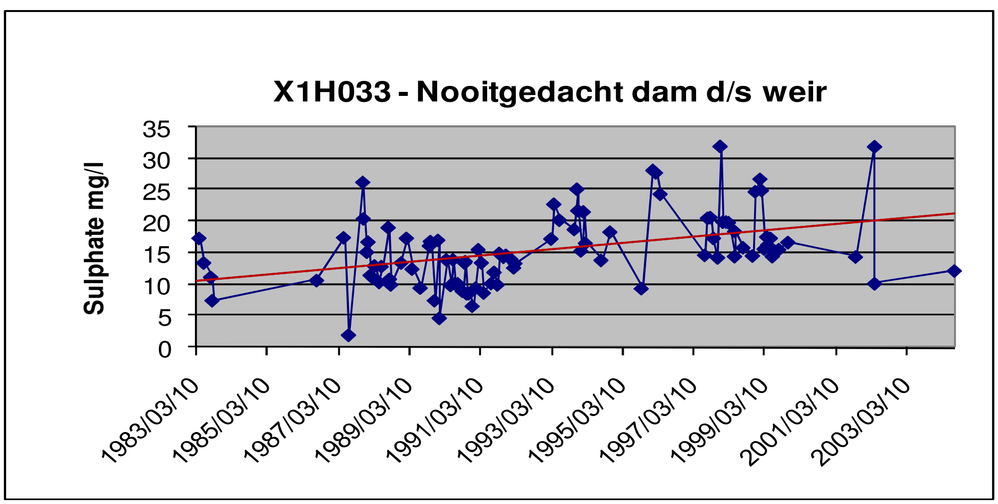



**Figure 17: Temporal variation in sulphate concentrations at (a) Nooitgedacht Dam (X1R001) and (b) downstream weir (X1H033) indicating observed trends.**

**pH:**

The pH of an aquatic ecosystem is important because it is closely linked to biological productivity. Dissolved inorganic carbon exists mostly in the form of bicarbonate ($HCO_3^-$) in rivers where the pH range is commonly between 6 and 8.4. The pH values in Komati River ranges between 6 and 9 in **Figure 18** (mean, 8.04) which are within the TWQR for domestic use. The pH of the river does display some variation along its length, (a minimal increase is observed in the upper Komati, with a decrease in the Vygeboom catchment observed and an increase again in the lower Komati).

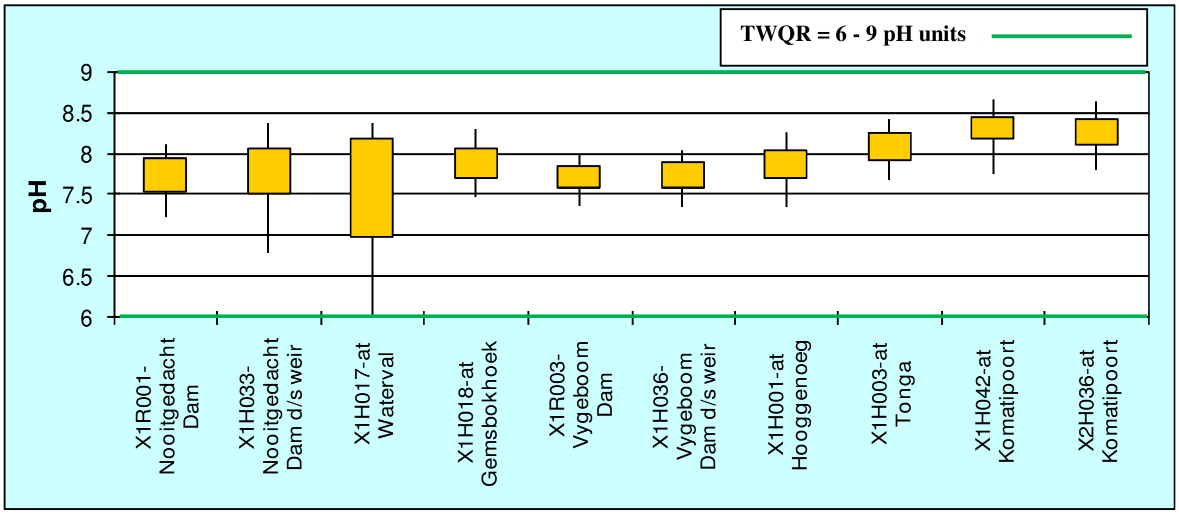



**Figure 18: Spatial variation in pH concentration along the Komati River**

**Magnesium:**

The mean concentration of magnesium in the Komati River is 12.73 mg/l. A gradual increase in magnesium concentration is observed in **Figure 19** along the upper Komati from Nooitgedacht Dam to Waterval. The concentration drops at Gemsbokhoek with the lowest readings noted at Vygeboom Dam. In the lower Komati region the magnesium concentration increases again from Tonga to Komatipoort There is in general compliance to the TWQR.

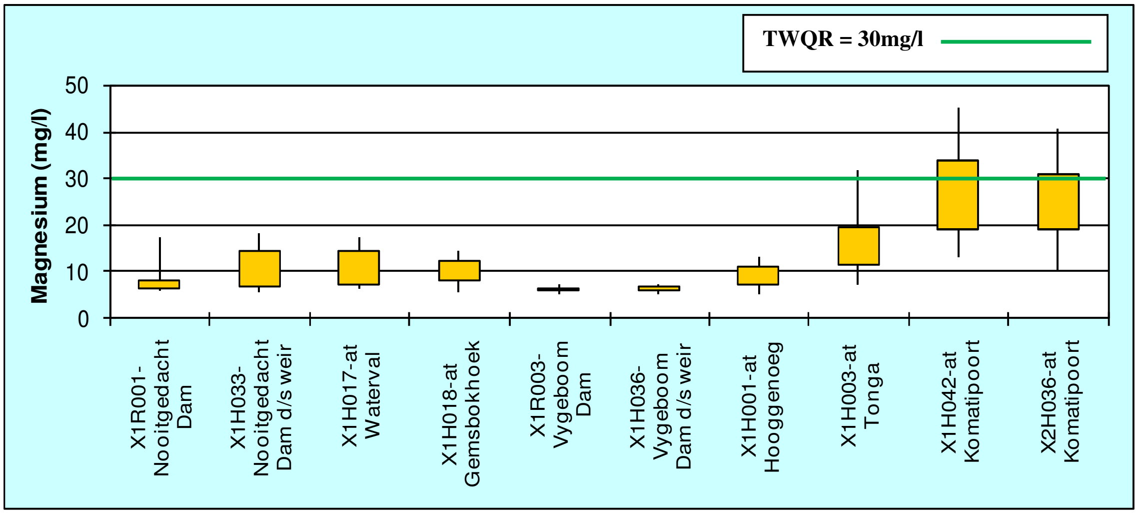



**Figure 19: Spatial variation in Magnesium concentrations (mg/l) along the Komati River**

**Total Alkalinity:**

Alkalinity is the acid-neutralising capacity of water and is usually expressed as mg $CaCO_3$/l. At high pH values (8 – 9), the bicarbonate ion ($HCO_3^-$) is the predominant form. Water of low alkalinity (<20 mg/l as $CaCO_3$) has a low buffering capacity and can, therefore, be susceptible to alterations in pH (sensitive to acidification), for example from atmospheric, acidic deposition.

The mean alkalinity value in the Komati River was high (mean of 104 mg/l). Alkalinity concentration in the Komati River follows a similar behavioural trend to that of magnesium. However, the majority of the values recorded exceed the TWQR guideline value of 50 mg/l (

**Figure** 20).

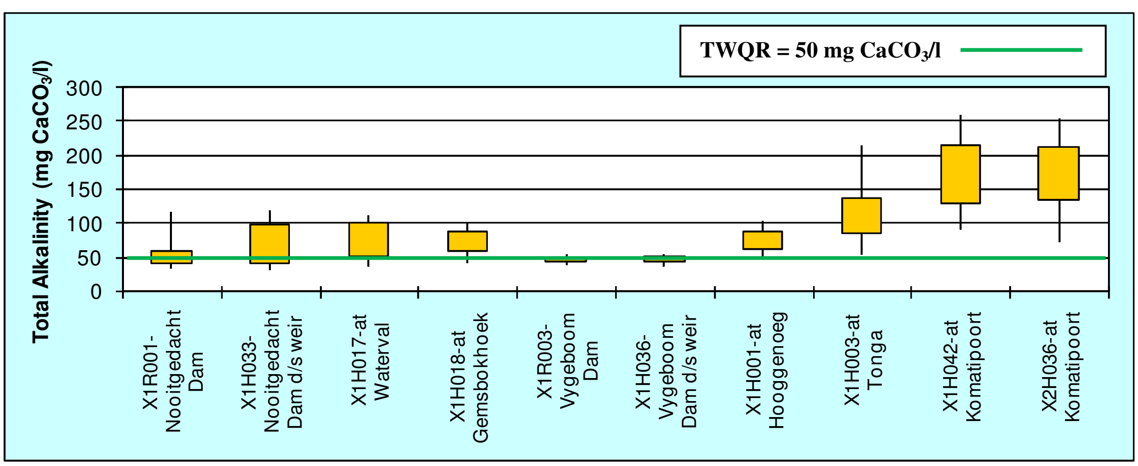



**Figure 20: Spatial variation in total alkalinity conc. (as mg $CaCO_3$/l) along the Komati River**

### 2.2.3 General Discussion of Results

The Komati River Catchment is characterized by substantial commercial farming and rural and urban settlements. The commercial farming encompasses the planting of crops such as sugar cane, maize, citrus and cash crops as well as forests such as pine, eucalyptus and wattle. The catchment also includes major water transfers from the Vygeboom and Nooitgedacht Dams to the Eskom power stations.

The major impacts on the water quality in the catchment are associated with diffuse sources including agricultural fertilisers, agricultural insecticides, pesticides and fungicides, sewage run-off and atmospheric deposition; and with point sources which include mining effluent, domestic sewage effluent and industrial effluent and organic pollutants (**AfriDev, 2006**).

In the Upper Komati region (Nooitgedacht Dam to Vygeboom Dam catchment) water quality appears to be in a good condition as the land use activity is minimal. The main impacts are related to dry land farming and forestry. The catchments are characterised by few agricultural practices and Carolina being the only major settlement. Commerical forestry is the dominant farming activity in this region. The slight increases in electrical conductivity, pH, alkalinity and sulphate readings in this region could be due to atmospheric depositions and coal mining in the area.

In the middle Komati River, in the reach between Vygeboom Dam and Swaziland, the water quality appears to be fairly good. There is minimal land use activity and hence the water quality is fairly un-impacted. This region also experiences higher rainfall which is a contributing factor to the quality observed in the river. The land use is characterised mainly by extensive grazing, limited cultivated land and a few settlements. The surrounding area of the Gladdespruit confluence with the Komati River is characterised by citrus and maize farming activities. The main water quality issues observed are elevated concentrations of the nutrients (phosphate, ammonia, nitrates) and slightly elevated salt concentrations at Hoogenoeg. As the middle Komati is more populated with a higher number of urban settlements, the water quality observed could be attributed to sewage effluent discharges and increased organic pollution. A further impact in the catchments are the water quality problems related to the changes in the river flows due to the transfers from the Vygeboom and Nooitgedacht Dams for Eskom.

The water quality in the lower Komati River appears to be significantly impacted with increased concentrations being observed for most water quality variables at the last three monitoring stations, namely X1H003, X1H042 and X2H036. As the Komati River flows through Swaziland it is bordered by intensive agricultural activity (within very close proximity of the river) and this continues into South Africa. This part of the catchment is characterised by intensive agricultural activity and intensive irrigation. This has resulted in the deterioration of the water quality. The available data shows that the main water quality issues appear to be related to nutrients and salinisation.

## 2.3 Water Quality Assessment of the Crocodile River

### 2.3.1 Identification of the Key Monitoring Points

The DWAF's RQS database has a total of 56 monitoring stations in the Crocodile River catchment. These stations are located from Kwena Dam in the Upper Crocodile (Crocodile West) to the confluence with the Komati River at Komatipoort in Crocodile East. The monitoring stations are located on the Crocodile River and on some major tributaries. The water quality data received was not very comprehensive as monitoring at some of the stations has ceased several years ago whilst at other stations monitoring is inconsistent resulting in scattered data, which is not representative of the entire monitoring period. Only 17 of stations had reliable, consistent data over a long monitoring period (greater than five years). **Table 3** lists the monitoring stations and includes the duration of the monitoring periods and locations of the monitoring stations.

**Table 3: Monitoring points selected for water quality assessment along the Crocodile River**

| Monitoring ID | Monitoring Point Name | Location Feature | No. of samples | Duration of Monitoring |
|---|---|---|---|---|
| 102953 | X2H006 – at Karino | Crocodile River | 610 | March 1962 – Nov 2006 |
| 102955 | X2H010 – at Bellevue | North Kaap River | 433 | Oct 1963 – Nov 2006 |
| 102956 | X2H011 – at Geluk | Elands River | 630 | March 1972 – Sept 2006 |
| 102958 | X2H013 – at Montrose | Crocodile River | 1246 | April 1966 – Dec 2006 |
| 102960 | X2H014 – at Sudwalaaskraal | Houtbosloopspruit | 530 | Aug 1966 – Nov 2006 |
| 102961 | X2H015 – at Lindenau | Elands River | 1267 | March 1972 – Nov 2006 |
| 102963 | X2H016 – at Ten Bosch | Crocodile River | 1856 | Feb 1970 – Dec 2006 |
| 102964 | X2H017 – at Thankerton | Crocodile River | 1184 | Nov 1969 – Dec 2006 |
| 102965 | X2H022 – at Dalton | Kaap River | 994 | June 1962 – Dec 2006 |
| 102974 | X2H031 – at Bornmansdrift | South Kaap River | 490 | Aug 1966 – Nov 2006 |
| 102975 | X2H032 – at Weltevrede | Crocodile River | 1466 | March 1972 – Dec 2006 |
| 102986 | X2H046 – at Riverside | Crocodile River | 927 | Oct 1986 – Dec 2006 |
| 102987 | X2H048 – at Malelane Bridge | Crocodile River | 372 | Oct 1983 – Aug 2006 |
| 102991 | X2H065 – Longemere Dam d/s weir | Wit River | 413 | July 1977 – Nov 2006 |
| 102993 | X2H068 – Witklip Dam d/s weir | Sand River | 112 | July 1977 – Oct 2006 |
| 102994 | X2H070 – Kwena Dam d/s weir | Crocodile River | 224 | Oct 1983 – Sept 2006 |
| 103006 | X2R005 – Kwena Dam | Dam/Barrage | 158 | Oct 1984 – Sept 2006 |

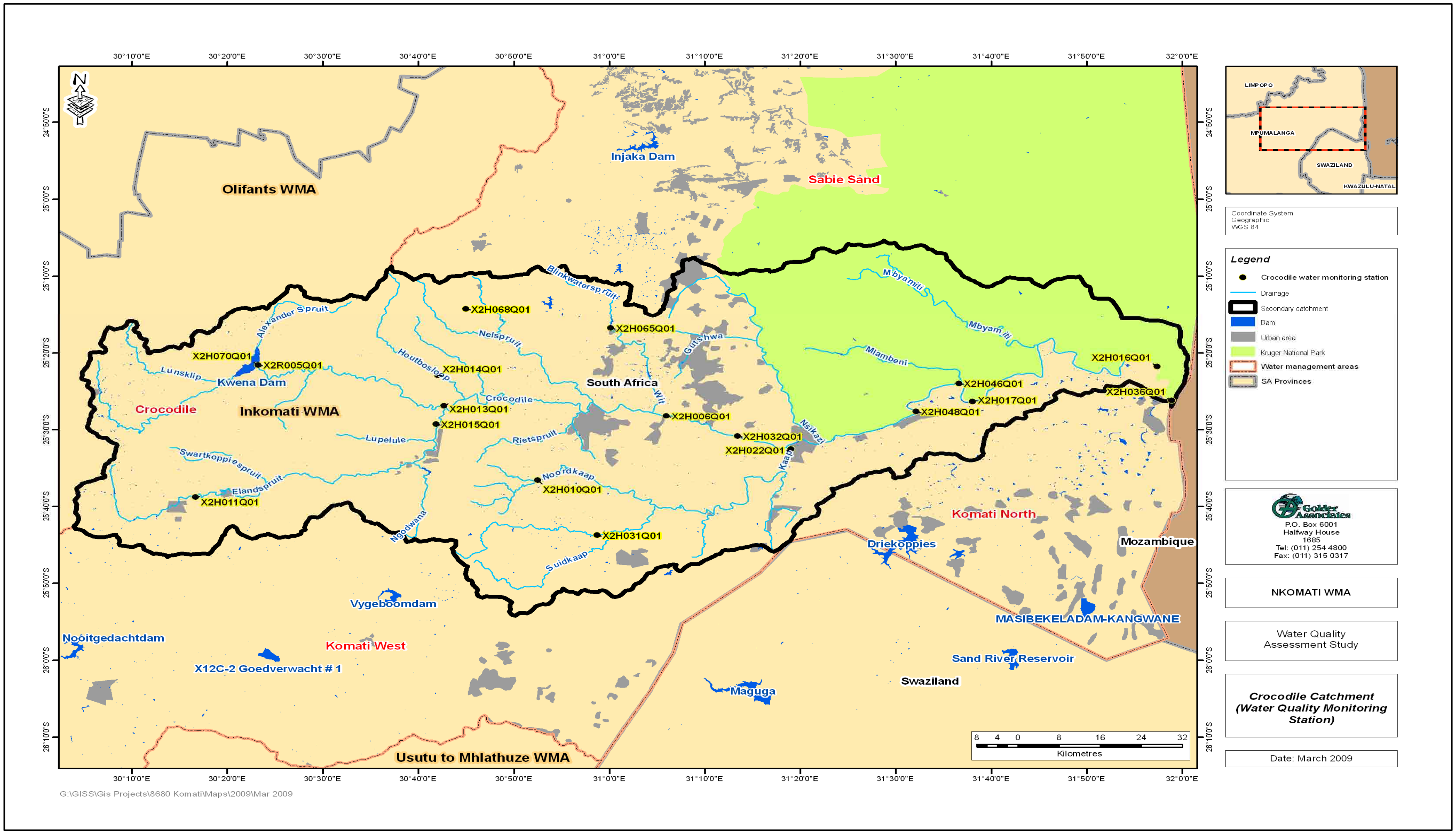



**Figure 21:** **Location of the monitoring points on the Crocodile River used for the assessment**

The water quality status assessment of the Crocodile River at these 17 stations was compiled by using the data from the last seven monitoring years (from 2000 to 2006). This provided a better understanding of the Present Ecological State (PES) according to the requirements of the Reserve study. The selected stations were monitored either on a weekly or monthly interval.

