DEPARTMENT OF WATER AFFAIRS AND FORESTRY

Directorate: National Water Resource Planning

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MZIMVUBU RIVER BASIN

WATER UTILIZATION OPPORTUNITIES

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MZIMVUBU RIVER BASIN

WATER UTILIZATION OPPORTUNITIES

SYNOPSIS

This report addresses the physical environment and the overall availability of water in the Mzimvubu River Basin as well as the development potential of the basin and the water required for this. This is followed by an analysis of the costs of securing water supplies in the basin and the incremental costs of transferring the potential surplus water to areas where it can be beneficially used, such as the Orange River Basin and the Fish and Lower Sundays River catchments in the Eastern Cape. The report also examines the factors that could limit the sustainable utilization of the water resources of the Mzimvubu River Basin, summarises the findings and conclusions and makes recommendations for further actions.

The study concluded that, for the foreseeable future the feasible and likely developments within the Mzimvubu River Basin would take up only a relatively small part of the potentially available water. Those uses include domestic and industrial supply, water for livestock, irrigation of crops, forestry, tourism and provision for the ecological Reserve. Hydropower generation, which could theoretically exploit all the surplus water, is not a consumptive user and would create relatively few long-term employment opportunities. The quantity of surplus water that could be secured from the basin can therefore be in excess of 600 million m^3/a.

Plans for the transfer of potentially surplus water to other areas could in years to come be initiated by the national DWAF or the Eastern Cape Government. The Eastern Cape Province could also include plans for the development of the Mzimvubu River Basin in its Growth and Development Strategy with the knowledge that adequate local water resources would be available for development, but at a cost.

This report does not express opinions on the justification for or feasibility of any possible development making use of water from the Mzimvubu River Basin.

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MZIMVUBU RIVER BASIN

WATER UTILIZATION OPPORTUNITIES

EXECUTIVE SUMMARY

1. Introduction

This report was prepared in order to inform the Eastern Cape Province of the development opportunities that exist within the Mzimvubu River Basin and possibly also in other parts of the province to utilize the water resources of the basin.

The study was a desk-top investigation performed at reconnaissance level of detail and has not addressed individual local water shortages, but only the availability and utilization of the water resources of the basin on a larger scale. A clear distinction is necessary between the availability of water in bulk and the distribution of such water to consumers. A shortage of water is frequently the result of inadequate distribution capacity and not of bulk availability. In rural areas such as the Mzimvubu River Basin the water required for urban use and livestock watering is generally relatively small and that these and some other smaller requirements can best be supplied by run-of-river or small local schemes that are likely to include the use of groundwater.

Development opportunities that have already been reported on in the past have been considered and supplemented or replaced where new opportunities have been identified during the course of this investigation. Development opportunities in the irrigation, forestry, hydropower and tourism sectors were considered and included the supply of bulk water in the Mzimvubu River Basin and the possible transfer of some of this water to other areas in the Eastern Cape. Such transfers could correspond to projects that are being considered in the development of the second phase of the Provincial Growth and Development Strategy.

The costs are first order estimates that are only intended to give perspective to decision makers and to inform possible follow-up work. All costs are given at June 2004 price levels and include 14% VAT. All water requirements, availability and unit costs are given at a 98% equivalent assurance of supply unless indicated otherwise.

It has been ensured that the water required for the ecological Reserve, including the estuary of the Mzimvubu River, is available before further consumptive uses can be considered. This requirement in the National Water Act of 1998 is likely to have an effect on the viability of a number of schemes that had been identified in the past.

This report addresses the availability of water in the Eastern Cape in general, and then in particular, the natural and physical environment of the Mzimvubu

River Basin, the overall availability of water in the basin, the development potential and the water required for this. This is followed by an analysis of the costs of securing water supplies in the basin and the incremental costs of transferring the potential surplus water to areas where it can be beneficially used, such as the Orange River Basin and the Fish and Lower Sundays River catchments in the Eastern Cape. The report also examines the factors that could limit the sustainable utilization of the water resources of the Mzimvubu River Basin, summarises the findings and conclusions and makes recommendations for further actions.

2. Findings and Conclusions

The natural mean annual run-off (MAR) of the Mzimvubu River Basin, which is shared by the Eastern Cape and KwaZulu-Natal Provinces, is about 2 900 million m^3. Relatively little of this water is utilized at present.

After providing for the ecological Reserve and the effects of the invasive alien plants in the basin, the total quantity of water available at present for net consumptive use is estimated to be 91 million m^3/a. This includes the groundwater that can be abstracted at present.

The estimated water requirements from the basin during 2000 were as follows:

• Forestry:	3
• Urban use	6
• Rural use	9
• Irrigation	15
Total	33 million m^3/a

There is thus a small (58 million m^3/a) surplus of utilizable water at present, but the expansion of forestry and irrigation will reduce the flows available for ecological water requirements and the effects will have to be carefully monitored. Improved assessments of management classes and the associated ecological water requirements are essential for a better evaluation of the remaining water that may still be available for use at an acceptable assurance of supply before providing additional storage.

Significant potential for large-scale water resource development therefore still exists in the basin, but the high cost of securing the water requires significant socio-economic benefits to be derived from its use for activities such as irrigation and forestry.

There are no large water shortages for the existing land use in the Eastern Cape. Significant quantities of unutilized water are still available in the Kei River catchment and further to the east, without having to do any major water resource development.

Water shortages do however occur in some localised areas and in the coastal catchments between Port Elizabeth and Port Alfred.

A feature of the water use in the Eastern Cape is the large number of under-utilized existing irrigation schemes. The problems that have led to the present situation include poor reliability of water supplies, a lack of local electricity supplies, inappropriate technology and irrigation systems, ineffective management and maintenance, inadequate farmer training and extension, the land-tenure system, poor access to finance and markets and local conflicts.

Provision has been made to supply more water from the Orange River to the Eastern Cape Province in order to expand irrigation by emerging farmers in the Province upstream of the Gariep Dam by 1 000 ha and by a further 4 000 ha in the Fish and Sundays River catchments.

Large transfers of water are already made from the Gariep Dam in the Upper Orange WMA to the Fish to Tsitsikamma WMA in the Eastern Cape. Besides the additional transfer for irrigation mentioned above, provision has also been made to transfer additional water from Gariep Dam via the Fish and Sundays Rivers to the Nelson Mandela Metropolitan Municipality (Port Elizabeth).

A large portion of the basin is occupied by numerous scattered rural villages. After providing for this and if the water supplies were increased sufficiently to meet all the requirements, the net areas of land with potential for forestry and crop cultivation are approximately as follows:

- Forestry 244 000 ha
- Dryland cultivation (high to moderate potential) 48 000 ha
- Dryland cultivation (low potential) 156 000 ha
- Irrigated cultivation (high potential) 11 000 ha
- Irrigated cultivation (moderate potential) 91 000 ha

Many of the above areas overlap each other and therefore decisions will have to be taken on the most suitable development. A maximum reference development scenario that provides an indication of the highest likely water use when taking account of the topographic, soil and climatic constraints could comprise the following (including existing development):

- Forestry 180 000 ha
- Irrigated cultivation 70 000 ha

A likely smaller development scenario of predominant activities is shown in Figure 9 and could comprise the following (including existing development):

- Forestry 120 000 ha
- Dryland cultivation (high to moderate potential) 1 600 ha
- Irrigated cultivation 44 600 ha

Much of the irrigated agriculture could be initiated as dryland agriculture that is then converted to irrigation as the necessary skills are acquired by the farmers.

Eskom is investigating conventional hydropower schemes of moderate installed capacity not exceeding 140 MW that will mainly be used for peak power generation. These are much smaller than those investigated by others in the past and will not be large net users of water.

Upstream water use by forestry and particularly irrigation can have a significant effect on the economics of conventional hydropower production and *vice versa* and needs to be considered when embarking on any large scale water resource development and water use projects.

Pumped-storage hydropower schemes have also been investigated in the past. The capacities can exceed 2 000 MW. One possibility is a high-head off-channel scheme in the west of the basin that straddles the continental divide. This scheme has the added potential of also being used to transfer water to the Orange River. Another scheme with a much lower head is situated in the Mzimvubu River near the coast.

Tourism potential is high, particularly near the coast, but does not consume much water in relation to the other potential water uses.

Irrigation in the basin will typically apply about 700 mm/a or 7 000 m^3/ha/a at field edge. Forestry in the basin reduces the mean annual run-off from the afforested area by about 115 mm or 1 150 m^3/ha.

It is estimated that the above so-called reference development scenario (which includes existing development) could use the following quantities of water at an equivalent assurance of 98%:

• Forestry	140 million m^3/a
• Irrigated cultivation	450 million m^3/a
• Domestic, industrial and livestock watering	50 million m^3/a
	640 million m^3/a

After full development of the water resources, the total utilizable water in the basin would amount to about 1 300 million m^3/a at. This will therefore result in a surplus of at least 660 million m^3/a that would be available for use in other areas if the cost of securing and transferring the water is affordable.

The capital cost of constructing a sufficient number of large dams to supply the water required in the basin for the reference scenario consumptive use of 640 million m^3/a, of which 140 million m^3/a is to compensate for the reduction in run-off by forestry, is approximately R5 700 million. The annual recurrent costs of operating and maintaining the dams would be approximately R23 million.

Present-value analyses have been used to derive a uniform Unit Reference Value of water (URV) in R/m^3 that accounts for both capital and recurrent costs. The URV, at a discount rate of 8%, to provide sufficient water for a consumptive use of 640 million m^3/a for the reference development scenario is approximately R1.12/m^3.

Significant sustainable socio-economic benefits will be required to offset the high cost of supplying water at adequate assurance in the rivers for any large-scale irrigation and forestry development in the basin. Bringing the water from the dams and rivers to the irrigation areas will entail significant further costs.

Three alternative options to transfer surplus water from the Mzimvubu River Basin to as far as the Fish and Sundays River catchments in the Eastern Cape have been assessed. These are the following:

- The Northern transfer option. This consists of a number of additional dams in the Mzimvubu River Basin together with a system of canals, pump stations, pipelines and tunnels that transfer the water into a small tributary of the Orange River near Rhodes. From here the water flows to the Orange River from where it can be released through the Orange Fish Tunnel into the headwaters of the Fish River at Teebus, for further distribution.
- The Southern Piped transfer option. This consists of a large dam in the lower reaches of the Mzimvubu River and pump stations and pipelines that transfer the water into another small tributary of the Orange River near Dordrecht. From here the water can flow to the headwaters of the Fish River as in the case of the Northern transfer option.
- The Southern Canal transfer option. This consists of a large dam in the lower reaches of the Mzimvubu River and pump stations, pipelines and canals that transfer the water as far as the Little Fish River at the outlet of the Cookhouse Tunnel near Somerset East. Through an exchange of water with that which is being supplied by the Orange River Project at present, it would also be possible to abstract water further upstream in the Fish River.

The environmental impacts of the transfer schemes have not been assessed. These are expected to be most severe for the Southern Canal transfer option, which will traverse areas of high population concentrations. The large canals may also have a very disruptive effect on the movement of people, livestock and game and also be particularly dangerous for children and animals.