### 2.3.2 Results of the Water Quality Analysis

The $5^{th}$, $25^{th}$, $50^{th}$, $75^{th}$ and $95^{th}$ percentiles of each of the identified water quality variables were calculated using the data sets obtained from DWAF. The tabulated results per water quality variable per monitoring station are included in **Appendix A**.

The observed concentrations for each variable was then compared to the most stringent TWQR guideline selected as per the SAWQGs and described in **Section 2.1.4**. Reference was also made to the ecological specifications (EcoSpecs) for water quality as outlined in **AfriDev (2006)** study.

The following were observed for each variable along the Crocodile River:

**Chloride:**

The mean chloride concentration in the Crocodile River is 26.3 mg/l. The concentrations are low in the upper reaches of the river (mean, 11.83 mg/l) but increase significantly downstream from Malelane (in the Kruger National Park) to Ten Bosch (mean, 35.5 mg/l) and are shown in **Figure 21**. The chloride concentrations in the upper reaches of the catchment do comply with the TWQR guideline limit of 20mg/l. However, from Karino downstream to Komatipoort an increase in concentration is observed, along with non-compliance to the TWQR. The Elands River, a major tributary of the Crocodile River in the upper reaches of the catchment has significantly high concentrations of chloride (mean, 38.7 mg/l) which exceeds the TWQR. This observation is indicative that the land use activities (forestry, irrigated agriculture, paper mill) in this catchment are significantly impacting on the water resources. The impact of the Elands River could be a contributing factor to the higher concentrations observed in the Crocodile River at Karino. The Kaap River tributary has a mean concentration of chloride of 24.5 mg/l which could be contributing to the increase in concentration observed from Weltevrede (mean of 17.5 mg/l) to Malelane (mean of 32.9 mg/l). This area is also under pressure from intensive agricultural, industrial and urban land use.

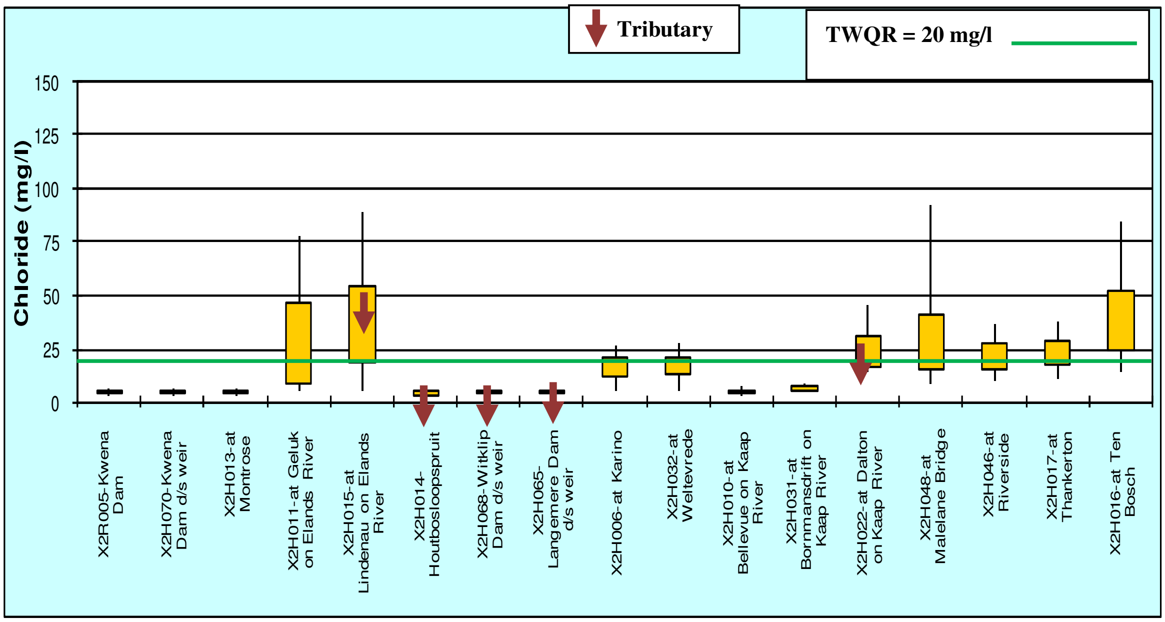



**Figure 21: Spatial variation of chloride concentrations (mg/l) along the Crocodile River**

**<u>Electrical Conductivity:</u>**

A similar trend to chloride is observed for electrical conductivity (EC) along the Crocodile River. The mean EC in the Crocodile River is 34.1 mS/m (222 mg/l TDS). The river shows a significant downstream increase in salts from Kwena Dam (mean, 14.1 mS/m) to Ten Bosch (mean, 49.1 mS/m) – a 250% increase as shown in **Figure 22**. These observations reflect the significant impact of the land use activities in the catchment. The EC in the Crocodile River is just within the TWQR in the upper preaches of the catchment, but is non-compliant from Karino downstream to Ten Bosch.

The Elands River tributary again shows high concentrations with the EC levels at 37.6 mS/m (mean). This tributary does appear to impact on the Crocodile River. The Kaap River also displays a similar trend with EC at a mean of 56.9 mS/m, which is impacting on the Crocodile River in the lower reaches.

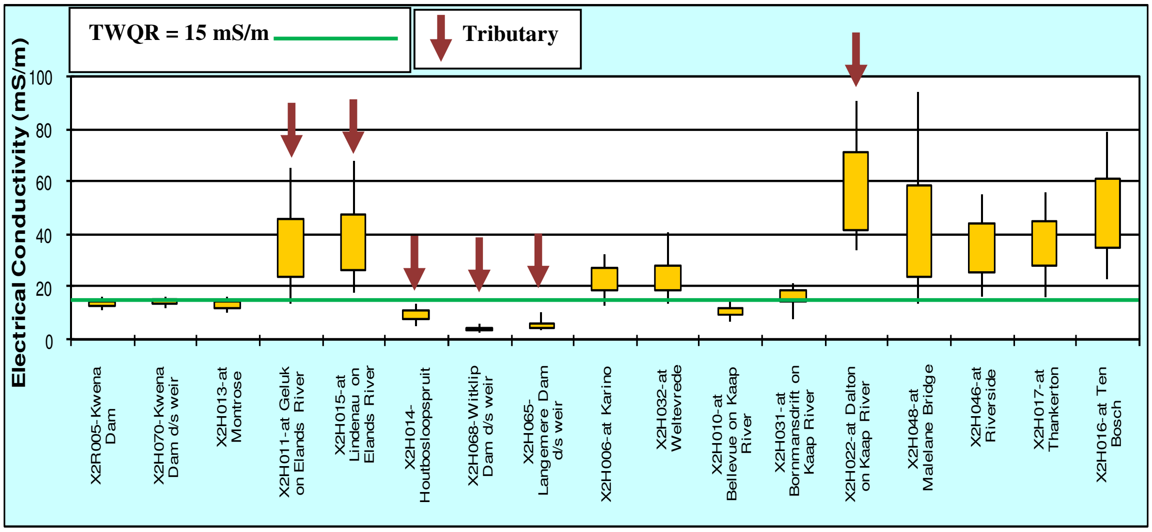



**Figure 22: Spatial variation in EC (mS/m) along the Crocodile River**

**Ammonia:**

The mean concentration of $NH_4$-N in the Crocodile River is relatively low - 0.046 mg/l as shown in **Figure 23**. A relatively steady trend is observed for ammonia along the Crocodile River with the exception of the middle catchment area where elevated concentrations of ammonia were observed. However, the elevated concentrations are observed mainly on the tributaries rather than main stem of the Crocodile River.

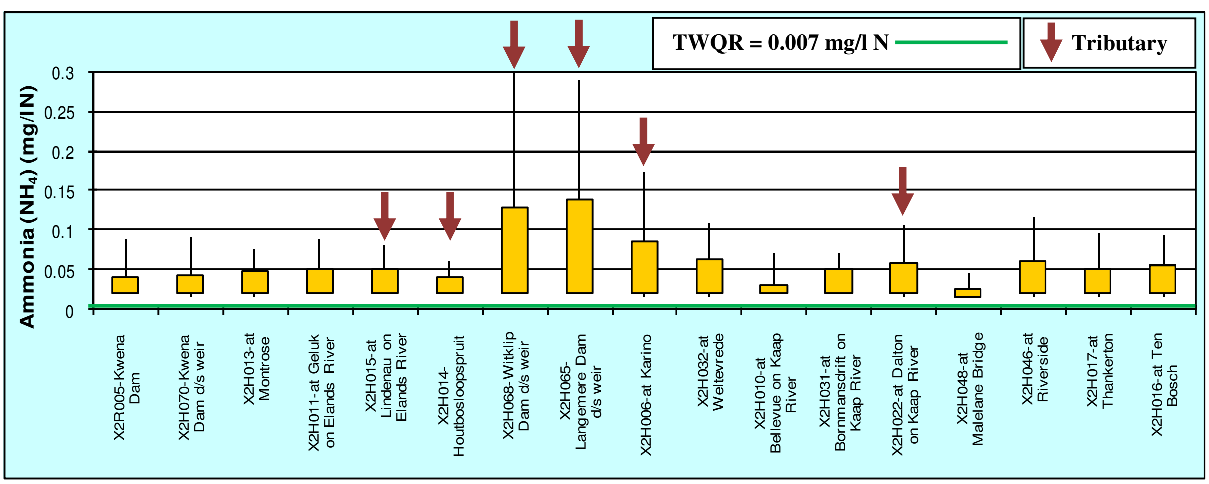



**Figure 23: Spatial variation in ammonia concentration (mg/l N) along the Crocodile River**

The mean concentration of $NH_4$-N at Karino which is downstream of the impacted tributaries is 0.098 mg/l which does indicate that the activities in these sub-catchments are impacting on the Crocodile River. The Crocodile River and its major tributaries do not comply with the TWQR of 0.007 mg/l for ammonia for the aquatic ecosystem (most stringent user), however the measured concentration plotted is total ammonia *i.e.* the free and saline ammonia so direct comparison to the 0.007mg/l TWQR is not possible.

**Nitrates and nitrites:**

The mean concentration of nitrates and nitrites observed in the Crocodile River is 0.43 mg/l N. The concentration is relatively low in the upper reaches of the river (mean, 0.16 mg/l) but shows an increasing trend downstream (mean of 0.5 mg/l from Karino to Ten Bosch) as shown in **Figure 24**. This is reflective of the intensive irrigation in the downstream catchments. Apart from the Kaap tributary, which has high concentrations of nitrates and nitrites (mean, 0.68 mg/l) the other tributaries have relatively low concentrations. The concentration of nitrate and nitrites in the Crocodile River are within the TWQR guideline limit of 6 mg/l N.

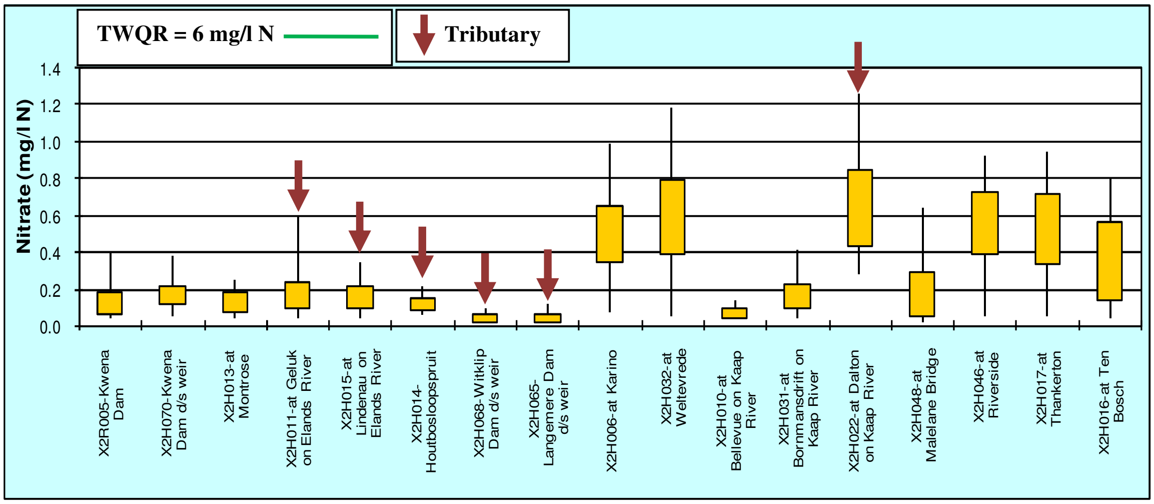



**Figure 24: Spatial variation in nitrate & nitrite concentrations (mg/l N) along the Crocodile River**

**Sodium:**

The concentration of sodium in the Crocodile River is relatively low with a mean concentration of 20.2 mg/l. The concentration of sodium in the upper reaches of the river is very low (mean of 4.2 mg/l) but this increases significantly in the downstream reaches from Karino to Komatipoort, (mean of 24.2 mg/l) as shown in **Figure 25**.

In the Elands and Kaap Rivers relatively high concentrations of sodium were also recorded. Sodium levels increase drastically from the Kaap / Crocodile confluence to Komatipoort. The high concentrations of sodium in these areas could be attributed to irrigation activities and associated irrigation return flows. The concentration of sodium in the Crocodile River for the most part (exceptions in lower catchment) complies with the TWQR guideline limit of 70 mg/l. The increase in sodium concentration at Lindenau is due to diffuse sources from the effluent irrigation at the SAPPI Ngodwana Mill.

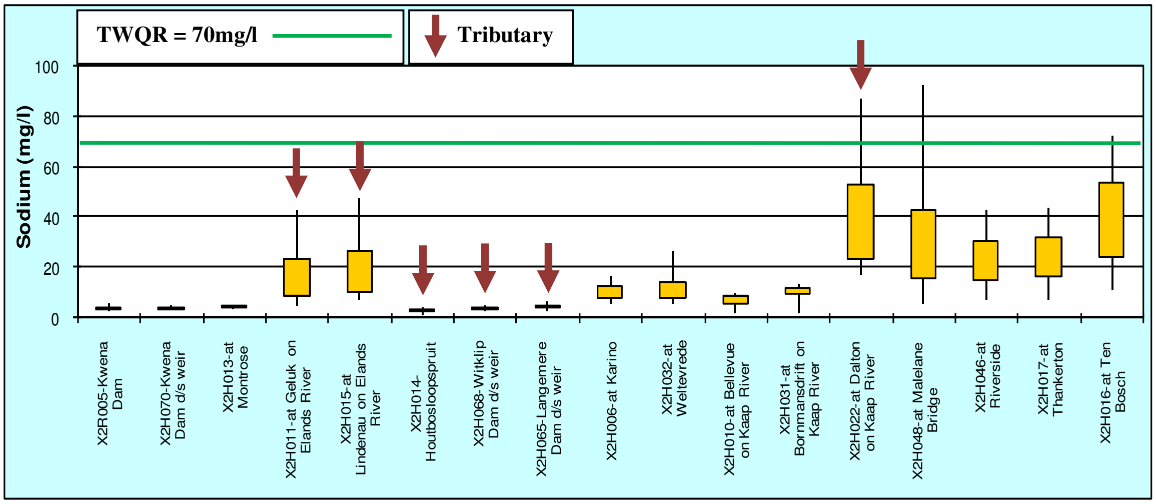



**Figure 25: Spatial variation in sodium concentration (mg/l) along the Crocodile River**

**Phosphates:**

The mean concentration of phosphate in the Crocodile River is 0.041 mg/l. The data shows a slight increase in downstream concentrations (mean, 0.045 mg/l) as shown in **Figure 26**. Exceptionally high levels were noted along the Crocodile River at Karino (mean of 0.052 mg/l) and Weltevrede (0.065 of mg/l). These observations are probably due to the land use activities in these areas, which are mainly urban, industrial and agricultural in nature and impact on downstream concentrations. The levels of phosphate in the Crocodile River and its tributaries do not comply with the TWQR guideline limit of 0.005 mg/l nor to the Reserve requirement of 0.017 mg/l.

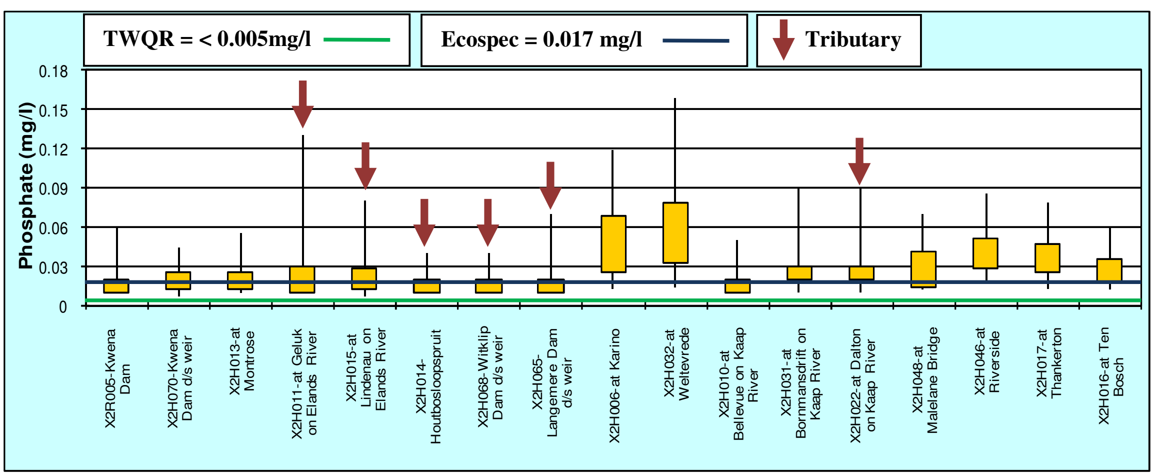



**Figure 26: Spatial variation in phosphate concentration (mg/l) along the Crocodile River**

**Sulphates:**

The sulphate concentration in the Crocodile River is relatively low in the upper reaches of the Crocodile catchments (mean of 6.3 mg/l) but increase going downstream as shown in **Figure 27**.

The mean concentration in the river is 20.2 mg/l. In the upper catchments the impact of return flows can be seen with high concentrations of sulphate being observed in the Elands River (mean of 31.6 mg/l). The concentration of sulphate increases again at Karino and Weltevrede and remains fairly steady as the river flows downstream (mean concentration of 23.8 mg/l). The Kaap River at Dalton shows significantly elevated concentrations of sulphate with a mean of 56 mg/l. This is probably associated with the abandoned gold mining activities in the Barberton area. The sulphate TWQR guideline limit is met in the upper reaches of the catchment, with non-compliances observed from Karino to Komatipoort and for the Elands and Kaap tributaries.

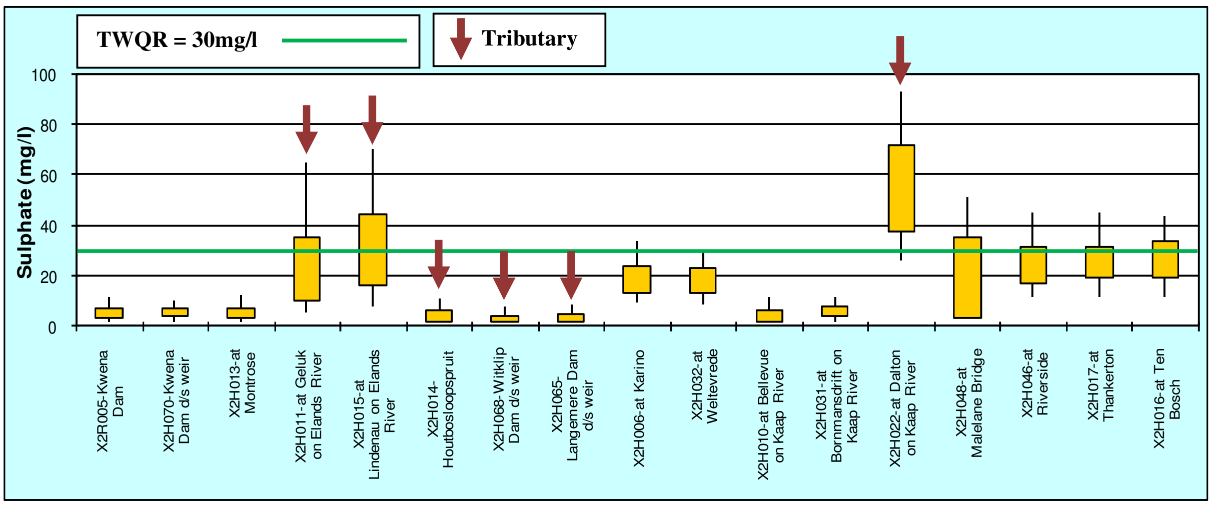



**Figure 27: Spatial variation in sulphate concentration (mg/l) along the Crocodile River**

**pH:**

The mean pH value in the Crocodile River is fairly steady along its length as shown in **Figure 28** and ranges between 7.8 and 8.0 from upstream to downstream. The pH along the river does comply with the TWQR guideline limit. The mean pH concentration in the Crocodile River catchments is 7.9.

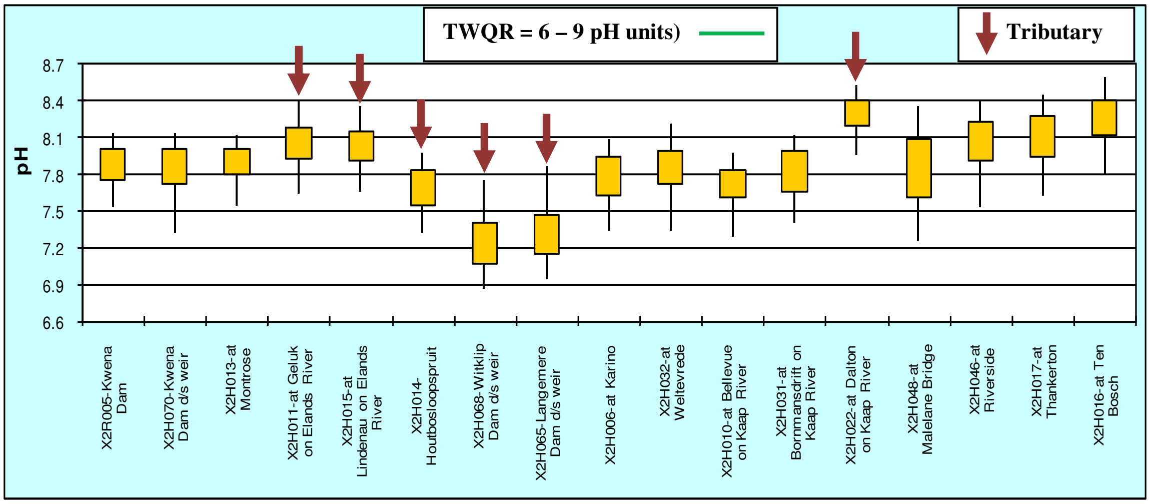



**Figure 28: Spatial variation in pH concentration along the Crocodile River**

**Magnesium:**

A similar trend to the other major ions is observed for magnesium in the Crocodile River. The upper reaches show low magnesium concentrations (mean of 7.7 mg/l) with the lower reaches having increased levels (mean of 16.4 mg/l) as shown in

**Figure** 29.

The concentrations increase from Karino downstream to Komatipoort. The Kaap River has high concentrations of magnesium (mean of 33.4 mg/l) and does appear to impact on the Crocodile River as it flows downstream. The TWQR guideline limit is generally complied with, with the exception of the Kaap River and some non-compliance in the lower Crocodile catchments.

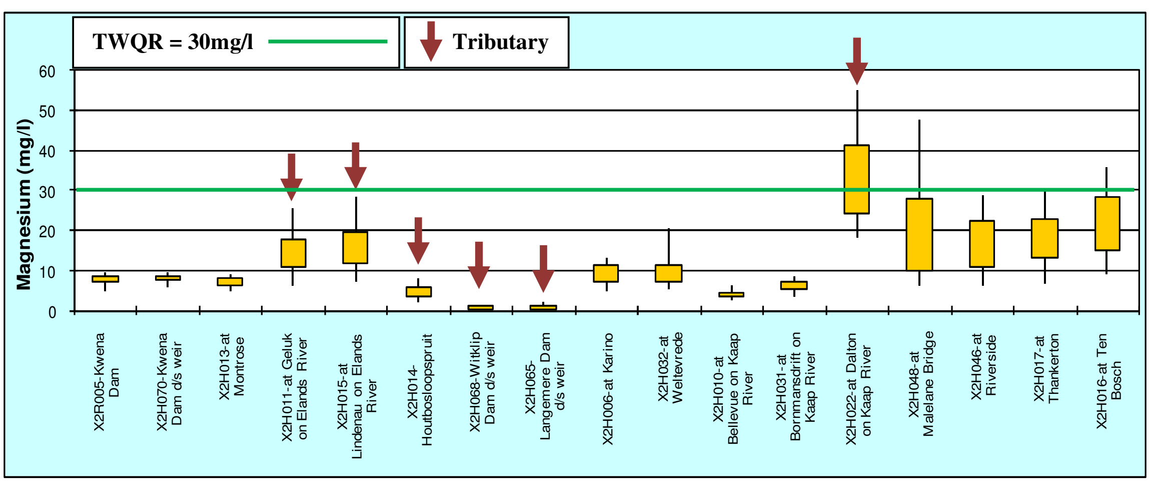



**Figure 29: Spatial variation magnesium in concentration (mg/l) along the Crocodile River**

**Total Alkalinity:**

The mean alkalinity concentration in the Crocodile River is 99.4 mg $CaCO_3$/l. This is consistent with the pH values recorded in the river. A similar trend to the salts and major ions is observed for alkalinity readings along the Crocodile River and is shown in **Figure 30**. The lower reaches again having higher concentrations (mean of 110.5 mg $CaCO_3$/l) due to upstream impacts. The Elands River and especially the Kaap River show increased concentrations in alkalinity. The TWQR guideline value is met in the upper reaches of the catchment, but non-compliance is observed from Karino to Komatipoort.

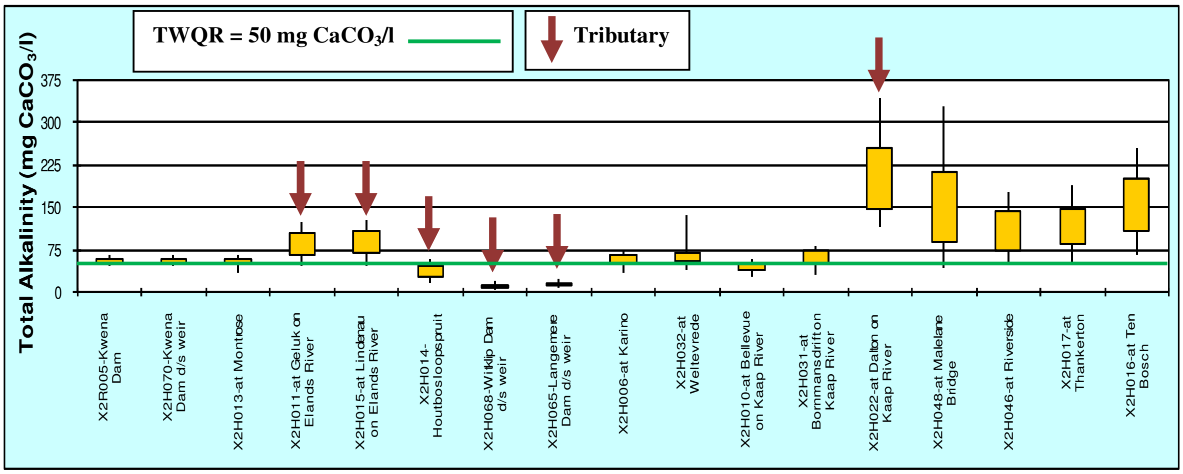



**Figure 30: Spatial variation in total alkalinity concentration ($CaCO_3$/l) along the Crocodile River**

## 2.3.3 General Discussion of Results

The Crocodile River Catchment is dominated by agricultural activities (pasture, dry land or irrigated cultivation), irrigation, forestry production and rural and urban settlements. There are also some mining activities in the Kaap River and the Sappi Mill in the Elands River catchment. The lower Crocodile region is occupied by the internationally renowned Kruger National Park. In recent times there has been an increase in urban development in the Crocodile River catchment which has led to concerns regarding the loss of natural habitats and increased pollution and waste (**WRC, 2001**).

The construction of weirs and dams in the upper Crocodile catchments to accommodate the increased trout farming near the towns of Dullstroom and Machadodorp has led to loss of wetland areas and is an overall threat to the status of the river. The encroachment of alien vegetation in this region, namely wattle, eucalyptus and poplar trees, also poses a problem to the availability and quality of water. The middle region of the Crocodile River is densely populated as it runs through the major towns of Nelspruit, Kaapmuiden and Malelane. The most important stresses and impacts in this part of the catchment are attributed to domestic and industrial land uses. The area is also characterised by commercial farming such as sugar cane, fruit orchards, vegetables and tobacco cultivation. The lower Crocodile River catchment forms the southern boundary of the Kruger National Park with a number of tourist lodges built on the banks of the river that have a negative affect on the quality of the water (increased nutrients). Citrus and sugar cane farming is also abundant in the area.

In general, the water quality in the upper Crocodile River catchment appears to be in a good to fair condition, with the exception of the Elands River sub-catchment. The area is of concern as it reflects escalated concentrations of salts (and major ions) and nutrients. The increased nutrients can be attributed to the greater number of communities located along this tributary (Machadodorp, Waterval Boven and Elandshoek) which inevitably leads to an increased sewage effluent and organic pollution from domestic origin. Another contributing factor is the increased trout farming activities in the area which are negatively impacting on the quality of water. A contributing factor to the increased salt concentrations observed in the Elands catchments are the return flows from the Sappi Paper Mill in the Ngodwana catchment.

The middle Crocodile River catchment is characterised by increased urbanisation and industrial activity. The river flows through the major towns of Nelspruit, Kaapmuiden and Malelane Commercial farming activities are also characteristic in these parts of the catchment and water is abstracted from the river for irrigation purposes. The impacts of these land use activities are observed at Karino and Weltevrede, where elevated concentrations of nutrients and salts are observed.