It has been found that the Northern transfer option from the Mzimvubu River to as far as the Fish and Sundays Rivers would be the least costly. River losses that would occur from the point of discharge into the Bell Spruit near Rhodes to the Orange River are estimated at approximately 1.2 m^3/s. These are much less than the river losses associated with the Southern Canal option, but 50% higher than those for the Southern Piped option.

The capital cost of the Northern transfer option to deliver 600 million m^3/a into the Orange River is approximately R16 800 million. This is the cost of the additional dams, canals, pump stations, pipelines and tunnels. The capital cost reduces to R5 000 million when only 100 million m^3/a is delivered. The annual costs of electricity and operating and maintaining the transfer schemes is approximately R570 million and R100 million respectively.

The resulting URV, at a discount rate of 8%, of 600 million m^3/a of water delivered in the Orange River is approximately R5.80/m^3. The URV however, increases to R6.85/m^3 when the delivered quantity is reduced to 100 million m^3/a.

The above transfers and URVs have accounted for losses in the receiving catchments. The URVs do not however include the likely costs to overcome the limited capacity of the Orange-Fish Tunnel if substantial additional volumes of water should be transferred to the Fish and Sundays River catchments. The tunnel capacity will then have to be increased and/or large balancing storage will have to be created in the upper Fish River. The cost of such actions will add substantially to the quoted URVs.

Very large sustainable socio-economic benefits will be required to offset the high incremental cost of transferring water from the Mzimvubu River to other areas, such as the Orange, Fish and Lower Sundays Rivers.

The enhancement of the labour content of large water transfer schemes had previously been examined. The obligation of securing the health, safety and welfare of the employees will be reflected in the construction costs. The harsh climatic conditions of the hotter and more arid areas that will be traversed by the Southern Canal transfer option will have a significant effect on the project cost and the benefit that can be derived from labour enhanced construction.

Increasing the total staff complement by 100% will increase the unskilled labour component by about 120%. The total salaries and wages paid would increase by about 70% while the cost of the project would increase by 8%. The work is also likely to take longer to complete. In the case of the Southern Canal transfer option, which has the largest labour content, the salaries and wages could be increased from about R 1 500 million to R 2 500 million, but the cost of the project will increase by about R 1 200 million.

Economic studies indicate that water is but a contributing factor to economic development. Any large-scale development needs a variety of supporting factors to have the desired effect of creating sustainable economic returns and employment opportunities. If water is not available most developments cannot proceed, but the availability of water is not a guarantee that development will happen.

Large amounts of initial capital and recurring annual funding are required to provide the extensive infrastructure in water, communications, other support services and industries, and education and training that are integral components of any large development.

Numerous other non-structural requirements such as one or more comparative advantages over other localities, reform of the existing land tenure system, willingness of the local communities to accommodate the new activities, developing locally acceptable relocation programmes, institutional capacity to implement and manage the projects, realistic implementation goals, Public-Private Partnerships and labour intensive and community-based methods for farming and forestry wherever possible are also necessary for the development to be sustainable.

There is a strong need for improved hydrological and weather observation in the Mzimvubu River Basin and also to improve the estimates of the ecological water requirements for different classes and the actual setting of ecological classes.

3. Recommendations

Existing unutilized water supplies and underutilized irrigation schemes in the Eastern Cape should be rehabilitated to their fullest extent possible while development plans are being formulated for the Mzimvubu River Basin.

In order to prevent a recurrence of the problems that have led to the under-utilization of existing irrigation projects in the Eastern Cape it is necessary to address the limiting factors before embarking on any large-scale irrigation or forestry developments in the basin.

An updated determination of the land utilization potential of the basin should be done at a reconnaissance level to indicate the locations and extent of the areas that are suitable for forestry, dryland cultivation and irrigated cultivation. The findings of studies that were in progress at the time that this report was completed must be evaluated before new studies are done.

The hydrological model calibration and run-off simulation for the Mzimvubu River and its tributaries should be updated.

A subsequent programme should be initiated to determine the ecological Reserve for the Mzimvubu River, its tributaries and the estuary, together with any initiatives for the further utilization of the substantial land and water resources in the basin.

It is essential that future development planning be integrated at an early stage of the planning process. Assessments of possible future development and water use must take account of the competing land uses and the social preferences of the local communities and the likely conflicts that could arise.

The possibility of multi-purpose water resource development and water transfer projects must be considered from the outset.

Land use and water resource development projects in the basin must be closely integrated with plans for promoting and facilitating tourism to the Eastern Cape and the Wild Coast (including Port St. Johns), and vice versa.

This study concentrated on the various possibilities for large scale use of Mzimvubu River water. The high costs involved do not reflect on the viability of possible smaller scale ad hoc developments in the basin, for which more than enough water could be made available. Localised developments such as irrigation or forestry developments on a village or sub-regional scale, could well make viable and meaningful contributions to poverty eradication, and should form part of the normal development planning undertaken by local authorities and the Province.

MZIMVUBU RIVER BASIN

WATER UTILIZATION OPPORTUNITIES

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MZIMVUBU RIVER BASIN

WATER UTILIZATION OPPORTUNITIES

1. INTRODUCTION

1.1 BACKGROUND TO INVESTIGATION

This report was prepared in order to inform the Eastern Cape Province of the development opportunities that exist within the Mzimvubu River Basin and possibly also in other parts of the province to utilize the water resources of the basin.

The study was a desk-top investigation performed at reconnaissance level of detail. The reported costs are therefore first order estimates that are only intended to give perspective to decision makers and to inform possible follow-up work. All costs are given at June 2004 price levels and include 14% VAT. All water requirements, availability and unit costs are given at a 98% equivalent assurance of supply unless indicated otherwise.

Development opportunities that have already been reported on in the past have been considered and supplemented or replaced where new opportunities have been identified during the course of this investigation.

The development opportunities that have been considered were in the irrigation, forestry, hydropower and tourism sectors. These have included the supply of bulk water in the Mzimvubu River Basin and the possible transfer of some of this water to other areas in the Eastern Cape. Such transfers could for example correspond to projects that are being considered in the development of the second phase of the Provincial Growth and Development Strategy.

It has been necessary to ensure that the water that is required for the ecological Reserve, including the estuary of the Mzimvubu River, is available before further consumptive uses can be considered. This requirement in the National Water Act of 1998 is likely to have an effect on the viability of a number of schemes that had been identified in the past.

A clear distinction is necessary between the availability of water in bulk and the distribution of such water to consumers. It is frequently found that a shortage of water is the result of inadequate distribution capacity and not of bulk availability. In rural areas such as the Mzimvubu River Basin it is generally the case that the water required for urban use and livestock watering is relatively small and that these and some other smaller requirements can best be supplied by run-of-river or small local schemes that are likely to include the use of groundwater. This investigation has not addressed local water shortages, but has been confined to the availability and utilization of the water resources of the Mzimvubu River on a larger scale.

This report addresses the availability of water in the Eastern Cape in general, and then in particular, the natural and physical environment of the Mzimvubu River Basin, the overall availability of water in the basin, the development potential and the water required for this. This is followed by an analysis of the costs of securing water supplies in the basin and the incremental costs of transferring the potential surplus water to areas where it can be beneficially used, such as the Orange River Basin and the Fish and Lower Sundays River catchments in the Eastern Cape. The report also examines the factors that could limit the sustainable utilization of the water resources of the Mzimvubu River Basin, summarises the findings and conclusions and makes recommendations for further actions.

1.2 WATER AVAILABILITY IN THE EASTERN CAPE

Summaries of the availability of water in each of the 19 Water Management Areas (WMAs) in South Africa are given in the National Water Resource Strategy (NWRS) (DWAF, 2004).

The Eastern Cape is mostly situated within the Mzimvubu to Keiskamma, Fish to Tsitsikamma and Upper Orange Water WMAs, as shown in Figure 1. Relatively small portions of the province occupy some of the headwaters of the Mvoti to Umzimkulu, Gouritz, and Lower Orange WMAs. The Upper Orange WMA forms part of an international watercourse that is shared by Botswana, Lesotho, Namibia and South Africa. Because of the existing water transfers from the Upper Orange River WMA to the Fish to Tsitsikamma WMA, water resource management in the former can also affect the latter.

A portion of KwaZulu-Natal is situated in the headwaters of the Mzimvubu River Basin.

On a macro scale there are no large water shortages for the existing land use in the Eastern Cape (DWAF, 2004). Significant quantities of unutilized water are still available in the Kei River catchment and further to the east, without having to do any major water resource development. Some water shortages do however occur locally such as in parts of the Karoo and in the coastal catchments between Port Elizabeth and Port Alfred.

The salinity in the Fish River is already a problem and the expansion of irrigation in the upper catchment will cause it to become worse as the return flows increase, unless additional water is provided for dilution. Careful management will therefore be required to reduce the additional quantities of water that will be required to manage the salinity increase and therefore the cost of supplying water for such irrigation development. Clearly any increase in irrigation in the upper Fish River catchment will be problematic.

A feature of the water use in the Eastern Cape is the large number of under-utilized existing irrigation schemes (Bembridge, 2000). Some 16% of the area of the small-scale farmer irrigation schemes that have been established is not being utilized, while about 70% of the participants achieved crop yields considerably below the potential of the schemes. This results in low economic and financial returns, which in turn discourage investment in irrigation. A number of problems that have led to the present situation have been identified (Bembridge, 2000). These include poor reliability of water supplies, a lack of local electricity supplies, inappropriate technology and irrigation systems, poor management and maintenance, inadequate farmer training and extension, the land-tenure system, poor access to finance and markets and local conflicts.

In the Mzimvubu River Basin existing irrigation development is apparently generally well utilized. The Department of Water Affairs and Forestry is investigating the economic and financial viability of providing some financial support to improve existing small-farmer irrigation in the Mzimvubu River Basin about 15 km inland from Port St Johns. The existing development consists of about 150 ha and could be expanded to about 200 to 300 ha. The area is suitable for the cultivation of sub-tropical fruits and various vegetables.

Provision has also been made to expand irrigation by emerging farmers in the Eastern Cape upstream of the Gariep Dam by 1 000 ha (DWAF, 2003a). This water will however have to be secured in future. Large transfers of water are already made from the Gariep Dam in the Upper Orange WMA to the Fish to Tsitsikamma WMA in the Eastern Cape. Provision has also been made to increase these transfers to expand irrigation by emerging farmers in the Fish River and Lower Sundays River catchments by 4 000 ha (DWAF, 2003a), which accounts for some of the present surplus (DWAF, 2003b). The remainder of this surplus can be accounted for by return flows downstream of the last point of abstraction from the Fish River where the salinity of the water becomes too high for beneficial use. Provision has also been made to transfer additional water from Gariep Dam via the Fish and Sundays Rivers to Port Elizabeth (DWAF, 2003b).

Agriculture, especially irrigated agriculture, is of major importance to the economy of the Eastern Cape and has linkages to several other economic sectors (DWAF, 2003b). However, irrigation efficiencies are fairly low at some schemes and significant conveyance losses are experienced from unlined canals in the Fish River catchment (DWAF, 2003b), which also aggravates the salinity problem. Potential exists for the intensification of irrigated agriculture in the Fish and Sundays River catchments, in particular through conversion to higher value crops and moving to more efficient irrigation methods (DWAF, 2003b).