The lower Crocodile River poses the greatest problem in the catchment as a notable increase in the concentrations of most of the variables is observed at these monitoring stations. The lower eastern region of the Crocodile River is expected to be of conservation standards as it forms part of the boundary to the Kruger National Park. However, the quality of water in this region is much poorer in comparison to the Upper Crocodile. The contributing factors could be the great number of tourist lodges built along the bank of the river which results in an increase in nutrient concentrations. Irrigation of the citrus and sugar cane farming results in low flows which in turn impacts negatively on the overall water quality.

## 2.4 The Sabie River Catchments

### 2.4.1 Identification of the Key Monitoring Points

The DWAF's RQS database has a total of 105 monitoring stations in the Sabie River catchments. The monitoring stations are located on the Sabie and Sand Rivers and on some major tributaries. However, the majority of these stations were not monitored at all or their monitoring data was inconsistent and outdated (regular monitoring ceased in the late 1990s). Only 11 of these stations had reliable, recent and consistent data over a long monitoring period (greater than five years monitoring) and were chosen for this study.

**Table 4** lists these monitoring stations and duration of the monitoring period. The locations of the monitoring points used for the water quality assessment are shown in **Figure 31**.

**Table 4: Monitoring points selected for water quality assessment in the Sabie River**

| Monitoring ID | Monitoring Point Name | Location Feature | No. of samples | Duration of Monitoring |
|---|---|---|---|---|
| 103007 | X3H001 – at Sabie | Sabie River | 517 | April 1966 – Dec 2006 |
| 103008 | X3H002 – at Little Sabie | Sabie River | 533 | April 1966 – Dec 2006 |
| 103009 | X3H003 – at Geelhoutboom | Mac-Mac River | 490 | April 1966 – Dec 2006 |
| 103011 | X3H004 – at De Rust | North Sand River | 825 | Nov 1969 – Dec 2006 |
| 103012 | X3H006 – at Perry's Farm | Sabie River | 898 | Nov 1969 – Dec 2006 |
| 103014 | X3H008 – at Exeter | Sand River | 466 | July 1977 – Dec 2006 |
| 103015 | X3H011 – at Injaka Dam | Marite River | 966 | April 1979 – Dec 2006 |
| 103016 | X3H012 – at Phabene | Sabie River | 396 | Nov 1983 – Dec 2006 |
| 103019 | X3H015 – at Lower Sabie rest camp, KNP | Sabie River | 1191 | Oct 1983 – Dec 2006 |
| 103020 | X3H019 – right canal from Da Gama Dam | White Waters River | 132 | Feb 1998 – Dec 2006 |
| 103024 | X3R001 – Da Gama Dam | White Waters River | 171 | March 1975 – Dec 2006 |

The water quality status assessment of the Sabie River catchment at these 11 stations was compiled by using the data from the last seven monitoring years (from 2000 to 2006). This provided a better understanding of the Present Ecological State (PES) according to the requirements of the Reserve study. However, the X3H012 and X3R001 monitoring stations had a gap in the monitoring between 1999 and 2001. Therefore, data for these two stations was selected from 2001 to 2006. All the selected stations were monitored either on a weekly, 14 day or monthly interval.

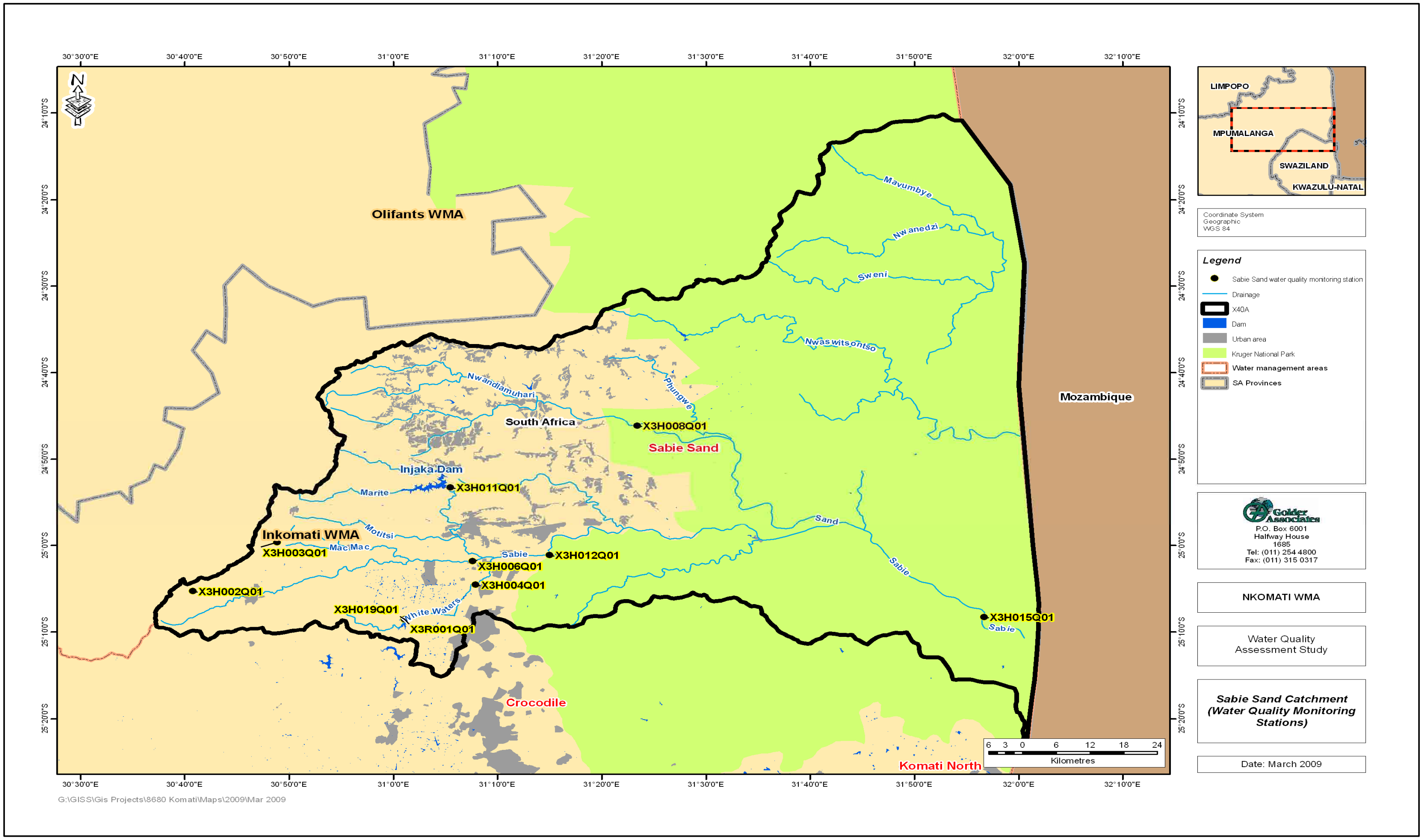



**Figure 31: Location of the monitoring points on the Sabie Rivers used for the assessment**

### 2.4.2 Results of the Water Quality Analysis

The 5th, 25th, 50th, 75th and 95th percentiles of each of the identified water quality variables were calculated using the data sets obtained from DWAF. The tabulated results per water quality variable per monitoring station are included in **Appendix A**.

The observed concentrations for each variable were compared to the most stringent TWQR guideline selected as per the SAWQGs in **Table 1** in **Section 2.1.4**. Reference was also made to the ecological specifications (EcoSpecs) for water quality as outlined by AfriDev (2006).

The following were observed for each variable in the Sabie River:

**Chloride:**

The mean chloride concentration in the Sabie River is 15.01 mg/l. The chloride concentrations in the upper part of the catchments are very close to natural concentrations (mean of 4.81 mg/l) and within the TWQR guideline limit of 20 mg/l. However, a significant increase in concentration is observed from Perry's Farm to the lower Sabie rest camp in the Kruger National Park (mean, 17 of 5 mg/l) which indicates deteriorating quality as the river flows downstream as shown in **Figure 32.**

The concentrations observed in the Sand River are also high (mean of 18.8 mg/l). Most of the values recorded in the lower Sand are above the TWQR guideline limit.

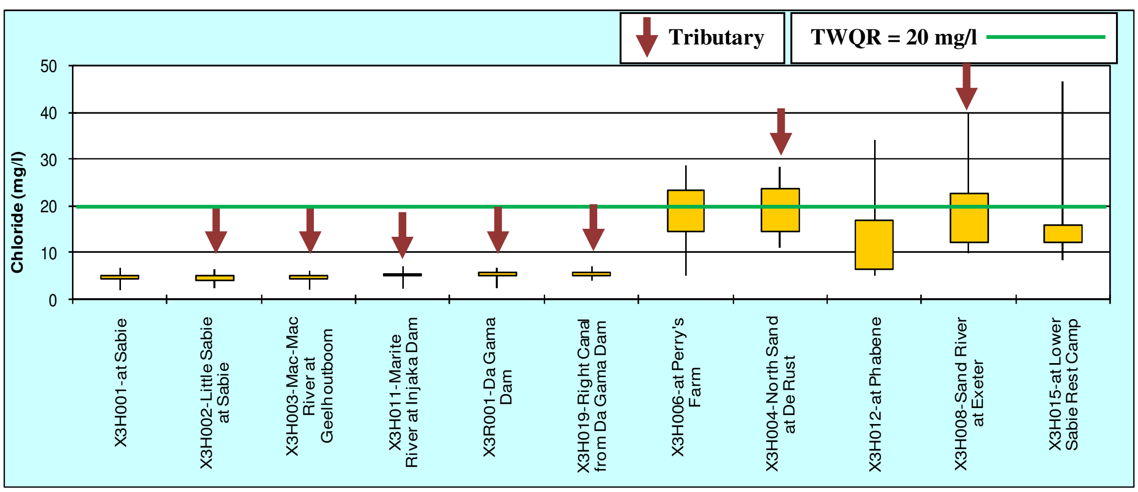



**Figure 32: Spatial variation in chloride concentration (mg/l) along the Sabie River**

**Electrical Conductivity:**

The mean concentration of EC in the Sabie River catchments is 19.6 mS/m. The electrical conductivity (EC) in the Upper Sabie is at a steady mean between 11 and 12 mS/m. At locations such as the Inyaka Dam on the Marite River and the Da Gama Dam in the White Waters River the conductivity drops to below 10 mS/m as shown in **Figure 33**. The observed conductivities are within the TWQR guideline limit in the upper parts of the catchments. An increase in concentration is observed once again from Perry's Farm to the rest camp in the Kruger National Park (mean of 21.1 mg/l). The deterioration in water quality due to the impact of salts is seen as the river flows through the Kruger National Park. However, the concentration of EC in the Sabie and Sand River catchments are below the TWQR guideline limit of 15 mS/m.

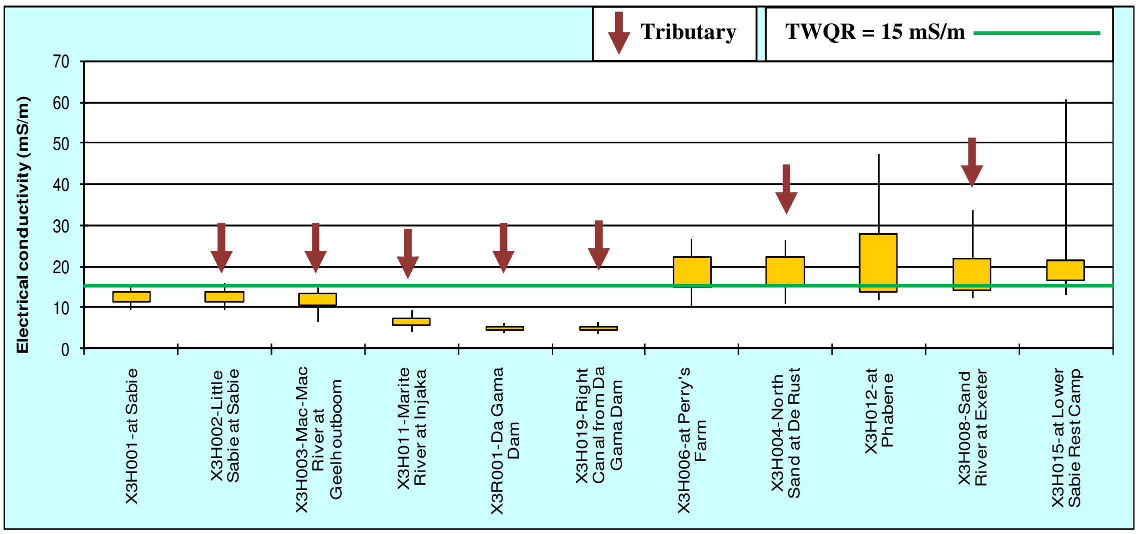



**Figure 33: Spatial variation in EC concentration (mS/m) along the Sabie River**

**Ammonia:**

The mean concentration of ammonia in the Sabie River is 0.05 mg/l N and is fairly constant. Relatively high concentrations of ammonia were observed at the Inyaka Dam on the Marite River as well as the Da Gama Dam on the White Waters River. The remaining monitoring stations displayed a steady trend with most concentration readings falling below 0.1 mg/l N as shown in **Figure 34**.

However, all the values recorded for ammonia along the river are above the most stringent TWQR guideline limit of 0.007 mg/l. As previously indicated, it must be emphasised that the TWQR for ammonia of 0.007mg/l N is for ammonia $NH_3$ and not total ammonia as reflected by the $NH_4$ concentration plotted in **Figure 34**.

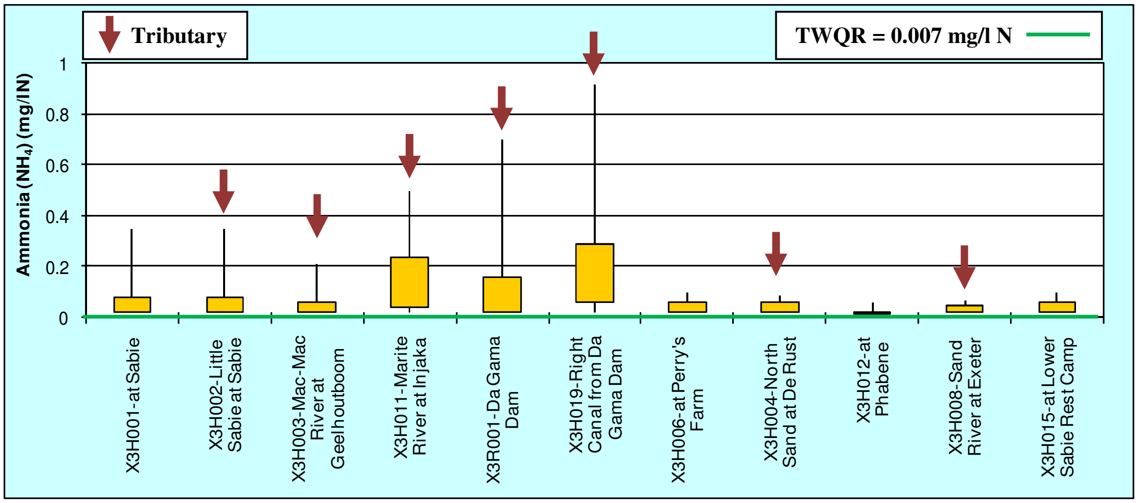



**Figure 34: Spatial variation in ammonia concentrations (mg/l N) along the Sabie River**

__Nitrates and nitrites:__

The concentration of nitrates and nitrites in the Sabie River is fairly low with a mean of 0.25 mg/l N. The concentration in the upper catchment is higher at a mean of 0.4 mg/l as compared to 0.21 mg/l in the lower reaches of the Sabie River and shown in **Figure 35**. The concentrations of nitrates and nitrites in the Klein Sabie and Mac-Mac Rivers are similar to that in the Sabie River while at the two major dams the concentrations drop significantly. The highest readings were observed in the middle of the catchment at Perry's Farm (mean, 0.31 mg/l N) and at De Rust (mean, 0.36 mg/l). Thereafter a decrease is observed as the river flows into the Kruger National Park. In general, the recorded nitrate and nitrite concentrations in the Sabie River catchment are below the domestic TWQR guideline limit of 6mg/l as N.