The Mzimvubu River Basin, which has a natural mean annual run-off (MAR) of 2 900 million m^3, stands out as being the river system with the largest potential for development of additional water resources in the Eastern Cape. It has been estimated that at full development an additional yield of 1 200 million m^3/a can be secured (DWAF, 2004). This amounts to about 75% of the remaining water resource development potential of all the river basins in the Eastern Cape, excluding the Orange River and its tributaries. Some of the water of the Mzimvubu River Basin must of course be shared with users in KwaZulu-Natal. The KwaZulu-Natal areas are situated mainly in the upper catchment and only about 16% of the total MAR is generated in those areas.

1.3 PHYSICAL AND ECONOMIC ENVIRONMENT OF THE MZIMVUBU RIVER BASIN

1.3.1 Natural Features

Location and Description of the Basin

The Mzimvubu River Basin discharges into the Indian Ocean and is bounded in the south by the Mtata and Mbashe River catchments, in the west by the Orange River Basin, in the north-east by the Umzimkulu and Mtamvuna River catchments and in the east by the Pondoland Coastal catchments, as shown in Figure 1. Although the basin shares an international border with Lesotho, there are no shared rivers between them.

Topography

The topography of the Mzimvubu River Basin, which has a catchment area of 19 852 km^2, is shown in Figure 1. The Mzimvubu River and its four main tributaries, the Tsitsa, Tina, Kinira and Mzintlava all have their headwaters in the Drakensberg Mountains. After descending through the escarpment the main stem and these tributaries flow through deep river valleys incised into the coastal belt, before discharging into the Indian Ocean at Port St Johns.

The Mzimvubu River is the largest undeveloped river in South Africa. Its estuary also has been given a fairly high conservation importance rating, placing it in the upper 15% of South African estuaries (DWAF, 2002b).

Climate, Rainfall and Evaporation

The climate and temperature variations of the Mzimvubu River Basin are closely related to elevation and proximity to the coast. The basin has a mild temperate climate along the coast to more extreme conditions inland with most rainfall occurring during the summer months.

Temperature variations along the coast are less pronounced than inland, where frost regularly occurs during the winter months. Snow occurs less frequently along the higher lying mountainous areas in the west. Temperatures can exceed 40^0C during the summer.

Rainfall increases from the west to the east and generally from inland to the coast with a mix of some local troughs and peaks in between. Mean annual rainfall varies from a low of about 700 mm in the centre of the basin to between 1 000 and 1 500 mm along the coast and portions of the Drakensberg Mountains, as shown in Figure 2.

Evaporation increases from the east to the west and from the coast to the interior. Gross mean annual Simon's Pan evaporation increases from about 1 100 mm along the coast to 1 400 mm in the west, as shown in Figure 2. Gross mean annual Class A-pan evaporation is approximately 25% greater than the gross mean annual Simon's Pan evaporation.

Geology and Soils

The predominant rock formations in the Mzimvubu River Basin consist of mudstone, sandstone and shale of the Karoo Sequence with some localised intrusions of dolerite dykes and sills. Basaltic lavas of the Drakensberg Formation occur in the upper parts of the basin and small patches of Dwyka tillite occur in the lower part of the basin. These dominant strata have limited water-bearing capacity and mineral potential. Some coal-bearing formations are found near Maclear and further to the north and a few other mineral deposits near Mt Ayliff and about 25 km up the Mzimvubu River from Port St Johns (Republic of Transkei, 1990).

A consequence of the predominant geological strata and the climate is that the soils of the basin can be categorised into the following three main groups, the distribution of which is shown in Figure 3:

- Moderately deep to deep clay soils on the steep slopes of the Drakensberg along the Lesotho border;
- Moderately deep to deep clayey loams on the steep slopes of the foothills of the Drakensberg; and
- Moderately deep to deep sandy loams in undulating to steep terrain further east as far as the coast.

Most of these soils are prone to erosion due to their dispersive nature emanating from weathering of the parent rocks. Overgrazing has exacerbated the erosion problems in most of those parts where there is a high concentration of villages.

Details of the suitability of the soils for forestry and cultivation are discussed in Section 4.

Vegetation

The natural veld in the Mzimvubu River Basin varies between lush coastal tropical forest type near the coast and along the watersheds up to about 60 km from the coast, false grassland and karoo and karroid types in the deeper river valleys, temperate and transitional forest and scrub type further than 50 km away from the coast and areas of pure grassland type in the west and north-west further than about 120 km from the coast.

1.3.2 Existing Land Use

The land use in the Mzimvubu River Basin is shown in Figure 4. A prominent feature is the extent of dryland cultivation and the large number of scattered rural villages. These villages are concentrated in the area of the former Transkei and occupy about 2% of the land area of the basin. Much of the remainder of the basin is being used for commercial agriculture, mainly livestock farming in the western part around Ugie and Maclear and in the portion of the basin in KwaZulu-Natal.

Most of the agricultural activity in the former Transkei is based on subsistence cultivation and rearing livestock. A very large part of this portion of the basin can be classified as degraded, mainly as a result of overgrazing that has caused severe soil erosion.

Except for one quarry there is no mining activity in the basin (Republic of Transkei, 1990).

The invasive alien plants, other than forestry, has been estimated to occupy an equivalent area of 22 600 ha in the basin (DWAF, 2003c).

A significant number of wetlands occur in the basin, mostly in the northern portion in KwaZulu-Natal. These wetlands are important to the ecology and in the hydrological cycle. Despite the natural beauty of the basin, only five nature reserves are found in the basin: two in the east and three in the west. Although the river flow in the estuary is still largely unaffected by upstream land use it has become highly silted due to degradation of the catchment and bad cultivation practices. The estuary is nevertheless of a relatively high conservation importance, as discussed in Section 6.2.

Sites with Iron Age artefacts are found in the deep valleys in the lower reaches of the Kinira, Mzimvubu and Mzintlava Rivers and could be vulnerable to inundation by future dams (Republic of Transkei, 1990).

At present the Mzimvubu River Basin is not linked to another river system through an inter-catchment water transfer.

Demography

The total population of the Mzimvubu River Basin in 2000 comprised 1 031 700 persons of which 106 900 were considered to be urbanised (DWAF, 2003c) with most of the remaining people living in a large number of small scattered rural villages, all in the Eastern Cape. Approximately 24% of the urban population and 6% of the rural population is resident in KwaZulu-Natal. The two largest urban centres are Kokstad and Mount Frere, which account for about 41% of the urban population.

The future demography of the basin will largely be influenced by economic opportunities and potential as well as the general trend towards urbanisation. The population of the basin is expected to have a slow decline after about 2005 (DWAF, 2003c). This is mainly attributed to a combination of factors including the lack of strong economic stimulants in the basin together with the effects of HIV/AIDS and migration towards the cities with their dominant economic activities. It is also not expected that the composition of the population will change much in the near future.

1.3.3 Economy of the Basin

Economic sectors contributing to the GGP

The main economic activities in the basin are government, commercial and subsistence agriculture, tourism and commercial forestry. However, with Bisho being the capital of the Eastern Cape, there has been a decline in the Gross Geographic Product (GGP) of the basin.

Subsistence sheep and cattle rearing are practiced extensively throughout the former Transkei area of the basin. Commercial farming mostly occurs outside the former Transkei in areas such as Kokstad, Maclear, Matatiele and Ugie, where irrigated pasture for dairy farming is also found. These are the areas where agriculture contributes most to the GGP of the basin.

Commercial forestry contributes significantly to the GGP and employment in the basin. Extensive commercial forestry occurs in the south-west of the basin, as shown in Figure 4.

The main opportunities for potential economic growth in the basin are the expansion of commercial forestry, dryland cultivation, irrigated cultivation and tourism, as discussed in Section 4. The development of the hydropower potential of the basin is also discussed in Section 4, but it is unlikely to create much local long-term economic benefits in the basin.

Employment

The Mzimvubu River Basin is one of the poorest areas in the country. The majority of the people (approximately 90%) live in rural areas where their incomes are directly linked to the agricultural sector, which is predominantly subsistence. The low levels of education and training in the rural areas means that not enough information is available as to how the assets in the basin can be effectively and productively used. In excess of 50% of the people are unemployed. There is an increasing poverty gap between the population of the basin and the areas of the Eastern Cape further to the west due to the following less favourable conditions in the basin:

- Lack of good port facilities and access to markets;
- Lack of available factors of production (skilled labour and infrastructure) necessary to compete in the available industries;
- Lack of availability of related industries and suppliers of specialised components, machinery and services; and
- Lack of demand-sophisticated and demanding consumers.

Land-tenure System

Land-tenure in the basin is characterised by the different systems found in the portion comprising the former Transkei and the remainder of the basin. Within the former Transkei the following five categories of land-tenure exist:

- Tribal land, sometimes coupled with the quitrent or leasehold tenure system;
- Freehold land;
- State land;
- Municipal land; and
- Institutional land (churches, etc.).

Within the portion of the basin outside the former Transkei, either individuals or farming syndicates hold the majority of land under freehold title. The remaining areas are state, municipal and institutional lands.

Problems associated with the tribal land-tenure system include overgrazing on communal lands, etc. Very little progress has been made to date to change the tenure system, but the national and provincial Departments of Agriculture have recently embarked on a land-care project to promote and implement sound grazing and soil cultivation practices, particularly in the rural areas of the former homelands. The project is characterised by strong community participation and ownership. Improved land use practices are an essential component of any intended large-scale development and utilization of the climatic and soil potential of the basin for commercial farming and forestry, which is discussed in Sections 4 and 5.

2 WATER RESOURCES OF THE MZIMVUBU RIVER BASIN

2.1 NATURAL RESOURCES

The Mzimvubu River Basin is one of the areas with the highest mean annual runoff in South Africa. No noteworthy dams have been constructed in the basin, where significant potential for water resource development remains.

Groundwater is not fully utilized in the basin although there is potential for groundwater to contribute to a reduction of poverty through the development of market gardens in this predominantly rural area.

Overall, the available groundwater resources within the basin are under-utilized, although this clearly depends both on the groundwater occurrence and the water requirement. Even areas of weak groundwater occurrence can often provide more than the RDP level of 25 litres per person per day. Groundwater can be the main source for rural water supplies because it is affordable and if managed properly can also be sustainable. Care is however, required to prevent pollution in highly populated areas with poor sanitation.

Under natural conditions the mean annual runoff from the Mzimvubu River Basin at the estuary has been estimated to be 2 900 million m^3 (DWAF, 2004). An interim mean annual base flow provision of 338 million m^3 has been allowed for the ecological Reserve at the estuary (DWAF, 2004). This must be provided from the above unregulated mean annual runoff before re-regulating or utilising any of the (remaining) water on a consumptive basis.

The surface water is soft sodium-carbonate water with a low mineral and saline content and the groundwater is generally suitable for domestic use (Republic of Transkei, 1990).

2.2 EXISTING UTILIZABLE RESOURCES

The total reduction of the yield of the system as a result of the ecological Reserve is only a proportion of the mean annual requirement. Under present conditions of water resource development the provision for the ecological Reserve has only reduced the quantity of water available for consumptive use by 156 million m^3/a (DWAF, 2003c).

The invasive alien plants have been estimated to reduce the mean annual runoff by 36 million m^3, but under present conditions of water resource development it has only reduced the quantity of water available for consumptive use by 1 million m^3/a (DWAF, 2003c).

After providing for the ecological Reserve and the effects of the invasive alien plants in the basin, the total quantity of water available at present for net consumptive use is estimated to be 91 million m^3/a (DWAF, 2004). This includes the groundwater that can be abstracted at present.

3. WATER REQUIREMENTS WITHIN THE BASIN

3.1 EXISTING LAND USE

Despite the large population, the Mzimvubu River Basin is one of the basins in South Africa with the lowest total water requirements. This can largely be attributed to the relatively high rainfall and the generally low level of development and economic activity.

The following are the estimated water requirements from the basin during 2000 at an equivalent assurance of supply of 98% (DWAF, 2004):

- Forestry: 3
- Urban use 6
- Rural use 9
- Irrigation 15

Total 33 million m^3/a

The above provisions for urban and rural water use include for the basic human needs Reserve at 25ℓ/c/d.

Almost all of the above irrigation water use is in KwaZulu-Natal and almost all of the rural and forestry water use is in the Eastern Cape. The urban water use is distributed about evenly between the two provinces (DWAF, 2002a).

The total mean annual reduction of runoff by the significant area of forestry in the south-west of the basin (73 000 ha) has been estimated to be 80 million m^3, but under present conditions of water resource development it has only reduced the quantity of water available to the other sectors for consumptive use by 3 million m^3/a (DWAF, 2003c).

The water requirement of irrigation is 18 million m^3/a at mixed assurance, but reduces to 15 million m^3/a at an equivalent assurance of 98% (DWAF, 2003c)

Although the basin has significant hydropower potential (Republic of Transkei, 1990), the only hydropower stations in the Eastern Cape (besides that at Gariep Dam) are in the Mtata and Mbashe River catchments (DWAF, 2003c). The total installed generating capacity is 62.4 MW.

3.2 RECONCILIATION OF EXISTING WATER REQUIREMENTS AND AVAILABILITY

The estimated overall quantities of water that are available and that were required in 2000 have been estimated to be 91 million m^3/a and 33 million m^3/a respectively. This leaves an overall surplus of approximately 58 million m^3/a that can still be apportioned from the basin for domestic, livestock and industrial users, forestry and irrigation, without providing additional storage. Additional storage may nevertheless be required if the additional use is situated in an upstream catchment where the local use already equals or exceeds the available local supply. This is known to occur in isolated instances at present, but this study has not addressed these small local problems. It has instead considered the macro availability and possible utilization of the water resources for economic development and poverty alleviation on a broad front.

The above estimates are approximations at best and depend on a number of factors such as the estimate of the ecological Reserve and its monthly and annual variation. These can have a marked effect on the estimated surplus and therefore, as the water use increases, it will become necessary to improve the estimates of water requirements and to develop strategies and plans for augmenting the water supplies.

4. DEVELOPMENT POTENTIAL WITHIN THE BASIN

4.1 FORESTRY

It has been estimated (Howard, 2004) that a gross area of about 380 000 ha or 19% of the area of the basin is suitable for forestry. This area has mainly been derived from considerations of rainfall, temperature (indirect measure of evapotranspiration) and topography at a mapping scale of 1:250 000 and does not consider any of the other limiting factors that will eventually affect actual development. Areas of natural forests and riparian zones are excluded. New initiatives to estimate areas of land suitable for forestry have in the meantime also been commenced.

The distribution of the areas of different forestry potential is shown in Figure 5. This is distributed within the main tributary catchments as follows, where the percentages represent the proportions of the areas of the tributary catchments:

• Tsitsa	119 000 ha (24.2%)
• Tina	49 100 ha (15.4%)
• Kinira	60 700 ha (18.3%)
• Mzintlava	63 600 ha (21.6%)
• Mzimvubu	87 000 ha (15.9%)
TOTAL	379 400 ha (19.1%)

The above areas have to be decreased to allow for physical factors such as access roads and rocky areas, existing land use, possible conflict with possible future irrigation and dryland cultivation and socio-economic considerations to estimate the possible future land use. The availability and cost of water are dealt with separately.

At this level of investigation and at a macro scale the likely net area of land that can be afforested would be of the order of 65% of the gross area, before consideration of water availability, socio-economic factors and likely conflict with other potential land uses, which is considered in more detail in Section 5.2. This area is in close agreement with an earlier estimate (Republic of Transkei, 1990).

The area of land with forestry potential that is situated in KwaZulu-Natal amounts to 16% of the above area.

4.2 DRYLAND AND IRRIGATED AGRICULTURE

4.2.1 Scope

Land-type mapping at a scale of 1:250 000 that is available from the Institute of Soil, Climate and Water formed the basis of the data presented in this section.

The potential for agriculture, especially irrigation and dryland production, in the Mzimvubu River Basin has been assessed by means of the soil and land capability classification system according to Scotney, et al (1987) and does not consider any of the other limiting factors that will eventually affect actual development. The land capability forms the basis for the rating of the potential for dryland cultivation and uses the soil and slope parameters obtained from the land type mapping in combination with the climatic parameters. The soil capability assessment forms the basis for the rating of the potential for irrigated cultivation but only uses the soil and slope parameters obtained from the land type mapping.

Two broad soil patterns dominate the landscape of the basin namely, red-yellow apedal freely drained soils and shallow and litholic soils.

The most likely predominant crops in the basin will be pasture, maize and potatoes, while some sub-tropical crops could be grown closer to the coast.

4.2.2 Dryland Agriculture

It has been estimated from the land capability (Verster, 2004) that a gross area of about 79 300 ha or 4% of the area of the basin consists of high to moderate potential arable land, while a further 260 600 ha or 13% of the area of the basin consists of low potential arable land. The total arable area is the same as found in an earlier study (Republic of Transkei, 1990). The remaining area is either non-arable or unsuitable for agriculture, making up 68% and 15% of the area of the basin respectively. These areas include land such as natural forest and riparian zones.

The distribution of the areas of different dryland potential is shown in Figure 6. This is distributed within the main tributary catchments as follows, where the percentages represent the proportions of the areas of the tributary catchments:

	High to Moderate Potential	Low Potential
• Tsitsa	31 200 ha (6.3%)	77 200 ha (15.7%)
• Tina	20 500 ha (6.4%)	27 800 ha (8.7%)
• Kinira	4 700 ha (1.4%)	42 500 ha (12.9%)
• Mzintlava	13 000 ha (4.4%)	47 200 ha (16.0%)
• Mzimvubu	9 900 ha (1.8%)	65 900 ha (12.1%)
TOTAL	79 300 ha (4.0%)	260 600 ha (13.1%)

The main physical features of the high to low potential arable soils are a dominant slope of less than 12%, an effective depth of greater than 450 mm, ploughing is possible, the clay content is between 5 and 50%, and where seasonal wetness does occur it is only for short periods.

The above areas have to be decreased to allow for physical factors such as access roads and rocky areas, existing land use, possible conflict with possible future irrigation and forestry and socio-economic considerations to estimate the possible future land use.

At this level of investigation and at a macro scale the likely net area of the land of the different orders of arable potential that can be cultivated under dryland conditions would be of the order of 60% of the above gross areas, before consideration of socio-economic factors and likely conflict with other potential land uses. The latter is considered in more detail in Section 5.2.

The areas of high to moderate potential and low potential land situated in KwaZulu-Natal amount to 12% and 21% of the above areas respectively.

4.2.3 Irrigated Agriculture

It has been estimated from the soil capability (Verster, 2004) that a gross area of about 170 300 ha or 9% of the area of the basin consists of soils with a high to moderate potential for irrigation. This area includes land such as natural forest and riparian zones and is about 20% less than estimated previously (Republic of Transkei, 1990).

The distribution of the areas of different irrigable potential is shown in Figure 7. This is distributed within the main tributary catchments as follows, where the percentages represent the proportions of the areas of the tributary catchments:

	High Potential	Moderate Potential
• Tsitsa	10 200 ha (2.1%)	51 400 ha (10.4%)
• Tina	5 600 ha (1.8%)	19 600 ha (6.1%)
• Kinira	1 400 ha (0.4%)	22 400 ha (6.8%)
• Mzintlava	1 400 ha (0.5%)	27 600 ha (9.4%)
• Mzimvubu	100 ha (0.0%)	30 600 ha (5.6%)
TOTAL	18 700 ha (0.9%)	151 600 ha (7.6%)

The main physical features of the high to low potential irrigable soils are a dominant slope of less than 12%, an effective depth of greater than 500 mm, ploughing is possible, the clay content is between 5 and 50%, and where seasonal wetness does occur it is only for short periods.

The above areas have to be decreased to allow for physical factors such as access roads and rocky areas, existing land use, possible conflict with likely future dryland cultivation and forestry and socio-economic considerations to estimate the possible future land use. The availability and cost of water are dealt with separately.

At this level of investigation and at a macro scale the likely net area of the land of the different orders of arable potential that can be cultivated under irrigated conditions would be of the order of 60% of the above gross areas, before consideration of water availability, socio-economic factors and likely conflict with other potential land uses. The latter is considered in more detail in Section 5.2.

The areas of high potential and moderate potential land situated in KwaZulu-Natal amount to 3% and 23% of the above areas respectively.

4.3 HYDROPOWER

Eskom is studying the possibility of hydropower generation in the Mzimvubu River Basin and has identified nine possible sites (Louwinger, 2003). The locations of these sites are shown in Figure 8.

The optimum installed generating capacities range from 16 MW to 140 MW. The four highest ranking sites are at Laleni, Tsitsa Falls, Mangwaneni and Gongo. At these four sites the optimum installed generating capacities range from 16 MW at Gongo to 104 MW at Laleni. Load factors at the four sites range between 15 and 30%. All the options will require large dams. The investigations are still at a reconnaissance stage and therefore the information could change as the studies continue.

The highest forestry and irrigation potential is situated upstream of most of these hydropower station sites and therefore the economics of all the options are likely to be affected by the harnessing of the natural resources for irrigation and forestry.

The hydropower stations are highly likely to be largely remote controlled because of the high degree of automation associated with such peak load hydropower stations. This means that there will be very few permanent employment opportunities after completion of the construction of any of these projects.

The sizes of the hydropower stations being investigated by Eskom are in strong contrast to earlier investigations where installed capacities of between 450 MW at a load factor of 30% (Republic of Transkei, 1990) and 1 600 MW at a load factor of about 8% (Republic of Transkei, 1987) were investigated, based on a large dam at Mbokazi. Subsequent concerns about the riverine and estuarine ecology are likely to prevent a scheme of this size from being built so close to the estuary.

Two pumped-storage hydropower possibilities have also been investigated in the basin and are shown in Figure 8. The largest scheme is Ben Avon-Ben Roy in the southwest of the basin with the head-pond dam at Ben Avon at the top of the escarpment on a small tributary of the Kraai River catchment and the tail pond dam at Ben Roy on the Klein Mooi River, which is a tributary of the Tsitsa River (George Orr and Associates, 1980). The maximum size of scheme identified had an installed capacity of 4 400 MW, but this does not preclude smaller schemes. The scheme was sized on the basis of operating for 121hrs per week or 72% of the time at a peak pumping rate of 380 m^3/s. Even for considerably smaller schemes this leaves ample capacity for a multi-purpose scheme to also transfer water from the Mzimvubu River Basin to the Orange River Basin. The scheme is however not ideally situated for this purpose (DWAF, 1996a), but it is likely that other more economical sites for conjunctive operation can be found along the Drakensberg Mountains. The unit capital cost of R3.60/MW installed generating capacity is consistent with that of the other 14 schemes situated throughout South Africa that were presented (George Orr and Associates, 1980), namely between about R6.50/MW installed generating capacity for a 500 MW scheme and R4.30/MW installed generating capacity for a 2 000 MW scheme. A drawback of the Ben Avon-Ben Roy scheme appears to be the long waterways (16 km in total), which are about double the preferred maximum length.