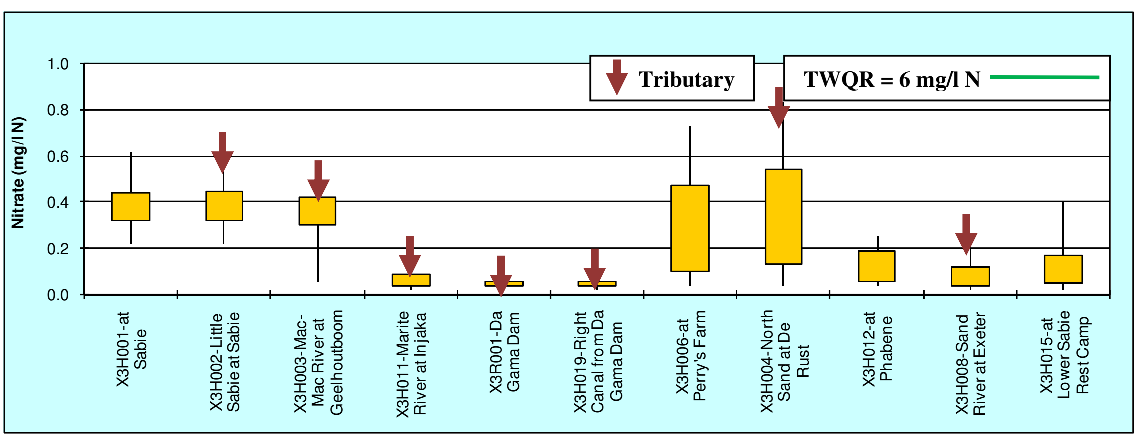



**Figure 35: Spatial variation in nitrate and nitrite concentrations (mg/l N) along the Sabie River**

**Sodium:**

The mean concentration of sodium observed in the Sabie River is relatively low (mean of 11.5 mg/l). A minimal increase in sodium concentration is observed in the upper Sabie River catchments and the concentration increases slightly from Perry's Farm to the rest camp in the Kruger National Park in the lower catchment as shown in **Figure 36**. However, all readings are below the TWQR guideline limit of 70 mg/l.

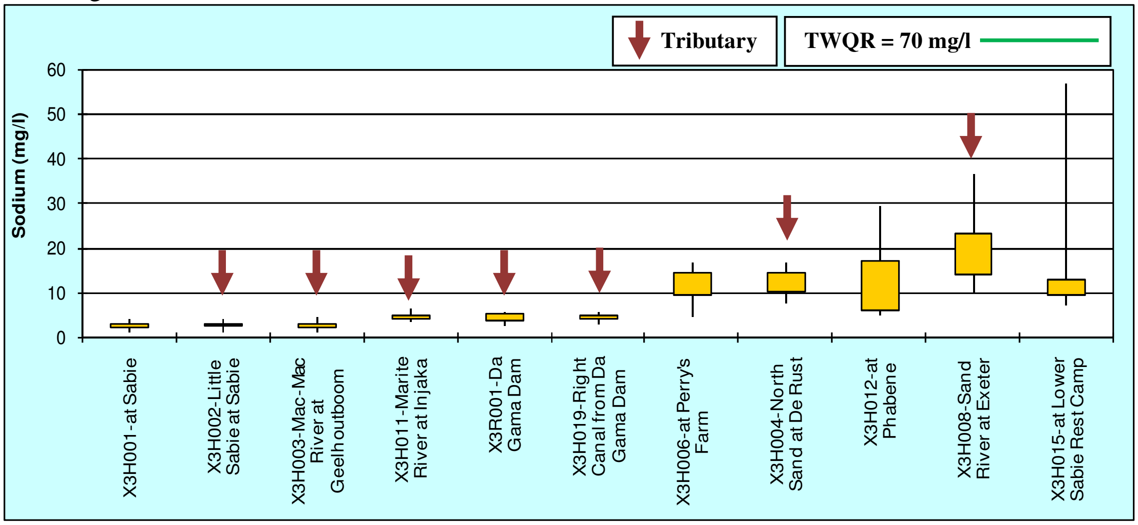



**Figure 36: Spatial variation in sodium concentration (mg/l) along the Sabie River**

**Phosphates:**

The phosphate readings in the Sabie River catchments are at a steady concentration with a mean concentration of 0.03 mg/l. There are slight increases observed at Perry's Farm on the Sabie River, at Exeter on the Sand River and at the Lower Sabie rest camp in the Kruger National Park as shown in **Figure 37**. Some values do not comply to the TWQR guideline limit of 0.005 mg/l.

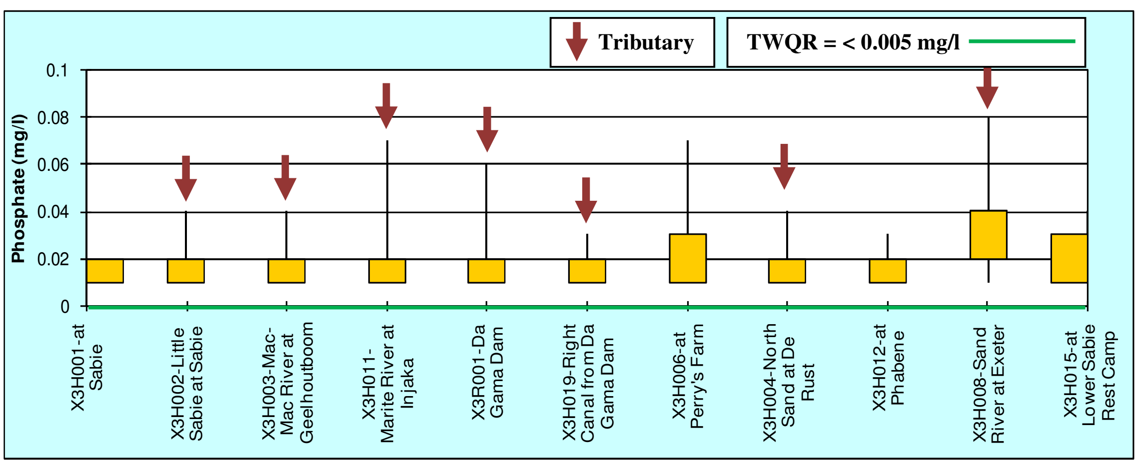



**Figure 37: Spatial variation in phosphate concentration (mg/l) along the Sabie River**

**Sulphates:**

The sulphate concentration in the Sabie River is low with a mean concentration of 8.40 mg/l. The concentration is fairly steady along the length of the river and tributaries and is shown in **Figure 38**. The concentrations of sulphate observed in the catchment are within the TWQR guideline limit of 30 mg/l with a slight exception at the rest camp in the Kruger National Park where some of the values recorded were above the guideline limit.

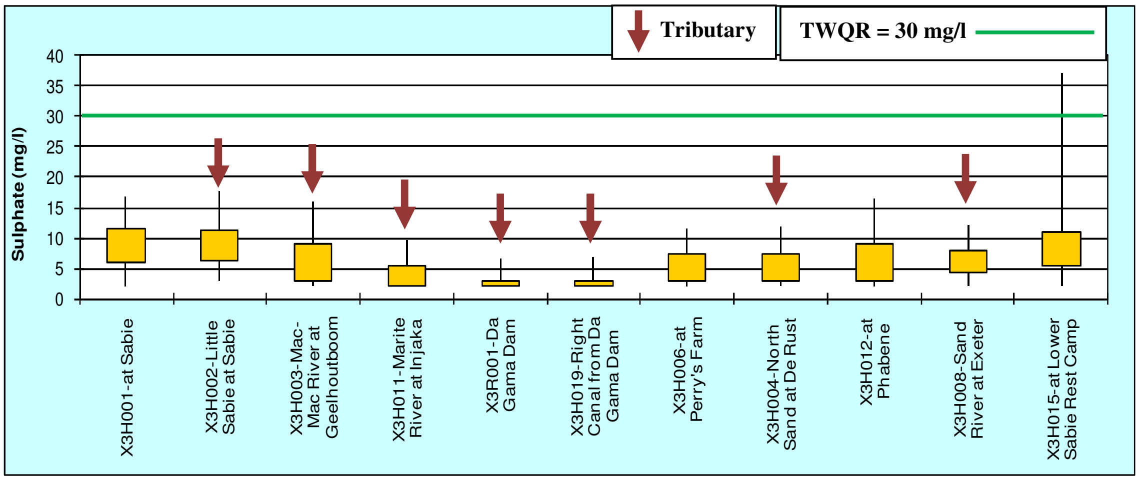



**Figure 38: Spatial variation in sulphate concentration (mg/l) along the Sabie River**

**pH:**

A general fluctuation trend can be seen for pH with the values ranging between 7.0 and 8.5 and shown in **Figure 39.** The mean concentration of pH in the Sabie River is 7.82. The observed values are compliant with the TWQR guideline limits.

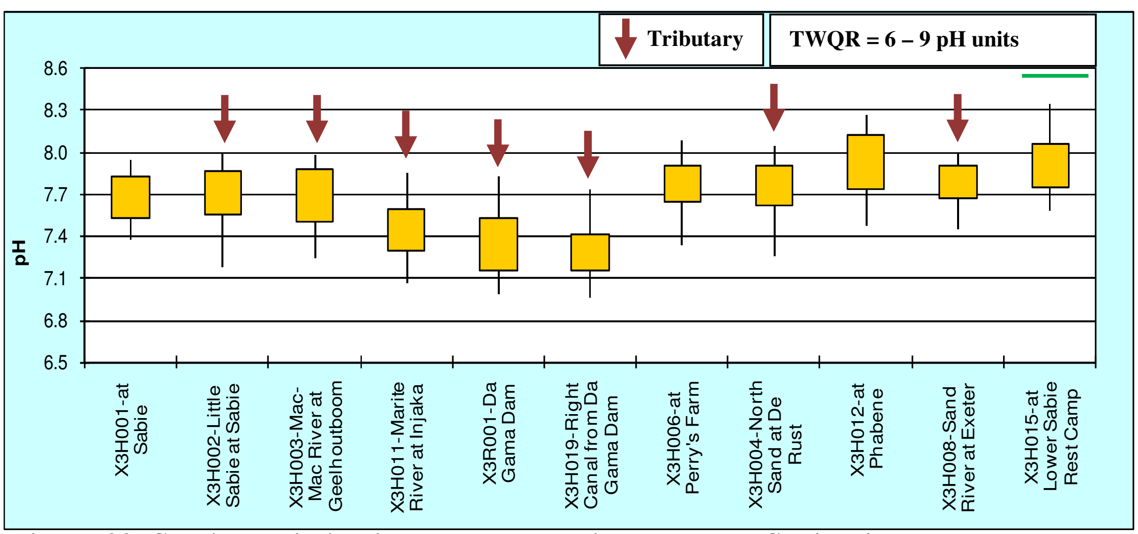



**Figure 39: Spatial variation in pH concentration along the Sabie River**

**Magnesium:**

Low concentrations of magnesium (mean of 8.1 mg/l) were observed in the Sabie River. The concentrations in the upper catchment drop to below 5 mg/l in the locations of the two major dams. The concentration of magnesium increases slightly from Perry's Farm into the Kruger National Park (mean of 8.61 mg/l) as shown in **Figure 40**.

All readings recorded within the Sabie Rivers are below the TWQR guideline limit of 30 mg/l.

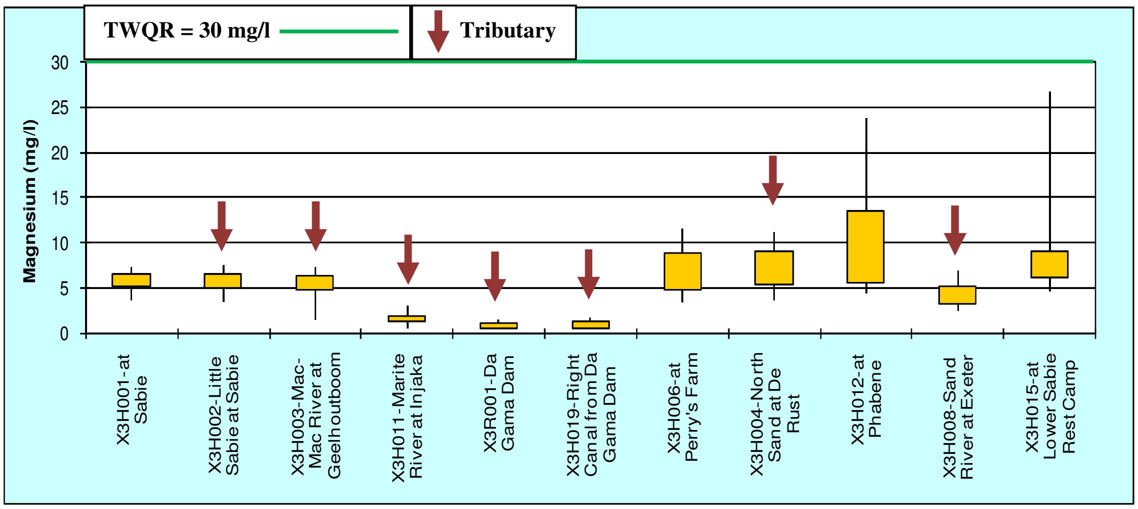



**Figure 40: Spatial variation in magnesium concentrations (mg/l) along the Sabie River**

**Total Alkalinity:**

The mean alkalinity concentration observed in the Sabie River is 60.9 mg $CaCO_3$/l. The concentration in the lower catchment shows a slight increase from Phabene to the Sabie rest camp with these points displaying the highest alkalinity levels (Figure 41). In general, the alkalinity readings for all the stations in the upper Sabie River region did not deviate far from the recommended TWQR guideline limit of 50 mg/l. However, in the lower Sabie and lower Sand River regions the majority of the readings recorded were above this guideline value.

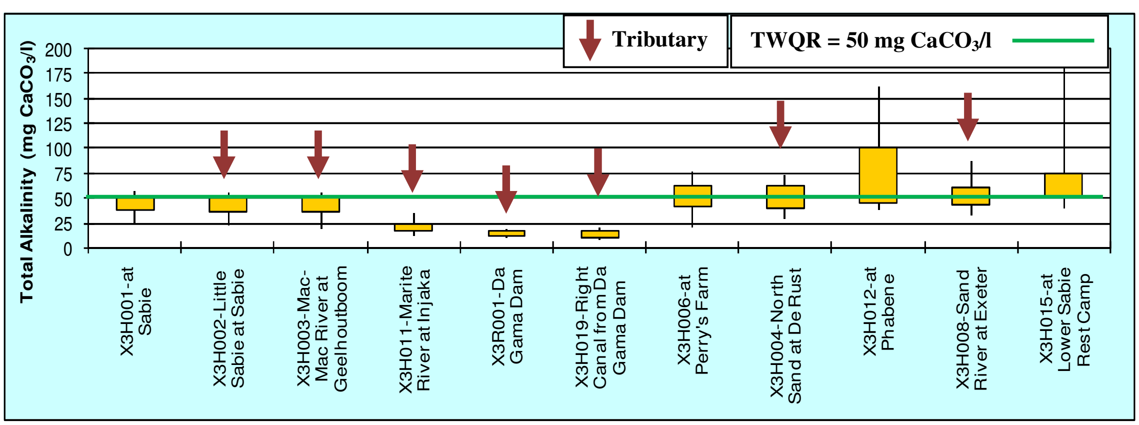



**Figure 41: Spatial variation in total alkalinity concentration (mg $CaCO_3$/l) along the Sabie River.**

### 2.4.3 General Discussion of Results

Overall, the water quality in the upper Sabie River region can be described as being in a good condition. The monitoring stations near the two dams revealed that the quality of water in these tributaries is in a good state with the exception of ammonia concentrations. The lower Sabie and lower Sand River reaches pose the greatest concern as a notable increase in the concentrations of most of the variables is observed at these monitoring stations.

The dominant land uses in the Sabie River catchments are forestry production, agricultural, industrial, irrigation and domestic (**WRC, 2001**). The upper section of the Drakensberg Escarpment is covered with mountain grasslands with extensive forests in gorges and slopes and the lower escarpment is considered a bushveld area. The increasing alien vegetation is a risk to the availability of water in these areas. Trout farming is also becoming a popular activity in these areas. A number of small communities such as Sabie, Graskop and Kiepersol are located in this region of the catchment. The area is also characterised by commercial farming such as banana plantations and madumbi (similar to sweet potato) and the minimal industrial activities (saw mills) are located in the Klein Sabie River area.

The lower Sabie and Sand River catchments are dominated by a large number of rural settlements. The activities of the local communities include subsistence and small scale farming of livestock and fruit. However, much of the lower catchment area falls within the Kruger National Park where conservation and eco-tourism are the most prominent activities.