The other pumped-storage scheme is Lukuni-Mkata and was investigated by Eskom (1992). A scheme with a 2 000 MW pumped-storage hydropower station at the base of a head-pond dam at Lukuni and a 50 MW conventional hydropower station at the base of the tail-pond dam at Mkata was proposed. Both dams are on the Mzimvubu River and therefore a large component of power is generated from the natural river flow, which enhances the economics of the scheme. The environmental impacts of this scheme, so close to the coast, are likely to be high.

The pumped-storage hydropower stations are also highly likely to be largely remote controlled because of the high degree of automation, and will therefore not create many permanent employment opportunities.

The conventional and Ben Avon-Ben Roy pumped-storage hydropower schemes have the potential to form part of a multi-purpose development.

The costs of transmission lines for the electricity will be substantial (Republic of Transkei, 1990).

4.4 TOURISM

Tourism *per se* is not a high consumer of water and can at best be enhanced by or become a secondary benefit derived from the construction of a large dam. Large fluctuations in water level, particularly over short periods such as happens with pumped-storage hydropower schemes can however, detract from the tourism benefits.

With the tourism potential of the area, care will have to be taken with the implementation of large-scale agricultural, forestry and water-resource development projects to minimise the aesthetic and ecological impacts on the natural environment. Any major land use and water-resource development projects will have to be closely integrated with the future plans for promoting and facilitating tourism to the Eastern Cape and the Wild Coast (including Port St. Johns) in particular as pointed out in the Strategy Framework for Growth and Development 2004-2014 (2003). The converse should also be observed.

5. POSSIBLE FUTURE LAND USE IN THE BASIN

The development potential in the basin has been discussed in Section 4.

This section only addresses possible forestry and irrigated agriculture as these are the largest potential future users of water. The availability and cost of securing sufficient water is dealt with in Sections 7 and 8 and are not introduced as possible limiting factors in this section, except in the headwater catchments.

Except for sugarcane, dryland cultivation will not have much impact on the water resources of the basin because the water use of the crops is expected to be very similar to that of the natural vegetation that they will replace. Tourism *per se* will not be a large consumer of water within the context of the basin. Conventional hydropower will not consume any significant quantities of water, except for the evaporation losses from the surface of the dam and provided that a dam with enough storage is provided downstream to re-regulate the hydropower releases for other applications of the water. In the case of the Ben Avon-Ben Roy pumped-storage hydropower scheme the evaporation losses were estimated to amount to about 7 million m^3/a (George, Orr and Associates, 1980).

A comparison of Figures 5, 6 and 7 shows that the portions of the basin that are suitable for irrigated agriculture frequently correspond to areas where the climate, soils and terrain are also suitable for dryland agriculture or forestry or both.

The most suitable areas frequently also correspond with areas of dense rural human habitation or intensive livestock grazing. This means that any assessment of possible future development and possible water use must take account of these competing land uses and the social preferences and likely conflicts. To allow for this it has been assumed that only about 55% of the gross areas of land considered suitable for forestry or cultivation will actually be available for development in these areas, compared to an assumption of 70% in the areas where there are no rural villages.

Dryland agriculture has a higher risk of being affected by droughts, and crop yields will frequently also be less than with irrigated agriculture, but it does have specific advantages that should be considered when contemplating either dryland or irrigated agriculture. These advantages include lower capital, maintenance and operating costs as well as significantly less farming and management skills than are required for irrigation. As such, dryland farming in suitable areas could become an important first step in establishing emerging farmers and alleviating poverty over a wider front with the available financial and other resources and establish patterns of crop preferences of the farmers.

Where irrigable soils occur in headwater catchments it is unlikely that large-scale irrigation will be performed in the area because of the lower river flows and the higher costs of securing irrigation water. It is therefore expected that dryland agriculture and forestry are the more likely developments.

The following approximate net areas of potentially utilizable land would be available for forestry and irrigation if there had been no overlap of utilization potential and the available water supplies were increased sufficiently to meet all the requirements:

Eastern Cape

- Forestry 201 000 ha
- Irrigation 78 000 ha

KwaZulu-Natal

- Forestry 43 000 ha
- Irrigation 25 000 ha

Since there will be some overlap of the above net areas estimated to be suitable for both forestry and irrigation and because of the limiting effects of water availability in the headwater catchments, the following reference development scenario could be envisaged to establish the likely maximum total development of forestry and irrigation in the basin:

Eastern Cape

- Forestry 150 000 ha
- Irrigation 57 000 ha

KwaZulu-Natal

- Forestry 30 000 ha
- Irrigation 13 000 ha

The above reference development scenario will require that dams be built in the basin, but can be used as a basis for comparison with other scenarios. This reference scenario also provides a basis for estimating the quantities of water that may be required for use in the basin and the likely minimum quantities of water available for transfer to other areas outside the basin.

Against the background of the possible reference development scenario a smaller future base development scenario has been developed for the basin and is shown in Figure 9.

Most of the existing forestry is in the southwest of the basin in the vicinity of Ugie, Maclear and Tsolo and largely occurs on the higher ground where the rainfall is likely to be higher. At this level of investigation it is therefore not expected to have had a large effect on the future availability of irrigable soils.

No significant forestry and agricultural development has been allowed for close to the coast because of its visual impact on the landscape in this area of higher tourist potential.

Hydropower schemes can be developed by Eskom or independent power producers, or jointly. Hydropower schemes have however, not been indicated because these are not expected to have a large effect on the other land uses. However, upstream water use by forestry and particularly irrigation can have a significant effect on the economics of conventional hydropower production and *vice versa* and needs to be considered when embarking on any large-scale water-resource development and water-use projects. It is essential that these activities be integrated at an early stage of the planning process of any future development.

Based on the predominant activities shown in Figure 9, it is estimated that, together with the existing land use, the following total net areas of land could be utilized in the basin for forestry and irrigation in a smaller likely development scenario:

Eastern Cape

- Forestry 100 000 ha
- Irrigation 37 000 ha

KwaZulu-Natal

- Forestry 20 000 ha
- Irrigation 7 600 ha

The above areas do not overlap since these have been estimated taking account of the existing development and on the basis of the predominant activities shown in Figure 9. The limiting effects of water availability in some of the headwater catchments have affected the above estimates of likely development, particularly within KwaZulu-Natal.

The above scenarios do not consider the numerous constraints to development that include the costs and socio-economic factors mentioned in this report or the incentives for higher value use outside the basin. These could have a major influence on the future development and the future water use within the basin. Such constraints could therefore increase the quantities of water that can be made available for use outside the basin.

To realise the above levels of development will require a significant overall expansion of the physical infrastructure in the basin that will include transportation, electricity supplies, water supplies, etc.

6. POSSIBLE FUTURE WATER REQUIREMENTS IN THE BASIN

6.1 SCOPE

This section only addresses the water required for the ecological Reserve and possible future forestry and irrigation water requirements.

This is based on the relatively small effect that the water required for domestic, livestock and industrial use is expected to have (DWAF, 2004). The water required for domestic, livestock and industrial use was expected to increase from 16 million m^3/a in 2000 to about 18 million m^3/a in 2025. Should there be concerted forestry and irrigation development the domestic and industrial use may however increase substantially because of the associated improvement in the standards of living, but even a threefold increase to some 50 million m^3/a would not have a large effect on the general availability of water at the level of this investigation. The most noticeable effect would be the increase in the marginal cost of the additional water.

The water required for hydropower is likely to be even less, although the future water use by other sectors could have significant cost implications for the hydropower or *vice versa*. Integrated planning of likely future water resource development and utilization is therefore essential, as stated earlier.

The national government is entrusted with the responsibility of ensuring the equitable allocation of water for beneficial use and to ensure that sufficient water is available to support the continued growth and prosperity of the country. This includes the preparation of guidelines for the spatial redistribution of water and the actual implementation of inter-catchment transfer projects where applicable. An example of such a transfer that is beneficial to the Eastern Cape is the Orange River Water Project where water is transferred from the Upper Orange WMA to the Fish to Tsitsikamma WMA. While beneficial to the Eastern Cape, it could in future be detrimental to potential users of the water situated elsewhere in the country.

In the National Water Resource Strategy (DWAF, 2004) it is stated that with the Mzimvubu River Basin being the largest undeveloped water resource in South Africa, the benefits to be derived from the development of this resource will potentially be of national importance. It has been stated that large development of the water resources of the basin should therefore be subject to authorisation at national level. It is also stated that appropriate planning is required to ensure that future developments of national importance that may require the abstraction and transfer of water from the Mzimvubu River Basin to other WMAs should not be unduly jeopardised by other developments in the basin. A conceptual study of a major water transfer scheme to the Vaal River has already been conducted (DWAF, 1996a).

6.2 RIVERINE AND ESTUARINE ECOLOGY

The National Water Act of 1998 provides for the ecological Reserve. This is the portion of the flow that needs to remain in the rivers and streams to ensure the sustainable healthy functioning of the aquatic ecosystems, while only a part of the remainder of the flow can practically and economically be harnessed for use. This requirement must be maintained at all points along the rivers and streams as well as at the estuary.

Quantification of the water requirements for the ecological Reserve has been based on the currently still incomplete understanding of the functioning of ecosystems and their habitat requirements. The estimates given here are therefore subject to improvement in future as better insights are gained in general and in the Mzimvubu River and its estuary in particular.

The water requirements of the estuary will largely determine the total quantity of water that can be used from the basin. The importance of the estuary has been rated as 36^{th} in South Africa, which places it in the upper 15% of importance of all the estuaries (DWAF, 2002b).

The mean annual base-flow component of the ecological Reserve at the estuary has been estimated to be 338 million m^3 (DWAF, 2003c). When provision was made for the full range of river flows that also include the floods, the estimate of the mean annual requirement for the ecological Reserve increased to 760 million m^3 or about 26% of the natural mean annual flow at the estuary (DWAF, 2002a). These requirements mimic the natural flow, but are not a constant proportion of the natural flow: proportionally more water is required during the low flow periods. In an earlier study a fixed proportion of 30% of the natural flow had been set aside for the ecological Reserve of the rivers inland of the estuary (DWAF, 1996a). In the same study the provision at the estuary was for a minimum annual flow of 915 million m^3 with the following monthly distribution: 10 m^3/s from April to September, 35.5 m^3/s from October to December and during February and March, and 110.5 m^3/s on average during January. However, the natural flow at the estuary would frequently have been less than this requirement and therefore it would be reasonable to assume that it would apply only after there was large storage in and water use from the basin that would reduce the magnitude of some of the natural flood events at the estuary. For this study it has therefore been assumed that this regulated minimum estuarine requirement would be phased in as the water use and storage in the basin increased, starting from the estimates adopted for the purpose of the NWRS (DWAF, 2004) for present conditions with relatively little water use in the basin.