The higher escarpment area of the upper Sabie River catchment is in a good state with increasing degradation observed further downstream. This can be attributed to the invasion of alien vegetation and the increasing forestry activities in the area. Trout (especially in the Mac-Mac River) has also become a threat to the health of the river as it competes with indigenous fish species and hence affects the concentration of nutrients in the river. Furthermore, the diversion of water into dams and weirs for trout farming activities had led to a decrease in water flows. The sewage output from the various small communities such as Sabie, Graskop and Kiepersol also lowers the quality of water in the catchment. In addition, sawdust from a local sawmill has a negative impact on the water quality. Organic contaminants are leached into the river during rainfalls which leads to an increase in the pH of the water (**WRC, 2001**). Irrigation of the banana plantations and small fruit orchards in the area may also impact negatively on the water flows and quality.

The lower Sabie and lower Sand River catchments are predominantly within the Kruger National Park and hence strict conservation measures are implemented in this region. However, the unprotected areas are vulnerable to increasing urbanisation and other land uses. The Sand River is densely populated with several rural communities. This results in an increased waste output and organic pollution in the rivers. Another threat to the quality of water in this region is overgrazing by livestock which causes extensive erosion of the river banks and in-stream sedimentation problems (**WRC, 2001**).

# 3 OVERALL CONCLUSIONS

The water quality of the Inkomati WMA appears to be in a good to fair condition. The main water quality issues are related to nutrients and in certain catchments elevated salt levels. These issues are related mainly to the land based activities such as urbanisation, industrial activity and agricultural activity (intensive irrigation). The control of these sources will contribute to maintaining the quality at current levels and prevent any further deterioration. The reduction of flows in the lower reaches of the river systems due to stream flow reduction activities and upstream abstractions will result in the continued deterioration in the downstream water quality due to the reduction in the assimilative capacities of rivers in the Inkomati WMA.

## 3.1 Komati River Catchment

The river water quality in the Komati River catchments meets the water quality requirements specified. The main water quality issues are related to ammonia and related nutrients, which requires stricter management. The other variables such as chloride, sodium, EC and sulphate do sometimes exceed the TWQR limits, but these deviations are not significant enough to identify trends or specific issues. With stricter source management controls the limits for these variables will be adhered to. Positive progress is clearly visible with respect to nitrate and nitrite concentrations. Current water quality management strategies must be reinforced and extended to manage all potential threats.

With regards to the effects on quality as a result of surrounding land use practices, the intensified agricultural activities in the lower Komati have attributed to a slightly poorer water quality status in the lowest reaches of the river within South Africa. Any further reduction in flows will impact negatively on the water quality of the lower Komati River.

## 3.2 Crocodile River Catchment

Overall, the quality of water in Crocodile River catchment can be described as good to fair. Most of the variables are within acceptable TWQR limits. The only areas of concern are the densely populated communities of the Elands River and the Crocodile East region where stricter controls need to be enforced with respect to solid waste disposal and effluent discharge. In the Elands River catchment the lower reaches at Lindenau are impacted by the irrigation effluent from the Sappi Paper Mill in the Ngodwana catchment. The extent of this impact needs to be investigated and stricter controls should be imposed to ensure that any further deterioration in the quality of the Elands River is minimised.

## 3.3 The Sabie River Catchment

The water quality of the Sabie River catchment can be described as being in a good condition mainly due to the conservation rules followed by the Kruger National Park. Most of the variables analysed have relatively low concentrations and are within the TWQR guideline values. The major factors affecting the health of the Sabie Rivers are the encroachment of alien vegetation, increased trout farming activities and increasing urban development.

# 4 REFERENCES

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WRC, 2001. **State-of-Rivers Report: Crocodile, Sabie – Sand and Olifants River Systems**. A report of the River Health Programme. Pretoria. Report No. TT/147/01.

# APPENDICES

# APPENDIX A

# PERCENTILE VALUES OF WATER QUALITY VARIABLES ANALYSED

## TABLES OF PERCENTILES FOR STATIONS ALONG THE KOMATI RIVER CATCHMENT

**102931 - X1H001**

| Percentile | Cl (mg/l) | EC (mS/m) | $NH_4$ (mg/l N) | $NO_3 + NO_2$ (mg/l N) | Na (mg/l) | $PO_4$ (mg/l) | $SO_4$ (mg/l) | pH (pH units) | Mg (mg/l) | Alkalinity (mg $CaCO_3$/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.05 | 4.25 | 14.46 | 0.02 | 0.02 | 7.11 | 0.01 | 3.00 | 7.34 | 5.35 | 49.93 |
| 0.25 | 5.00 | 16.73 | 0.02 | 0.06 | 8.24 | 0.01 | 6.67 | 7.72 | 7.11 | 61.39 |
| 0.50 | 5.94 | 19.00 | 0.02 | 0.08 | 9.66 | 0.02 | 7.99 | 7.86 | 8.75 | 76.03 |
| 0.75 | 6.88 | 21.70 | 0.05 | 0.16 | 10.88 | 0.03 | 9.89 | 8.04 | 10.90 | 89.18 |
| 0.95 | 8.69 | 25.42 | 0.11 | 0.32 | 13.07 | 0.06 | 14.99 | 8.26 | 13.04 | 104.82 |

**102933 - X1H003**

| Percentile | Cl (mg/l) | EC (mS/m) | $NH_4$ (mg/l N) | $NO_3 + NO_2$ (mg/l N) | Na (mg/l) | $PO_4$ (mg/l) | $SO_4$ (mg/l) | pH (pH units) | Mg (mg/l) | Alkalinity (mg $CaCO_3$/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.05 | 15.50 | 21.36 | 0.02 | 0.04 | 12.53 | 0.01 | 6.11 | 7.69 | 7.27 | 54.27 |
| 0.25 | 41.57 | 35.80 | 0.02 | 0.06 | 32.53 | 0.01 | 8.38 | 7.92 | 11.34 | 85.77 |
| 0.50 | 52.28 | 42.30 | 0.04 | 0.16 | 40.23 | 0.02 | 10.83 | 8.12 | 14.27 | 107.74 |
| 0.75 | 83.62 | 59.20 | 0.05 | 0.27 | 64.38 | 0.03 | 13.18 | 8.26 | 19.47 | 136.56 |
| 0.95 | 153.29 | 88.12 | 0.09 | 0.56 | 109.92 | 0.06 | 24.16 | 8.41 | 31.54 | 215.11 |

**102937 - X1H017**

| Percentile | Cl (mg/l) | EC (mS/m) | $NH_4$ (mg/l N) | $NO_3 + NO_2$ (mg/l N) | Na (mg/l) | $PO_4$ (mg/l) | $SO_4$ (mg/l) | pH (pH units) | Mg (mg/l) | Alkalinity (mg $CaCO_3$/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.05 | 2.58 | 10.43 | 0.02 | 0.02 | 4.56 | 0.00 | 2.00 | 6.03 | 6.60 | 37.56 |
| 0.25 | 3.50 | 11.58 | 0.02 | 0.02 | 4.60 | 0.00 | 2.00 | 7.00 | 7.30 | 51.30 |
| 0.50 | 5.00 | 13.05 | 0.02 | 0.02 | 5.50 | 0.01 | 4.50 | 7.35 | 9.10 | 61.30 |
| 0.75 | 13.20 | 20.38 | 0.04 | 0.05 | 7.50 | 0.01 | 7.39 | 8.18 | 14.60 | 102.60 |
| 0.95 | 19.30 | 25.62 | 0.05 | 0.12 | 8.84 | 0.02 | 8.68 | 8.39 | 17.42 | 112.30 |

**102938 - X1H018**

| Percentile | Cl (mg/l) | EC (mS/m) | $NH_4$ (mg/l N) | $NO_3 + NO_2$ (mg/l N) | Na (mg/l) | $PO_4$ (mg/l) | $SO_4$ (mg/l) | pH (pH units) | Mg (mg/l) | Alkalinity (mg $CaCO_3$/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.05 | 2.50 | 11.77 | 0.02 | 0.04 | 4.36 | 0.01 | 2.00 | 7.47 | 5.48 | 42.56 |
| 0.25 | 5.00 | 15.40 | 0.02 | 0.10 | 5.44 | 0.01 | 3.00 | 7.71 | 8.21 | 59.85 |
| 0.50 | 5.84 | 17.80 | 0.02 | 0.14 | 6.08 | 0.02 | 6.45 | 7.92 | 10.38 | 75.20 |
| 0.75 | 6.93 | 21.38 | 0.05 | 0.19 | 7.03 | 0.03 | 8.63 | 8.06 | 12.49 | 89.47 |
| 0.95 | 8.75 | 23.64 | 0.09 | 0.39 | 8.38 | 0.05 | 13.05 | 8.30 | 14.61 | 102.36 |

**102947 - X1HO33**

| Percentile | Cl (mg/l) | EC (mS/m) | $NH_4$ (mg/l N) | $NO_3 + NO_2$ (mg/l N) | Na (mg/l) | $PO_4$ (mg/l) | $SO_4$ (mg/l) | pH (pH units) | Mg (mg/l) | Alkalinity (mg $CaCO_3$/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| **0.05** | 5.00 | 14.08 | 0.02 | 0.02 | 5.90 | 0.00 | 8.27 | 6.79 | 5.69 | 32.38 |
| **0.25** | 6.30 | 16.18 | 0.02 | 0.02 | 7.20 | 0.01 | 11.35 | 7.51 | 7.05 | 41.28 |
| **0.50** | 8.60 | 19.25 | 0.04 | 0.07 | 8.30 | 0.01 | 14.70 | 7.84 | 9.50 | 66.25 |
| **0.75** | 11.30 | 24.90 | 0.06 | 0.13 | 8.90 | 0.02 | 18.00 | 8.07 | 14.66 | 98.03 |
| **0.95** | 14.65 | 27.50 | 0.10 | 0.24 | 10.10 | 0.03 | 26.45 | 8.38 | 18.36 | 118.43 |

**102948 - X1H036**

| Percentile | Cl (mg/l) | EC (mS/m) | $NH_4$ (mg/l N) | $NO_3 + NO_2$ (mg/l N) | Na (mg/l) | $PO_4$ (mg/l) | $SO_4$ (mg/l) | pH (pH units) | Mg (mg/l) | Alkalinity (mg $CaCO_3$/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| **0.05** | 2.00 | 11.80 | 0.02 | 0.04 | 3.48 | 0.01 | 3.00 | 7.36 | 5.41 | 37.47 |
| **0.25** | 2.50 | 12.49 | 0.02 | 0.05 | 4.43 | 0.01 | 6.40 | 7.60 | 6.05 | 44.02 |
| **0.50** | 5.00 | 13.20 | 0.03 | 0.12 | 4.73 | 0.01 | 7.70 | 7.76 | 6.29 | 48.98 |
| **0.75** | 5.37 | 14.10 | 0.06 | 0.17 | 5.14 | 0.02 | 10.82 | 7.89 | 6.78 | 51.60 |
| **0.95** | 6.43 | 15.14 | 0.09 | 0.23 | 6.39 | 0.04 | 15.25 | 8.04 | 7.22 | 55.36 |

**102949 - X1H042**

| Percentile | Cl (mg/l) | EC (mS/m) | $NH_4$ (mg/l N) | $NO_3 + NO_2$ (mg/l N) | Na (mg/l) | $PO_4$ (mg/l) | $SO_4$ (mg/l) | pH (pH units) | Mg (mg/l) | Alkalinity (mg $CaCO_3$/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| **0.05** | 25.96 | 31.57 | 0.02 | 0.04 | 22.53 | 0.01 | 13.08 | 7.76 | 13.00 | 92.28 |
| **0.25** | 38.05 | 47.48 | 0.02 | 0.11 | 34.71 | 0.02 | 20.48 | 8.20 | 19.16 | 129.00 |
| **0.50** | 56.47 | 59.10 | 0.05 | 0.29 | 49.82 | 0.03 | 25.60 | 8.31 | 26.81 | 179.23 |
| **0.75** | 99.36 | 74.43 | 0.06 | 0.52 | 67.82 | 0.04 | 30.27 | 8.44 | 33.79 | 216.28 |
| **0.95** | 147.43 | 94.45 | 0.10 | 0.79 | 85.67 | 0.06 | 44.88 | 8.67 | 45.33 | 259.16 |

**102950 - X1R001**

| Percentile | Cl (mg/l) | EC (mS/m) | $NH_4$ (mg/l N) | $NO_3 + NO_2$ (mg/l N) | Na (mg/l) | $PO_4$ (mg/l) | $SO_4$ (mg/l) | pH (pH units) | Mg (mg/l) | Alkalinity (mg $CaCO_3$/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| **0.05** | 2.50 | 13.62 | 0.02 | 0.02 | 4.80 | 0.01 | 4.80 | 7.24 | 6.01 | 34.27 |
| **0.25** | 5.00 | 15.60 | 0.02 | 0.04 | 6.81 | 0.01 | 11.59 | 7.55 | 6.41 | 41.51 |
| **0.50** | 7.64 | 16.50 | 0.03 | 0.06 | 7.16 | 0.01 | 15.58 | 7.73 | 6.83 | 49.55 |
| **0.75** | 8.59 | 19.90 | 0.06 | 0.08 | 7.51 | 0.02 | 19.95 | 7.94 | 8.14 | 59.12 |
| **0.95** | 10.37 | 27.26 | 0.17 | 0.16 | 8.30 | 0.04 | 23.20 | 8.13 | 17.55 | 116.37 |

**102951 - X1R003**

| Percentile | Cl (mg/l) | EC (mS/m) | $NH_4$ (mg/l N) | $NO_3 + NO_2$ (mg/l N) | Na (mg/l) | $PO_4$ (mg/l) | $SO_4$ (mg/l) | pH (pH units) | Mg (mg/l) | Alkalinity (mg $CaCO_3$/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| **0.05** | 2.50 | 11.53 | 0.02 | 0.02 | 3.31 | 0.01 | 3.00 | 7.38 | 5.08 | 38.67 |
| **0.25** | 3.43 | 12.01 | 0.02 | 0.04 | 4.28 | 0.01 | 6.00 | 7.59 | 5.96 | 43.69 |
| **0.50** | 5.00 | 12.71 | 0.02 | 0.06 | 4.65 | 0.01 | 7.97 | 7.76 | 6.24 | 47.04 |
| **0.75** | 5.01 | 13.70 | 0.05 | 0.12 | 5.08 | 0.02 | 10.27 | 7.85 | 6.56 | 50.44 |
| **0.95** | 6.65 | 14.50 | 0.09 | 0.17 | 6.26 | 0.04 | 13.62 | 7.99 | 7.18 | 54.90 |

**102979 - X2H036**

| Percentile | Cl (mg/l) | EC (mS/m) | $NH_4$ (mg/l N) | $NO_3 + NO_2$ (mg/l N) | Na (mg/l) | $PO_4$ (mg/l) | $SO_4$ (mg/l) | pH (pH units) | Mg (mg/l) | Alkalinity (mg $CaCO_3$/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| **0.05** | 17.28 | 25.34 | 0.02 | 0.04 | 16.63 | 0.01 | 12.65 | 7.81 | 10.33 | 72.81 |
| **0.25** | 35.05 | 45.10 | 0.02 | 0.11 | 34.14 | 0.02 | 20.35 | 8.11 | 18.88 | 133.97 |
| **0.50** | 53.07 | 57.70 | 0.05 | 0.28 | 47.85 | 0.03 | 26.67 | 8.30 | 25.89 | 180.60 |
| **0.75** | 82.31 | 70.60 | 0.07 | 0.47 | 64.93 | 0.04 | 31.87 | 8.42 | 30.99 | 213.27 |
| **0.95** | 142.08 | 91.92 | 0.12 | 0.71 | 84.71 | 0.05 | 40.59 | 8.65 | 40.70 | 254.92 |

## TABLES OF PERCENTILES FOR STATIONS IN THE CROCODILE RIVER CATCHMENT

**102953 - X2H006**

| Percentile | Cl (mg/l) | EC (mS/m) | $NH_4$ (mg/l N) | $NO_3 + NO_2$ (mg/l N) | Na (mg/l) | $PO_4$ (mg/l) | $SO_4$ (mg/l) | pH (pH units) | Mg (mg/l) | Alkalinity (mg $CaCO_3$/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| **0.05** | 5.00 | 12.55 | 0.02 | 0.07 | 5.32 | 0.01 | 9.15 | 7.33 | 4.90 | 36.38 |
| **0.25** | 12.22 | 18.70 | 0.02 | 0.34 | 7.93 | 0.03 | 13.20 | 7.62 | 7.25 | 50.14 |
| **0.50** | 15.75 | 23.10 | 0.05 | 0.47 | 10.07 | 0.04 | 16.78 | 7.82 | 9.42 | 59.31 |
| **0.75** | 21.24 | 27.20 | 0.09 | 0.65 | 12.85 | 0.07 | 23.45 | 7.94 | 11.41 | 66.87 |
| **0.95** | 26.56 | 32.43 | 0.17 | 0.98 | 16.41 | 0.12 | 33.70 | 8.09 | 13.04 | 74.46 |