The remaining water in the basin would typically be available for forestry and for direct abstraction and storing in dams for consumptive domestic, livestock, industrial and irrigation use.

The water required for the ecological Reserve in the rivers and the estuary is determined by the class of the water resource and the resource quality objectives determined in terms of procedures specified in the National Water Act of 1998. This could therefore result in flows that differ significantly from those adopted at this stage. Any major changes will necessarily affect the availability and cost of securing water for the different user sectors.

6.3 FORESTRY

The water use or reduction in runoff has previously been estimated by others. For this investigation the estimates made in the Vaal River Augmentation Planning Study (DWAF, 1996a) have been adopted as applicable, since these were used for updating the hydrology at the time and for estimating the possible yield available from the Mzimvubu River Basin.

The mean annual reduction in runoff was found to be 115 mm or 1 150 m^3/ha for a development of 118 000ha. The seasonal and annual variation is large, depending on a number of factors, of which the weather fluctuations are the most significant. This also results in variations across the basin. The effect of forestry on the water available for use by other sectors, or the yield, is however, less than the above mean annual reduction in runoff. The reduction in yield available to other user sectors increases as the storage capacity in the system increases. This reduction in yield could exceed 80% of the mean reduction in runoff in the basin if the water resources were to be fully developed.

The following total mean annual reductions in runoff are estimated for the reference development scenario:

Eastern Cape	173 million m^3
KwaZulu-Natal	35 million m^3
	208 million m^3

The following mean annual reductions in runoff due to forestry can be expected in the basin for the existing forestry as well as the likely forestry shown in Figure 9:

Eastern Cape	115 million m^3
KwaZulu-Natal	23 million m^3
	138 million m^3

In overall terms the water required by any associated industries will be relatively small in relation to the water required for the timber that is processed.

6.4 IRRIGATION

The water required for irrigation is influenced by a number of factors that include the crop types, growing seasons, climate, and irrigation efficiency. For the purpose of this investigation it has been assumed that double cropping will be applied if seasonal crops are being grown in order to obtain maximum benefit from the irrigation infrastructure and the available land. A mixed cropping pattern consisting of summer maize, winter pastures and two potato crops (January and August plantings) has been adopted. With an irrigation efficiency of 75% the mean annual field-edge irrigation-water requirements within the basin have been estimated to vary between about 570 mm and 800 mm or an average of about 700 mm or 7 000 m^3/ha.

The following field edge quantities of irrigation water may be required at in the basin for the reference development scenario:

Eastern Cape	400 million m^3/a
KwaZulu-Natal	90 million m^3/a
	490 million m^3/a

The following field edge quantities of irrigation water may be required in the basin for the existing irrigation as well as the likely irrigation shown in Figure 9:

Eastern Cape	260 million m^3/a
KwaZulu-Natal	50 million m^3/a
	310 million m^3/a

The above quantities are likely to be net requirements and therefore adjustments must be made for the effects of distribution losses and utilizable return flows to establish the quantities that will be abstracted from the rivers.

Water required for irrigation can be supplied at a lower assurance than water required for domestic, livestock and industrial use, which is usually made available at a 98% assurance of supply, but also depends on the proportion of non-essential water use. For the purpose of this investigation it has been assumed that the so-called low-assurance water required for irrigation will consist of two components, viz. a high assurance component and a rationed component. It has been assumed that the high assurance component will comprise 80% of the total allocation or field edge requirement and be available at a 98% assurance of supply and that the rationed component will comprise the remaining 20% of the allocation and be available at an 80% assurance of supply. On this basis 1.00 m^3 of water at low assurance in the basin is equivalent to about 0.91 m^3 of water at the high assurance of domestic supplies.

Different conversion ratios apply in the case of forestry, invasive alien plants and the ecological Reserve. All of these relationships or the so-called effects on the yield at 98% assurance are very dependent on the total storage volume provided by dams in the basin.

In overall terms the water required by any associated industries will be relatively small in relation to the water required for the irrigated crops that are processed or the livestock that uses the pastures.

7. CAPITAL COSTS OF SURFACE WATER RESOURCE DEVELOPMENT

7.1 EXISTING AND POTENTIAL SUPPLIES

The unutilized future surplus water available in the Mzimvubu River Basin has previously been shown to be approximately 58 million m^3/a if no further dams are built and there are no increases in invasive alien plants, forestry and irrigation. This estimate could however be revised in future depending on improved understanding of the functioning of riverine and estuarine ecosystems and their habitat requirements and consequent revised estimates of their water requirements.

The potential increase in the utilizable water resources has been estimated to be 1 200 million m^3/a (DWAF, 2004), but this will only be available after a number of new large dams have been built. The total consumptive water use in the basin plus any transfers out of the basin is therefore limited to about 1 300 million m^3/a. This will require a number of large dams, including at least one on the Mzimvubu River and each of the major tributaries. Some smaller dams could also be required if these are found to be a more economical way of providing the water near the places where it will be consumed. A typical layout of such a system of dams is shown in Figure 10, which has been reproduced in part from a previous study performed to investigate the transfer of water to the Vaal River Basin (DWAF, 1996a). The cost of securing these water supplies is high, as discussed later in this section, and needs to be weighed up against the benefits and any alternative options for achieving the socio-economic goals that have been set at local, provincial and national level.

Preliminary analyses have been performed to estimate the amount of storage that will be required and the cost to supply the quantities of water estimated in Section 6 of this report for various development scenarios. In all instances it has been assumed that the spread of invasive alien plants within the basin will be contained. The results are set out below.

7.2 DAMS FOR REFERENCE DEVELOPMENT SCENARIO IN THE BASIN

The following consumptive water uses have been adopted for the reference development scenario:

Domestic, livestock and industrial	54 million m^3/a
Forestry	208 million m^3/a
Irrigation	490 million m^3/a
	752 million m^3/a at mixed assurance

This amounts to about 640 million m^3/a at equivalent 98% assurance, but excludes losses, which have been assumed to be offset by the enhanced return flows, mainly from irrigation.

Based on the possible distribution of the above water uses within the basin, it is estimated that a gross storage capacity of about 1 760 million m^3 will be required to supply the above water requirement and cater for sediment deposition for about 50 years. The distribution of this storage within the tributary catchments could be as follows:

- Tsitsa 820 million m^3 (46%)
- Tina 170 million m^3 (10%)
- Kinira 180 million m^3 (10%)
- Mzintlava 350 million m^3 (20%)
- Mzimvubu 240 million m^3 (14%)

1 760 million m^3 (100%)

In most of the cases a significant proportion of the storage will be required in the upper catchments, with the remainder being distributed further downstream in the basin.

The estimated cost of providing the above storage capacity is R5 700 million. This cost is already high and only provides for securing the water in the rivers. It does not include the cost of distributing the water to the consumers. These costs of distribution and utilization for irrigation are estimated to be about R60 000/ha, and are high because of the ruggedness of much of the terrain and the widely dispersed occurrence of the irrigable soils.

7.3 DAMS FOR LIKELY DEVELOPMENT SCENARIO IN THE BASIN

The following consumptive water uses have been adopted for the smaller likely development scenario:

Domestic, livestock and industrial	36 million m^3/a
Forestry	138 million m^3/a
Irrigation	310 million m^3/a
	484 million m^3/a at mixed assurance

This amounts to about 390 million m^3/a at equivalent 98% assurance.

Based on the possible distribution of the above water uses within the basin, it is estimated that a gross storage capacity of about 900 million m^3 will be required to supply the above water requirement and cater for sediment deposition for about 50 years. The distribution of this storage within the tributary catchments could be as follows:

- Tsitsa 590 million m^3 (65%)
- Tina 60 million m^3 (7%)
- Mzintlava 190 million m^3 (21%)
- Mzimvubu 60 million m^3 (7%)

900 million m^3

In the case of the Mzintlava and Mzimvubu Rivers the storage is mainly required in the upper catchments.

The estimated cost of providing the above storage capacity is R3 550 million. This cost is still high and again only provides for securing the water in the rivers. It does not include the cost of distributing the water to the consumers. These costs of distribution and utilization for irrigation are estimated to be about R60 000/ha and are high, for the same reasons stated before.

In practice such a development will be implemented as a number of phases over a period of time, which will therefore distribute the expenditure accordingly.

8. COMPARATIVE COSTS OF ADDITIONAL SURFACE WATER SUPPLIES IN THE BASIN

A Unit Reference Value of water (URV) in R/m^3 has been derived in order to compare the relative unit costs of supplying water for different scenarios of bulk water use. The URV is derived by equalising the discounted present value of the costs and the discounted present value of the water. This has been based on the discounted present value of the capital and recurrent costs and the discounted present value of the water when valued at the URV.

All values have been discounted to a base date of 1 April 2007 using June 2004 prices, including VAT. The discount period has been from the earliest likely commencement date of implementation of the options to 45 years after likely completion of the dams. Provision has been made for the time to fill the dams before the benefits start to accrue (DWAF, 1996a). Salvage values at the end of the discounting period have been ignored at this stage because of the very small effect on the URV.

The recurrent annual costs adopted for the analyses have been based on the Departmental Guidelines (DWAF, 1994). A corresponding weighted uniform average annual rate of 0.4% of the capital cost of the dams has been adopted for operation and maintenance costs to allow for both the civil and mechanical components. Recurrent costs have been deemed to commence in the year of completion of the dams.

Discount rates of 6%, 8% and 10% have been considered. The estimated URVs are shown in Table 8.1. The expected high cost of distributing the water to the consumers is not provided for and will increase the total cost of water supply.

Table 8.1: URV of Water Secured for Use in the Basin

Scenario	Unit Reference Value (R/m^3)		
	6% Discount	8% Discount	10% Discount
Reference	0.81	1.12	1.48
Likely	0.75	1.01	1.30

The URVs are based on the quantities of water secured for all user sectors, at an equivalent assurance of 98%. In the case of irrigation, the URV of the allocated water (7 000 m^3/ha/a) would therefore be 9% less than indicated above. In the case of forestry the URV of the long-term mean annual reduction of water use (115mm) would be 30% less than indicated above for the reference scenario and 50% less in the case of the likely scenario.

The above URVs are average values for the full development scenario or objective being considered. Smaller initial phases are expected to have lower URVs, which will progressively increase for subsequent phases as more water is utilized. The number of phases and the size of each phase must however, be determined within a long-term development objective.

9. WATER TRANSFERS TO OTHER CATCHMENTS

9.1 WATER AVAILABLE FOR TRANSFER

The following consumptive water uses have been considered within the basin:

Reference scenario	640 million m^3/a
Likely scenario	390 million m^3/a

It is expected that as much as possible of the water resources of the Mzimvubu River Basin will be retained for use within the basin. This is where the water can be provided at the least cost.

The total consumptive water use in the basin plus the transfers are limited to about 1 300 million m^3/a, as stated earlier. Water transfers of up to 660 million m^3/a from the basin are therefore unlikely to inhibit future development in the basin. With the likely scenario the transfers could be increased to as much as 910 million m^3/a.

9.2 WATER TRANSFER OPTIONS

Except for the Orange River Basin, which is already fully committed, the existing water supplies plus the potential undeveloped water resources in the catchments adjacent to the Mzimvubu River Basin are all in excess of the expected medium-term water requirements (DWAF, 2004). Only large transfer schemes that will deliver water as far as the Orange, Fish and Lower Sundays Rivers have therefore been considered and are described below. With these schemes water can be transferred further to other river systems in the Eastern and Western Cape, such as the Upper Sundays River or Upper Olifants River (Klein Karoo), or elsewhere in South Africa, such as to the Upper Vaal River.

The following large-scale water transfer schemes that have the potential to supply water to the more arid western portions of the Eastern Cape have previously been investigated:

- A Northern transfer option, as shown in Figure 10, delivering water near Rhodes to the Bell Spruit, a tributary of the Kraai River, which in turn is a tributary of the Orange River (DWAF, 1996a). The proposed scheme consisted of a combination of large dams, tunnels, canals, pump stations and pipelines.

  Water delivered to the Orange River by this scheme could be transferred to the Fish River at Teebus through the Orange Fish Tunnel and also then be diverted to the Little Fish and/or Lower Sundays Rivers and beyond through the Cookhouse Tunnel, that has its outlet near Somerset.

- A Southern Piped transfer option, as shown in Figure 11, delivering water as far as the Orange River's southern tributaries and the Great Fish River tributaries (Tarka River) (Republic of Transkei, 1987). The alternatives that were investigated all required a large dam in the Lower Mzimvubu River and were mostly piped pumping schemes. In the few alternatives where canals were also used the canals constituted only 20% of the total length of the conveyances at most. The reasons given for the short lengths of canal were the vulnerability and length of canals in such steep and rugged terrain. The total length of the pipelines for the shortest and least costly scheme is about 290 km. Water is pumped by means of a number of pumping stations through a total static pumping head of about 1 670 m and is delivered into a tributary of the Orange River near Dordrecht. From here the water can flow to the headwaters of the Fish River and beyond, as in the case of the Northern transfer option.

The following additional option has also been developed as part of this investigation to provide an alternative scheme with a greater labour component:

- A Southern Canal transfer option as shown in Figure 12, delivering water as far as the Little Fish River at the outlet of the Cookhouse Tunnel near Somerset East. The scheme consists of a large dam in the Lower Mzimvubu River and a combination of mostly canals, major piped siphons to cross the deep river valleys, pump stations and short pipelines. Because of the rugged terrain the total conveyance length is about 1 140 km, of which the open canals comprise 1 030 km. The total static pumping head is about 950 m, which includes provision for the head loss in the canals.

  This option will make additional water available in the Little Fish and/or Lower Sundays Rivers. Through an exchange of water with that which is being supplied by the Orange River Project at present, it would also be possible to abstract water further upstream in the Fish River.

At this stage none of the options have been optimised since the main purpose has been to conceptualise schemes capable of transferring the large quantities of water available from the Mzimvubu River to other river basins in the drier inland western areas of the Eastern Cape and to establish the order of magnitude of the costs of the options and the delivered water. The most detailed investigation so far has been for the northern transfer scheme (DWAF, 1996a).

Water losses are significant in all instances and increase the cost of the water most markedly for smaller schemes.

The environmental impacts of the schemes have not been assessed, but these are expected to be most severe for the Southern Canal option, which will traverse areas of high population concentrations. The large canals will have a very disruptive effect on the movement of people, livestock and game and also be particularly dangerous for children and animals.

It is also important to recognise, and to cater for, the very human nature of placing additional demands on the water *en route* to its final destination.

10. COSTS OF TRANSFERING SURPLUS SURFACE WATER TO OTHER CATCHMENTS

10.1 CAPITAL AND ELECTRICITY COSTS

10.1.1 Scope

The capital costs are all inclusive in respect of the dams and conveyances, including the pumping stations.

The cost of distributing the water in bulk from the receiving catchment to the users has not been allowed for at this stage. The indicated transfer capacities of the schemes do however, account for the losses along the route of the transfer scheme and refer to the quantities of water that will be available within the receiving catchment after allowing for estimated conveyance losses and incremental local river losses beyond the point of discharge.

10.1.2 Northern Transfer Option

The additional costs of transferring water from the basin by means of the Northern Transfer option have been estimated from previous work (DWAF, 1996a) and are shown in the table below.

Table 10.1: Estimated Additional Costs of the Northern Transfer Option

Water Available (million m^3/a)	Capital Cost (R billion)	Electricity Cost (R billion/a)
100	5.0	0.075
200	7.9	0.140
300	10.4	0.205
600	16.8	0.450
800	21.8	0.625

The water available refers to the additional quantity of water available from the Orange River because of the transfer of Mzimvubu River Water.

Losses within the Mzimvubu River Basin have not been included since these have been considered to be recycled by the dams of the scheme. However, incremental losses of 1.2 m^3/s (38 million m^3/a) from the point of discharge near Rhodes to the Orange River have been provided for.

10.1.3 Southern Piped Transfer Option

The additional costs of transferring water from the basin by means of the Southern Piped transfer option have been estimated from previous work (Republic of Transkei, 1987) and are shown in the table below.

Table 10.1.3.1: Estimated Additional Costs of the Southern Piped Transfer Option

Water Available (million m^3/a)	Capital Cost (R billion)	Electricity Cost (R billion/a)
100	8.6	0.170
200	14.3	0.305
300	19.7	0.430

The water available refers to the additional quantity of water available from the Orange River.

There are no losses within the Mzimvubu River Basin. However, incremental losses of 0.8 m^3/s (25 million m^3/a) from the point of discharge south of Dordrecht to the Orange River have been provided for.

10.1.4 Southern Canal Transfer Option

The additional costs of transferring water from the basin by means of the Southern Canal transfer option have been estimated as part of this investigation and are shown in the table below.

Table 10.1.4.1: Estimated Additional Costs of the Southern Canal Transfer Option

Water Available (million m^3/a)	Capital Cost (R billion)	Electricity Cost (R billion/a)
100	16.5	0.120
200	22.2	0.195
300	26.6	0.265

The water available refers to the additional quantity of water available from the Little Fish and Lower Sundays Rivers.

There are no losses within the Mzimvubu River Basin. However, incremental losses of 5.2 m^3/s (164 million m^3/a) for the small scheme increasing to 6.7 m^3/s (211 million m^3/a) for the large scheme from the Mzimvubu River to the point of discharge at the outlet of the Cookhouse Tunnel near Somerset East have been provided for.

10.2 COMPARATIVE UNIT COSTS OF WATER

10.2.1 Scope

The cost of distributing the water in bulk to the users in the receiving catchment has again not been included, as mentioned in the previous section. The indicated transfer capacities of the schemes do however allow for the losses as mentioned in the previous section.

A Unit Reference Value of water (URV) in R/m^3 has been derived in order to compare the relative unit costs of supplying water for different scenarios of bulk water transfers. The derivation has been as described in Section 8.

All values have been discounted to a base date of 1 April 2007 using June 2004 prices, including VAT. The discount period has been from the earliest likely commencement date of implementation of the options to 45 years after likely completion of increasing the dam storage capacity from that required for the water use within the basin only. Provision has been made for the time to fill the dams before the delivery of water commences. Conveyances have been deemed to have been completed when the delivery of water commences. Salvage values at the end of the discounting period have been ignored as before.

The recurrent annual costs adopted for the analyses have been based on the Departmental Guidelines (DWAF, 1994). A corresponding weighted uniform average annual rate of 0.4% of the capital cost has been adopted for operation and maintenance costs of the dams to allow for both the civil and mechanical components. Recurrent costs have been deemed to commence in the year of completion of the dams.

Due to the integration of the Northern transfer option with the dams that are required to supply the water requirements in the basin, a weighted uniform average annual rate for operation and maintenance costs has been adopted for all the components of the scheme, in addition to the annual electricity costs for the water transfers. This has been varied from 0.5% of the capital cost of the works for schemes with a transfer capacity of 300 million m^3/a or less and 0.7% for larger schemes. The average rates for operation and maintenance and the annual distribution of the capital expenditure have been derived from previous work and have been phased in as the different transfer scheme components have been completed (DWAF, 1996a).

Discount rates of 6%, 8% and 10% have again been considered.

The URVs are based on the quantities of water secured and transferred, at an equivalent assurance of 98%. In the case of irrigation the allocated water would be at a lower assurance and therefore the URV of the allocated water would be less than indicated above and depend on the actual assurance adopted and its equivalent at 98% assurance.

10.2.2 Northern Transfer Option

The estimated URVs for the Northern transfer option are shown in Table 10.2.2.1.

Table 10.2.2.1: URV of Additional Water Available in Orange River from the Northern Transfer Option

Water Available (million m^3/a)	Unit Reference Value (R/m^3)		
	6% Discount	8% Discount	10% Discount
100	5.30	6.85	8.80
200	4.60	6.10	8.00
300	4.40	5.90	7.80
600	4.25	5.80	7.80
800	4.50	6.25	8.60

The water available and the URV refer to the additional quantity of water available from the Orange River.

10.2.3 Southern Piped Transfer Option

The estimated URVs for the Southern Piped transfer option are shown in Table 10.2.3.1.

Table 10.2.3.1: URV of Additional Water Available in Orange River from the Southern Piped Transfer Option

Water Available (million m^3/a)	Unit Reference Value (R/m^3)		
	6% Discount	8% Discount	10% Discount
100	8.45	10.40	12.45
200	7.05	8.65	10.40
300	6.65	8.15	9.90

The water available and the URV refer to the additional quantity of water available from the Orange River.

10.2.4 Southern Canal Transfer Option

The estimated URVs for the Southern Canal transfer option shown in Table 10.2.4.1.

Table 10.2.4.1: URV of Additional Water Available in Fish and Lower Sundays Rivers from the Southern Canal Transfer Option

Water Available (million m^3/a)	Unit Reference Value (R/m^3)		
	6% Discount	8% Discount	10% Discount
100	14.05	18.05	22.55
200	10.25	12.55	16.15
300	8.20	10.55	13.45

The water available and the URV refer to the additional quantity of water available from the Fish and Lower Sundays Rivers.

10.3 LABOUR-ENHANCED CONSTRUCTION

The enhancement of the labour content of large water transfer schemes had previously been examined as part of the Vaal Augmentation Planning Study (DWAF, 1996b).

Using conventional construction techniques where the emphasis is to minimise the costs of the project, canals were found to have the highest labour content, with salaries and wages actually paid to personnel (which differs from the cost of personnel) amounting to about 12% of the total cost of the work excluding VAT. Pipelines have the lowest labour content, and salaries and wages amount to about 7% of the total cost of the work excluding VAT. On average the salaries and wages paid to the employees would therefore amount to about 10% of the total cost excluding VAT.

If the total staff complement is increased by 100% to enhance the labour content it is necessary to increase the numbers of all staff categories. The unskilled labour component would increase by about 120% and the total salaries and wages paid would increase by about 70%. This would cause the cost of the work to increase by 8% and could also extend the duration of the work. In the case of the Southern Canal transfer option the salaries and wages could therefore be increased from about R1 500 million to R2 500 million after enhancement of the labour content, but the capital cost of the scheme will increase by about R1 200 million, excluding VAT.

The health, safety and welfare of the employees is an important obligation placed upon a contractor. The harsh climatic conditions of the hotter and more arid areas that will be traversed by the Southern Canal scheme will therefore have a significant negative influence on the other benefits that can be derived from labour enhanced construction.