**102958 - X2H013**

| Percentile | Cl (mg/l) | EC (mS/m) | $NH_4$ (mg/l N) | $NO_3 + NO_2$ (mg/l N) | Na (mg/l) | $PO_4$ (mg/l) | $SO_4$ (mg/l) | pH (pH units) | Mg (mg/l) | Alkalinity (mg $CaCO_3$/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| **0.05** | 2.50 | 10.03 | 0.02 | 0.04 | 3.17 | 0.01 | 2.00 | 7.54 | 4.88 | 35.87 |
| **0.25** | 5.00 | 12.30 | 0.02 | 0.07 | 3.70 | 0.01 | 3.00 | 7.81 | 6.52 | 52.00 |
| **0.50** | 5.00 | 14.10 | 0.02 | 0.13 | 4.12 | 0.02 | 5.36 | 7.93 | 7.49 | 56.12 |
| **0.75** | 5.00 | 15.00 | 0.05 | 0.18 | 4.55 | 0.03 | 6.85 | 8.01 | 8.22 | 60.45 |
| **0.95** | 6.72 | 16.36 | 0.08 | 0.25 | 5.01 | 0.06 | 12.63 | 8.13 | 9.18 | 68.16 |

**102963 - X2H016**

| Percentile | Cl (mg/l) | EC (mS/m) | $NH_4$ (mg/l N) | $NO_3 + NO_2$ (mg/l N) | Na (mg/l) | $PO_4$ (mg/l) | $SO_4$ (mg/l) | pH (pH units) | Mg (mg/l) | Alkalinity (mg $CaCO_3$/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| **0.05** | 14.41 | 22.84 | 0.02 | 0.04 | 11.03 | 0.01 | 11.71 | 7.81 | 9.25 | 64.91 |
| **0.25** | 23.60 | 35.10 | 0.02 | 0.14 | 24.12 | 0.02 | 19.20 | 8.12 | 14.88 | 109.87 |
| **0.50** | 35.41 | 48.80 | 0.02 | 0.33 | 37.48 | 0.03 | 26.79 | 8.26 | 22.47 | 157.78 |
| **0.75** | 52.26 | 61.10 | 0.06 | 0.57 | 53.77 | 0.04 | 33.32 | 8.41 | 28.50 | 201.71 |
| **0.95** | 84.68 | 79.16 | 0.09 | 0.80 | 72.40 | 0.06 | 43.45 | 8.60 | 35.91 | 255.36 |

**102964 - X2H017**

| Percentile | Cl (mg/l) | EC (mS/m) | $NH_4$ (mg/l N) | $NO_3 + NO_2$ (mg/l N) | Na (mg/l) | $PO_4$ (mg/l) | $SO_4$ (mg/l) | pH (pH units) | Mg (mg/l) | Alkalinity (mg $CaCO_3$/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| **0.05** | 11.24 | 16.46 | 0.02 | 0.06 | 7.25 | 0.01 | 11.64 | 7.62 | 6.99 | 53.50 |
| **0.25** | 17.73 | 28.20 | 0.02 | 0.34 | 16.50 | 0.03 | 19.43 | 7.95 | 13.23 | 87.88 |
| **0.50** | 22.84 | 39.60 | 0.02 | 0.52 | 24.40 | 0.03 | 26.57 | 8.12 | 19.57 | 125.58 |
| **0.75** | 28.36 | 44.90 | 0.05 | 0.71 | 32.05 | 0.05 | 31.49 | 8.27 | 23.07 | 147.92 |
| **0.95** | 37.05 | 55.96 | 0.10 | 0.94 | 43.65 | 0.08 | 45.28 | 8.45 | 29.67 | 189.44 |

**102975 - X2H032**

| Percentile | Cl (mg/l) | EC (mS/m) | $NH_4$ (mg/l N) | $NO_3 + NO_2$ (mg/l N) | Na (mg/l) | $PO_4$ (mg/l) | $SO_4$ (mg/l) | pH (pH units) | Mg (mg/l) | Alkalinity (mg $CaCO_3$/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| **0.05** | 5.00 | 14.19 | 0.02 | 0.06 | 5.94 | 0.01 | 8.36 | 7.34 | 5.21 | 39.95 |
| **0.25** | 12.73 | 18.73 | 0.02 | 0.39 | 8.14 | 0.03 | 13.35 | 7.73 | 7.32 | 53.70 |
| **0.50** | 16.33 | 23.55 | 0.04 | 0.52 | 10.80 | 0.05 | 17.12 | 7.89 | 9.45 | 63.50 |
| **0.75** | 20.55 | 27.90 | 0.06 | 0.79 | 14.03 | 0.08 | 22.70 | 7.99 | 11.48 | 72.28 |
| **0.95** | 27.53 | 41.17 | 0.11 | 1.18 | 26.74 | 0.16 | 29.96 | 8.21 | 20.57 | 137.43 |

**102986 - X2H046**

| Percentile | Cl (mg/l) | EC (mS/m) | $NH_4$ (mg/l N) | $NO_3 + NO_2$ (mg/l N) | Na (mg/l) | $PO_4$ (mg/l) | $SO_4$ (mg/l) | pH (pH units) | Mg (mg/l) | Alkalinity (mg $CaCO_3$/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| **0.05** | 10.07 | 16.12 | 0.02 | 0.06 | 7.15 | 0.02 | 11.63 | 7.52 | 6.30 | 50.91 |
| **0.25** | 15.67 | 25.48 | 0.02 | 0.39 | 15.10 | 0.03 | 17.22 | 7.92 | 10.83 | 76.02 |
| **0.50** | 22.43 | 37.25 | 0.02 | 0.53 | 23.66 | 0.04 | 25.25 | 8.09 | 17.89 | 117.55 |
| **0.75** | 27.87 | 44.23 | 0.06 | 0.72 | 30.78 | 0.05 | 31.32 | 8.23 | 22.55 | 144.65 |
| **0.95** | 36.38 | 55.11 | 0.12 | 0.92 | 42.98 | 0.08 | 45.41 | 8.40 | 28.60 | 179.67 |

**102987 - X2H048**

| Percentile | Cl (mg/l) | EC (mS/m) | $NH_4$ (mg/l N) | $NO_3 + NO_2$ (mg/l N) | Na (mg/l) | $PO_4$ (mg/l) | $SO_4$ (mg/l) | pH (pH units) | Mg (mg/l) | Alkalinity (mg $CaCO_3$/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| **0.05** | 8.28 | 14.14 | 0.02 | 0.02 | 6.00 | 0.01 | 3.00 | 7.26 | 6.13 | 44.55 |
| **0.25** | 15.39 | 24.15 | 0.02 | 0.05 | 16.08 | 0.01 | 3.00 | 7.61 | 9.99 | 89.44 |
| **0.50** | 29.86 | 47.00 | 0.02 | 0.06 | 34.37 | 0.03 | 9.87 | 7.83 | 22.51 | 156.28 |
| **0.75** | 41.32 | 58.25 | 0.03 | 0.29 | 43.11 | 0.04 | 34.86 | 8.09 | 28.00 | 214.85 |
| **0.95** | 91.53 | 93.63 | 0.05 | 0.64 | 92.65 | 0.07 | 51.22 | 8.36 | 47.82 | 326.72 |

**102994 - X2H070**

| Percentile | Cl (mg/l) | EC (mS/m) | $NH_4$ (mg/l N) | $NO_3 + NO_2$ (mg/l N) | Na (mg/l) | $PO_4$ (mg/l) | $SO_4$ (mg/l) | pH (pH units) | Mg (mg/l) | Alkalinity (mg $CaCO_3$/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| **0.05** | 2.50 | 11.83 | 0.02 | 0.05 | 3.11 | 0.01 | 2.00 | 7.33 | 5.77 | 47.43 |
| **0.25** | 4.97 | 13.80 | 0.02 | 0.12 | 3.76 | 0.01 | 3.81 | 7.73 | 7.65 | 52.93 |
| **0.50** | 5.00 | 14.50 | 0.02 | 0.17 | 4.12 | 0.02 | 6.35 | 7.89 | 8.18 | 56.24 |
| **0.75** | 5.29 | 15.30 | 0.04 | 0.22 | 4.42 | 0.03 | 7.39 | 8.00 | 8.71 | 60.13 |
| **0.95** | 6.40 | 16.62 | 0.09 | 0.38 | 5.16 | 0.04 | 9.89 | 8.13 | 9.48 | 67.08 |

**102956 - X2H011**

| Percentile | Cl (mg/l) | EC (mS/m) | $NH_4$ (mg/l N) | $NO_3 + NO_2$ (mg/l N) | Na (mg/l) | $PO_4$ (mg/l) | $SO_4$ (mg/l) | pH (pH units) | Mg (mg/l) | Alkalinity (mg $CaCO_3$/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| **0.05** | 5.00 | 13.92 | 0.02 | 0.04 | 4.94 | 0.01 | 5.41 | 7.64 | 6.18 | 48.84 |
| **0.25** | 8.32 | 24.30 | 0.02 | 0.09 | 8.53 | 0.01 | 9.76 | 7.93 | 11.02 | 68.65 |
| **0.50** | 24.94 | 30.35 | 0.02 | 0.16 | 14.81 | 0.02 | 22.32 | 8.06 | 14.59 | 86.61 |
| **0.75** | 46.07 | 45.63 | 0.05 | 0.24 | 23.14 | 0.03 | 34.81 | 8.18 | 17.91 | 105.01 |
| **0.95** | 77.28 | 64.85 | 0.09 | 0.60 | 42.57 | 0.13 | 65.05 | 8.41 | 25.53 | 124.53 |

**102960 - X2H014**

| Percentile | Cl (mg/l) | EC (mS/m) | $NH_4$ (mg/l N) | $NO_3 + NO_2$ (mg/l N) | Na (mg/l) | $PO_4$ (mg/l) | $SO_4$ (mg/l) | pH (pH units) | Mg (mg/l) | Alkalinity (mg $CaCO_3$/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| **0.05** | 2.00 | 5.36 | 0.02 | 0.06 | 1.00 | 0.01 | 2.00 | 7.32 | 2.40 | 16.39 |
| **0.25** | 2.50 | 7.50 | 0.02 | 0.08 | 2.38 | 0.01 | 2.00 | 7.54 | 3.50 | 29.13 |
| **0.50** | 5.00 | 9.50 | 0.02 | 0.11 | 2.81 | 0.02 | 3.00 | 7.71 | 4.60 | 37.12 |
| **0.75** | 5.00 | 11.61 | 0.04 | 0.15 | 3.09 | 0.02 | 6.22 | 7.83 | 6.02 | 49.38 |
| **0.95** | 5.00 | 14.20 | 0.06 | 0.22 | 4.16 | 0.04 | 10.83 | 7.97 | 7.95 | 59.34 |

**102961 - X2H015**

| Percentile | Cl (mg/l) | EC (mS/m) | $NH_4$ (mg/l N) | $NO_3 + NO_2$ (mg/l N) | Na (mg/l) | $PO_4$ (mg/l) | $SO_4$ (mg/l) | pH (pH units) | Mg (mg/l) | Alkalinity (mg $CaCO_3$/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| **0.05** | 5.00 | 17.93 | 0.02 | 0.04 | 6.88 | 0.01 | 7.71 | 7.66 | 7.35 | 48.50 |
| **0.25** | 18.16 | 26.10 | 0.02 | 0.09 | 10.57 | 0.01 | 15.91 | 7.91 | 11.65 | 70.00 |
| **0.50** | 34.36 | 33.70 | 0.02 | 0.15 | 17.70 | 0.02 | 27.95 | 8.04 | 15.82 | 88.67 |
| **0.75** | 54.29 | 47.43 | 0.05 | 0.22 | 26.36 | 0.03 | 44.08 | 8.15 | 19.64 | 107.42 |
| **0.95** | 88.52 | 68.19 | 0.08 | 0.34 | 47.41 | 0.08 | 70.21 | 8.36 | 28.37 | 126.88 |

**102965 - X2H022**

| Percentile | Cl (mg/l) | EC (mS/m) | $NH_4$ (mg/l N) | $NO_3 + NO_2$ (mg/l N) | Na (mg/l) | $PO_4$ (mg/l) | $SO_4$ (mg/l) | pH (pH units) | Mg (mg/l) | Alkalinity (mg $CaCO_3$/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| **0.05** | 13.60 | 33.67 | 0.02 | 0.28 | 17.10 | 0.01 | 26.11 | 7.96 | 18.29 | 115.98 |
| **0.25** | 16.54 | 41.75 | 0.02 | 0.44 | 23.10 | 0.02 | 37.13 | 8.20 | 24.02 | 148.46 |
| **0.50** | 20.92 | 53.50 | 0.04 | 0.61 | 30.68 | 0.03 | 53.40 | 8.32 | 31.74 | 183.39 |
| **0.75** | 31.16 | 70.80 | 0.06 | 0.85 | 53.15 | 0.03 | 71.88 | 8.40 | 41.30 | 254.28 |
| **0.95** | 44.87 | 90.91 | 0.11 | 1.26 | 86.70 | 0.09 | 92.74 | 8.53 | 55.05 | 344.13 |

**102991 - X2H065**

| Percentile | Cl (mg/l) | EC (mS/m) | $NH_4$ (mg/l N) | $NO_3 + NO_2$ (mg/l N) | Na (mg/l) | $PO_4$ (mg/l) | $SO_4$ (mg/l) | pH (pH units) | Mg (mg/l) | Alkalinity (mg $CaCO_3$/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| **0.05** | 2.50 | 3.54 | 0.02 | 0.02 | 2.87 | 0.01 | 2.00 | 6.94 | 0.50 | 7.43 |
| **0.25** | 5.00 | 4.21 | 0.02 | 0.02 | 3.92 | 0.01 | 2.00 | 7.15 | 0.50 | 11.30 |
| **0.50** | 5.00 | 5.09 | 0.05 | 0.04 | 4.60 | 0.02 | 3.00 | 7.30 | 1.13 | 14.10 |
| **0.75** | 5.69 | 5.79 | 0.14 | 0.06 | 5.19 | 0.02 | 5.05 | 7.46 | 1.41 | 16.58 |
| **0.95** | 7.66 | 10.13 | 0.29 | 0.12 | 6.71 | 0.07 | 8.38 | 7.86 | 2.30 | 25.82 |

**102993 - X2H068**

| Percentile | Cl (mg/l) | EC (mS/m) | $NH_4$ (mg/l N) | $NO_3 + NO_2$ (mg/l N) | Na (mg/l) | $PO_4$ (mg/l) | $SO_4$ (mg/l) | pH (pH units) | Mg (mg/l) | Alkalinity (mg $CaCO_3$/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| **0.05** | 2.00 | 3.17 | 0.02 | 0.02 | 2.50 | 0.01 | 2.00 | 6.86 | 0.50 | 4.00 |
| **0.25** | 4.66 | 3.74 | 0.02 | 0.02 | 3.18 | 0.01 | 2.00 | 7.07 | 0.50 | 9.18 |
| **0.50** | 5.00 | 4.19 | 0.06 | 0.04 | 3.63 | 0.02 | 2.00 | 7.21 | 0.50 | 11.24 |
| **0.75** | 5.00 | 4.54 | 0.13 | 0.06 | 3.98 | 0.02 | 4.16 | 7.41 | 1.09 | 13.62 |
| **0.95** | 5.49 | 5.88 | 0.30 | 0.09 | 4.79 | 0.04 | 7.65 | 7.75 | 1.50 | 19.37 |

**103006 - X2R005**

| Percentile | Cl (mg/l) | EC (mS/m) | $NH_4$ (mg/l N) | $NO_3 + NO_2$ (mg/l N) | Na (mg/l) | $PO_4$ (mg/l) | $SO_4$ (mg/l) | pH (pH units) | Mg (mg/l) | Alkalinity (mg $CaCO_3$/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| **0.05** | 2.50 | 11.15 | 0.02 | 0.04 | 2.83 | 0.01 | 2.00 | 7.53 | 5.17 | 46.72 |
| **0.25** | 4.65 | 12.78 | 0.02 | 0.06 | 3.54 | 0.01 | 3.00 | 7.76 | 7.31 | 51.21 |
| **0.50** | 5.00 | 13.90 | 0.02 | 0.13 | 3.92 | 0.02 | 6.18 | 7.86 | 7.86 | 55.00 |
| **0.75** | 5.00 | 14.60 | 0.04 | 0.18 | 4.29 | 0.02 | 7.45 | 8.01 | 8.52 | 58.55 |
| **0.95** | 6.00 | 16.26 | 0.09 | 0.40 | 5.55 | 0.06 | 11.70 | 8.13 | 9.57 | 66.05 |

**102974 - X2H031**

| Percentile | Cl (mg/l) | EC (mS/m) | $NH_4$ (mg/l N) | $NO_3 + NO_2$ (mg/l N) | Na (mg/l) | $PO_4$ (mg/l) | $SO_4$ (mg/l) | pH (pH units) | Mg (mg/l) | Alkalinity (mg $CaCO_3$/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| **0.05** | 5.00 | 8.18 | 0.02 | 0.04 | 2.08 | 0.01 | 2.00 | 7.41 | 3.42 | 32.04 |
| **0.25** | 5.00 | 14.70 | 0.02 | 0.10 | 9.14 | 0.02 | 4.40 | 7.66 | 5.31 | 51.10 |
| **0.50** | 5.00 | 17.40 | 0.02 | 0.16 | 10.37 | 0.02 | 6.82 | 7.83 | 6.31 | 65.15 |
| **0.75** | 7.63 | 19.00 | 0.05 | 0.23 | 11.94 | 0.03 | 8.06 | 7.99 | 7.27 | 73.12 |
| **0.95** | 8.70 | 21.46 | 0.07 | 0.41 | 13.57 | 0.09 | 11.31 | 8.12 | 8.76 | 83.43 |

**102955 - X2H010**

| Percentile | Cl (mg/l) | EC (mS/m) | $NH_4$ (mg/l N) | $NO_3 + NO_2$ (mg/l N) | Na (mg/l) | $PO_4$ (mg/l) | $SO_4$ (mg/l) | pH (pH units) | Mg (mg/l) | Alkalinity (mg $CaCO_3$/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| **0.05** | 3.24 | 7.38 | 0.02 | 0.04 | 1.49 | 0.01 | 2.00 | 7.29 | 2.58 | 28.81 |
| **0.25** | 5.00 | 9.70 | 0.02 | 0.04 | 5.43 | 0.01 | 2.00 | 7.61 | 3.44 | 38.81 |
| **0.50** | 5.00 | 11.27 | 0.02 | 0.06 | 7.57 | 0.02 | 4.61 | 7.75 | 4.12 | 45.39 |
| **0.75** | 5.31 | 12.34 | 0.03 | 0.10 | 8.40 | 0.02 | 6.64 | 7.84 | 4.61 | 52.31 |
| **0.95** | 6.96 | 15.24 | 0.07 | 0.14 | 9.79 | 0.05 | 11.37 | 7.98 | 6.28 | 58.75 |

## TABLES OF PERCENTILES FOR STATIONS IN THE SABIE RIVER CATCHMENT

**103007 - X3H001**

| Percentile | Cl (mg/l) | EC (mS/m) | $NH_4$ (mg/l N) | $NO_3 + NO_2$ (mg/l N) | Na (mg/l) | $PO_4$ (mg/l) | $SO_4$ (mg/l) | pH (pH units) | Mg (mg/l) | Alkalinity (mg $CaCO_3$/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| **0.05** | 2.08 | 9.34 | 0.02 | 0.22 | 1.00 | 0.01 | 2.15 | 7.37 | 3.63 | 24.44 |
| **0.25** | 4.58 | 11.31 | 0.02 | 0.32 | 2.36 | 0.01 | 6.05 | 7.53 | 5.12 | 37.99 |
| **0.50** | 5.00 | 12.56 | 0.05 | 0.39 | 2.70 | 0.01 | 7.85 | 7.70 | 5.98 | 44.39 |
| **0.75** | 5.00 | 13.93 | 0.08 | 0.44 | 3.07 | 0.02 | 11.41 | 7.83 | 6.49 | 50.47 |
| **0.95** | 6.76 | 15.57 | 0.35 | 0.62 | 4.00 | 0.06 | 16.88 | 7.94 | 7.37 | 57.18 |

**103008 - X3H002**

| Percentile | Cl (mg/l) | EC (mS/m) | $NH_4$ (mg/l N) | $NO_3 + NO_2$ (mg/l N) | Na (mg/l) | $PO_4$ (mg/l) | $SO_4$ (mg/l) | pH (pH units) | Mg (mg/l) | Alkalinity (mg $CaCO_3$/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| **0.05** | 2.50 | 9.44 | 0.02 | 0.22 | 1.00 | 0.01 | 3.00 | 7.18 | 3.54 | 21.90 |
| **0.25** | 4.30 | 11.40 | 0.02 | 0.32 | 2.43 | 0.01 | 6.32 | 7.56 | 4.96 | 36.72 |
| **0.50** | 5.00 | 12.44 | 0.05 | 0.39 | 2.72 | 0.01 | 8.46 | 7.71 | 5.98 | 44.27 |
| **0.75** | 5.00 | 13.90 | 0.08 | 0.45 | 3.12 | 0.02 | 11.18 | 7.86 | 6.61 | 49.95 |
| **0.95** | 6.64 | 15.74 | 0.35 | 0.66 | 4.24 | 0.04 | 17.59 | 8.00 | 7.47 | 54.87 |

**103009 - X3H003**

| Percentile | Cl (mg/l) | EC (mS/m) | $NH_4$ (mg/l N) | $NO_3 + NO_2$ (mg/l N) | Na (mg/l) | $PO_4$ (mg/l) | $SO_4$ (mg/l) | pH (pH units) | Mg (mg/l) | Alkalinity (mg $CaCO_3$/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| **0.05** | 2.00 | 6.63 | 0.02 | 0.06 | 1.00 | 0.01 | 2.00 | 7.24 | 1.47 | 18.60 |
| **0.25** | 4.52 | 10.60 | 0.02 | 0.30 | 2.33 | 0.01 | 3.00 | 7.50 | 4.80 | 36.82 |
| **0.50** | 5.00 | 12.16 | 0.04 | 0.34 | 2.64 | 0.01 | 6.46 | 7.71 | 5.70 | 46.77 |
| **0.75** | 5.00 | 13.60 | 0.06 | 0.42 | 3.06 | 0.02 | 8.95 | 7.88 | 6.38 | 51.82 |
| **0.95** | 6.12 | 15.20 | 0.21 | 0.53 | 4.52 | 0.04 | 16.04 | 7.98 | 7.31 | 55.96 |

**103011 - X3H004**

| Percentile | Cl (mg/l) | EC (mS/m) | $NH_4$ (mg/l N) | $NO_3 + NO_2$ (mg/l N) | Na (mg/l) | $PO_4$ (mg/l) | $SO_4$ (mg/l) | pH (pH units) | Mg (mg/l) | Alkalinity (mg $CaCO_3$/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| **0.05** | 11.08 | 11.20 | 0.02 | 0.04 | 7.73 | 0.01 | 2.00 | 7.26 | 3.63 | 29.56 |
| **0.25** | 14.55 | 15.30 | 0.02 | 0.13 | 10.39 | 0.01 | 3.00 | 7.62 | 5.32 | 40.34 |
| **0.50** | 18.62 | 19.30 | 0.04 | 0.34 | 12.32 | 0.02 | 5.06 | 7.78 | 7.56 | 51.49 |
| **0.75** | 23.77 | 22.50 | 0.06 | 0.54 | 14.54 | 0.02 | 7.30 | 7.90 | 9.01 | 62.18 |
| **0.95** | 28.50 | 26.40 | 0.09 | 0.83 | 16.59 | 0.04 | 11.68 | 8.05 | 11.18 | 72.99 |

**103012 - X3H006**

| Percentile | Cl (mg/l) | EC (mS/m) | $NH_4$ (mg/l N) | $NO_3 + NO_2$ (mg/l N) | Na (mg/l) | $PO_4$ (mg/l) | $SO_4$ (mg/l) | pH (pH units) | Mg (mg/l) | Alkalinity (mg $CaCO_3$/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| **0.05** | 5.00 | 10.14 | 0.02 | 0.04 | 4.56 | 0.01 | 2.00 | 7.34 | 3.45 | 27.12 |
| **0.25** | 14.70 | 14.88 | 0.02 | 0.10 | 9.51 | 0.01 | 3.00 | 7.65 | 4.85 | 40.89 |
| **0.50** | 19.39 | 19.15 | 0.03 | 0.30 | 12.42 | 0.02 | 5.55 | 7.78 | 7.21 | 50.43 |
| **0.75** | 23.34 | 22.33 | 0.06 | 0.47 | 14.32 | 0.03 | 7.39 | 7.91 | 8.95 | 62.15 |
| **0.95** | 28.60 | 26.60 | 0.10 | 0.73 | 16.64 | 0.07 | 11.47 | 8.09 | 11.60 | 76.03 |

**103014 - X3H008**

| Percentile | Cl (mg/l) | EC (mS/m) | $NH_4$ (mg/l N) | $NO_3 + NO_2$ (mg/l N) | Na (mg/l) | $PO_4$ (mg/l) | $SO_4$ (mg/l) | pH (pH units) | Mg (mg/l) | Alkalinity (mg $CaCO_3$/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| **0.05** | 9.94 | 12.04 | 0.02 | 0.02 | 9.82 | 0.01 | 2.00 | 7.45 | 2.48 | 32.14 |
| **0.25** | 12.33 | 14.35 | 0.02 | 0.04 | 14.21 | 0.02 | 4.26 | 7.67 | 3.31 | 43.06 |
| **0.50** | 15.89 | 17.10 | 0.02 | 0.06 | 16.60 | 0.03 | 5.96 | 7.81 | 3.92 | 51.31 |
| **0.75** | 22.85 | 21.75 | 0.05 | 0.12 | 23.29 | 0.04 | 8.05 | 7.91 | 5.17 | 59.67 |
| **0.95** | 40.03 | 33.40 | 0.07 | 0.24 | 36.52 | 0.08 | 12.17 | 8.00 | 6.97 | 86.60 |

**103015 - X3H011**

| Percentile | Cl (mg/l) | EC (mS/m) | $NH_4$ (mg/l N) | $NO_3 + NO_2$ (mg/l N) | Na (mg/l) | $PO_4$ (mg/l) | $SO_4$ (mg/l) | pH (pH units) | Mg (mg/l) | Alkalinity (mg $CaCO_3$/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| **0.05** | 2.50 | 4.09 | 0.02 | 0.02 | 3.38 | 0.01 | 2.00 | 7.07 | 0.50 | 11.40 |
| **0.25** | 5.00 | 5.85 | 0.04 | 0.04 | 4.32 | 0.01 | 2.00 | 7.29 | 1.36 | 17.52 |
| **0.50** | 5.00 | 6.76 | 0.09 | 0.06 | 4.73 | 0.02 | 3.00 | 7.45 | 1.65 | 20.77 |
| **0.75** | 5.60 | 7.38 | 0.24 | 0.09 | 5.08 | 0.02 | 5.32 | 7.59 | 1.96 | 24.26 |
| **0.95** | 7.01 | 9.24 | 0.50 | 0.20 | 6.40 | 0.07 | 9.62 | 7.85 | 3.03 | 33.48 |

**103016 - X3H012**

| Percentile | Cl (mg/l) | EC (mS/m) | $NH_4$ (mg/l N) | $NO_3 + NO_2$ (mg/l N) | Na (mg/l) | $PO_4$ (mg/l) | $SO_4$ (mg/l) | pH (pH units) | Mg (mg/l) | Alkalinity (mg $CaCO_3$/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| **0.05** | 5.00 | 11.69 | 0.02 | 0.04 | 4.98 | 0.01 | 2.00 | 7.48 | 4.39 | 38.38 |
| **0.25** | 6.60 | 13.90 | 0.02 | 0.06 | 6.20 | 0.01 | 3.00 | 7.74 | 5.50 | 45.38 |
| **0.50** | 13.15 | 18.90 | 0.02 | 0.10 | 11.62 | 0.01 | 5.77 | 7.97 | 7.28 | 64.48 |
| **0.75** | 16.81 | 27.80 | 0.02 | 0.19 | 17.11 | 0.02 | 8.90 | 8.12 | 13.56 | 99.78 |
| **0.95** | 34.19 | 47.46 | 0.06 | 0.25 | 29.47 | 0.03 | 16.58 | 8.26 | 23.84 | 162.33 |

**103019 - X3H015**

| Percentile | Cl (mg/l) | EC (mS/m) | $NH_4$ (mg/l N) | $NO_3 + NO_2$ (mg/l N) | Na (mg/l) | $PO_4$ (mg/l) | $SO_4$ (mg/l) | pH (pH units) | Mg (mg/l) | Alkalinity (mg $CaCO_3$/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| **0.05** | 8.49 | 12.94 | 0.02 | 0.02 | 7.22 | 0.01 | 2.00 | 7.58 | 4.61 | 40.22 |
| **0.25** | 12.10 | 16.65 | 0.02 | 0.05 | 9.43 | 0.01 | 5.34 | 7.75 | 6.15 | 51.22 |
| **0.50** | 13.41 | 19.30 | 0.04 | 0.10 | 10.69 | 0.02 | 7.33 | 7.90 | 7.70 | 62.44 |
| **0.75** | 16.11 | 21.50 | 0.06 | 0.17 | 12.92 | 0.03 | 11.06 | 8.06 | 9.16 | 74.37 |
| **0.95** | 46.72 | 60.71 | 0.10 | 0.40 | 56.75 | 0.04 | 36.96 | 8.35 | 26.67 | 182.63 |

**103020 - X3H019**

| Percentile | Cl (mg/l) | EC (mS/m) | $NH_4$ (mg/l N) | $NO_3 + NO_2$ (mg/l N) | Na (mg/l) | $PO_4$ (mg/l) | $SO_4$ (mg/l) | pH (pH units) | Mg (mg/l) | Alkalinity (mg $CaCO_3$/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| **0.05** | 4.11 | 3.85 | 0.02 | 0.02 | 3.06 | 0.01 | 2.00 | 6.96 | 0.50 | 8.16 |
| **0.25** | 5.00 | 4.63 | 0.06 | 0.04 | 4.19 | 0.01 | 2.00 | 7.15 | 0.50 | 10.62 |
| **0.50** | 5.19 | 5.05 | 0.12 | 0.05 | 4.73 | 0.01 | 2.00 | 7.26 | 1.10 | 13.76 |
| **0.75** | 5.95 | 5.43 | 0.29 | 0.06 | 5.08 | 0.02 | 3.00 | 7.41 | 1.25 | 16.31 |
| **0.95** | 7.13 | 6.64 | 0.92 | 0.13 | 5.55 | 0.03 | 6.89 | 7.74 | 1.64 | 20.56 |

**103024 - X3R001**

| Percentile | Cl (mg/l) | EC (mS/m) | $NH_4$ (mg/l N) | $NO_3 + NO_2$ (mg/l N) | Na (mg/l) | $PO_4$ (mg/l) | $SO_4$ (mg/l) | pH (pH units) | Mg (mg/l) | Alkalinity (mg $CaCO_3$/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| **0.05** | 2.50 | 3.89 | 0.02 | 0.02 | 2.61 | 0.01 | 2.00 | 6.98 | 0.50 | 8.97 |
| **0.25** | 5.00 | 4.74 | 0.02 | 0.04 | 3.86 | 0.01 | 2.00 | 7.16 | 0.50 | 11.20 |
| **0.50** | 5.16 | 5.04 | 0.08 | 0.05 | 4.70 | 0.02 | 2.00 | 7.30 | 1.07 | 12.89 |
| **0.75** | 5.84 | 5.35 | 0.16 | 0.06 | 5.21 | 0.02 | 3.00 | 7.53 | 1.15 | 16.00 |
| **0.95** | 6.81 | 6.17 | 0.70 | 0.10 | 5.81 | 0.06 | 6.57 | 7.82 | 1.43 | 19.02 |

# APPENDIX B
# DOCUMENT LIMITATIONS

# DOCUMENT LIMITATIONS

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