11. LIMITING FACTORS TO WATER RESOURCE DEVELOPMENT AND UTILIZATION IN THE MZIMVUBU RIVER BASIN

Economic studies indicate that water is but a contributing factor to economic development and the mere availability of water does not stimulate or generate development on its own. Any large-scale development needs a variety of supporting factors to have the desired effect of creating sustainable economic returns and employment opportunities.

The Mzimvubu River Basin has large undeveloped water resources and significant potential for the development of forestry and irrigation within the basin, which make it possible to create relatively large numbers of long-term employment opportunities. However, such development would require large amounts of initial capital and recurring annual funding to provide and sustain the extensive infrastructure in water, communications, other support services and industries, and education and training that are integral components of any such development.

The following are some of the necessary requirements for the development to be sustainable:

- Comparative advantages over other localities, such as proximity to produce markets and efficient production of crops that are in demand;
- The existing land-tenure system, which is not unique to the Mzimvubu River Basin and the associated constraints that could lead to under-performance or failure of development programmes;
- Willingness of the local communities to accommodate the new activities in their societies and value systems, which may require some transformation;
- Developing very costly relocation programmes in conjunction with and acceptable to the local communities;
- The institutional capacity to implement and continue to manage projects and to provide extension services;
- Implementation goals that are realistic and attainable in reasonably short periods;
- Creating Public-Private Partnerships (Eastern Cape Provincial Government, 2003); and
- Employing labour intensive and community based methods for farming and forestry wherever possible.

12. FINDINGS AND CONCLUSIONS

The natural MAR of the Mzimvubu River Basin, which is shared by the Eastern Cape and KwaZulu-Natal Provinces, is about 2 900 million m^3. Relatively little of this water is utilized at present. Significant potential for large-scale water resource development therefore still exists in the basin. However, the high cost of securing the utilizable water requires significant socio-economic benefits to be derived from the utilization of such water for activities such as irrigation and forestry.

There is a small (58 million m^3/a) surplus of utilizable water at present, but the expansion of forestry and irrigation will reduce the flows available for ecological water requirements and the effects will have to be carefully monitored.

Improved assessments of management classes and the associated ecological water requirements are essential for a better evaluation of the remaining water that may still be available for use at an acceptable assurance of supply before providing additional storage.

There are no large water shortages for the existing land use in the Eastern Cape. Significant quantities of unutilized water are still available in the Kei River catchment and further to the east, without having to do any major water resource development.

Some water shortages do however occur locally such as in parts of the Karoo and in the coastal catchments between Port Elizabeth and Port Alfred. Of the rivers that are shared with other provinces there will also be a water shortage along the Upper Orange River, which is as a result of the provision for the ecological Reserve, that must still be implemented.

A feature of the water use in the Eastern Cape is the large number of under-utilized existing irrigation schemes. The problems that have led to the present situation include poor reliability of water supplies, a lack of local electricity supplies, inappropriate technology and irrigation systems, poor management and maintenance, inadequate farmer training and extension, the land-tenure system, poor access to finance and markets and local conflicts.

Provision has been made to expand irrigation by emerging farmers in the Eastern Cape upstream of the Gariep Dam by 1 000 ha. This water will however have to be secured in future.

Large transfers of water are already made from the Gariep Dam in the Upper Orange WMA to the Fish to Tsitsikamma WMA in the Eastern Cape. Provision has also been made to increase these transfers to expand irrigation by emerging farmers in the Fish River and Lower Sundays River catchments by 4 000 ha, which accounts for some of the present surplus. The remainder of this surplus can be accounted for by return flows downstream of the last point of abstraction from the Fish River where the salinity of the water becomes too high for beneficial use. Provision has also been made to transfer additional water from Gariep Dam via the Fish and Sundays Rivers to Port Elizabeth.

A large portion of the basin is occupied by numerous scattered rural villages. After providing for this and if the water supplies were increased sufficiently to meet all the requirements, the net areas of land with potential for forestry and crop cultivation are approximately as follows:

- Forestry 244 000 ha
- Dryland cultivation (high to moderate potential) 48 000 ha
- Dryland cultivation (low potential) 156 000 ha
- Irrigated cultivation (high potential) 11 000 ha
- Irrigated cultivation (moderate potential) 91 000 ha

Many of the above areas overlap each other and therefore decisions will have to be taken on the most suitable development. A maximum reference development scenario that provides an indication of the highest likely water use when taking account of the topographic, soil and climatic constraints could comprise the following (including existing development):

- Forestry 180 000 ha
- Irrigated cultivation 70 000 ha

A likely smaller development scenario of predominant activities is shown in Figure 9 and could comprise the following (including existing development):

- Forestry 120 000 ha
- Dryland cultivation (high to moderate potential) 1 600 ha
- Irrigated cultivation 44 600 ha

Much of the irrigated agriculture could be initiated as dryland agriculture that is then converted to irrigation as the necessary skills are acquired by the farmers.

Eskom is investigating conventional hydropower schemes of moderate installed capacity not exceeding 140 MW that will mainly be used for peak power generation. These are much smaller than those investigated by others in the past and will not be large net users of water.

Upstream water use by forestry and particularly irrigation can have a significant effect on the economics of conventional hydropower production and *vice versa* and needs to be considered when embarking on any large scale water resource development and water use projects.

Pumped-storage hydropower schemes have also been investigated in the past. The capacities can exceed 2 000 MW. One possibility is a high-head off-channel scheme in the west of the basin that straddles the continental divide. This scheme has the added potential of also being used to transfer water to the Orange River. Another scheme with a much lower head is situated in the Mzimvubu River near the coast.

Tourism potential is high, particularly near the coast, but does not consume much water in relation to the other potential water uses.

Irrigation in the basin will typically apply about 700 mm/a or 7 000 m^3/ha/a at field edge. Forestry in the basin reduces the mean annual run-off from the afforested area by about 115 mm or 1 150 m^3/ha.

It is estimated that the above so-called reference development scenario (which includes existing development) could use the following quantities of water at an equivalent assurance of 98%:

• Forestry	140 million m^3/a
• Irrigated cultivation	450 million m^3/a
• Domestic, industrial and livestock watering	50 million m^3/a
	640 million m^3/a

After full development of the water resources, the total utilizable water in the basin would amount to about 1 300 million m^3/a. This will therefore result in a surplus of at least 660 million m^3/a that would be available for use in other areas if the cost of securing and transferring the water is affordable.

The capital cost of constructing a sufficient number of large dams to supply the water required in the basin for the reference scenario consumptive use of 640 million m^3/a, of which 140 million m^3/a is to compensate for the reduction in run-off by forestry, is approximately R5 700 million. The annual recurrent costs of operating and maintaining the dams would be approximately R23 million.

The resulting Unit Reference Value (URV) at a discount rate of 8% to provide sufficient water for a consumptive use of 640 million m^3/a for the reference development scenario is approximately R1.12/m^3, as shown in Table 8.1. The URV reduces to about R1.01/m^3 for a consumptive use of 390 million m^3/a for the likely scenario.

Significant sustainable socio-economic benefits will be required to offset the high cost of supplying water at adequate assurance in the rivers for any large-scale irrigation and forestry development. Bringing the water from the dams and rivers to the irrigation areas will entail significant further costs.

Three alternative options to transfer surplus water from the Mzimvubu River Basin to as far as the Fish and Sundays River catchments in the Eastern Cape have been assessed. These are the following:

- The Northern transfer option. This consists of a number of additional dams in the Mzimvubu River Basin together with a system of canals, pump stations, pipelines and tunnels that transfer the water into a small tributary of the Orange River near Rhodes. From here the water flows to the Orange River from where it can be released through the Orange Fish Tunnel into the headwaters of the Fish River at Teebus, for further distribution.
- The Southern Piped transfer option. This consists of a large dam in the lower reaches of the Mzimvubu River and pump stations and pipelines that transfer the water into another small tributary of the Orange River near Dordrecht. From here the water can flow to the headwaters of the Fish River as in the case of the Northern transfer option.

- The Southern Canal transfer option. This consists of a large dam in the lower reaches of the Mzimvubu River and pump stations, pipelines and canals that transfer the water as far as the Little Fish River at the outlet of the Cookhouse Tunnel near Somerset East. Through an exchange of water with that which is being supplied by the Orange River Project at present, it would also be possible to abstract water further upstream in the Fish River.

The environmental impacts of the transfer schemes have not been assessed. These are expected to be most severe for the Southern Canal transfer option, which will traverse areas of high population concentrations. The large canals may also have a very disruptive effect on the movement of people, livestock and game and also be particularly dangerous for children and animals.

It has been found that the Northern transfer option from the Mzimvubu River to as far as the Fish and Sundays Rivers would be the least costly. River losses that would occur from the point of discharge into the Bell Spruit near Rhodes to the Orange River are estimated at approximately 1.2 m^3/s. These are much less than the river losses associated with the Southern Canal option, but 50% higher than those for the Southern Piped option.

The capital cost of the Northern transfer option to deliver 600 million m^3/a into the Orange River is approximately R16 800 million, as shown in Table 10.1. This is the cost of the additional dams, canals, pump stations, pipelines and tunnels. The capital cost reduces to R5 000 million when only 100 million m^3/a is delivered. The annual costs of electricity and operating and maintaining the transfer schemes is approximately R570 million and R100 million respectively.

The resulting URV, at a discount rate of 8%, of 600 million m^3/a of water delivered in the Orange River is approximately R5.80/m^3, as shown in Table 10.2.2.1. The URV however, increases to R6.85/m^3 when the delivered quantity is reduced to 100 million m^3/a.

The above transfers and URVs have accounted for losses in the receiving catchments.

Very large sustainable socio-economic benefits will be required to offset the high incremental cost of transferring water from the Mzimvubu River to other areas, such as the Orange, Fish and Lower Sundays Rivers.

The enhancement of the labour content of large water transfer schemes had previously been examined. The obligation of securing the health, safety and welfare of the employees will be reflected in the construction costs. The harsh climatic conditions of the hotter and more arid areas that will be traversed by the Southern Canal transfer option will have a significant effect on the project cost and the benefit that can be derived from labour enhanced construction.

Increasing the total staff complement by 100% will increase the unskilled labour component by about 120%. The total salaries and wages paid would increase by about 70% while the cost of the project would increase by 8%. The work is also likely to take longer to complete. In the case of the Southern

Canal transfer option, which has the largest labour content, the salaries and wages could be increased from about R 1 500 million to R 2 500 million, but the cost of the project will increase by about R 1 200 million.

Economic studies indicate that water is but a contributing factor to economic development. Any large-scale development needs a variety of supporting factors to have the desired effect of creating sustainable economic returns and employment opportunities.

Large amounts of initial capital and recurring annual funding are required to provide the extensive infrastructure in water, communications, other support services and industries, and education and training that are integral components of any large development.

Numerous other non-structural requirements such as one or more comparative advantages over other localities, reform of the existing land tenure system, willingness of the local communities to accommodate the new activities, developing locally acceptable relocation programmes, institutional capacity to implement and manage the projects, realistic implementation goals, Public-Private Partnerships and labour intensive and community-based methods for farming and forestry wherever possible are also necessary for the development to be sustainable.

There is a strong need for improved hydrological and weather observation in the Mzimvubu River Basin and also to improve the estimates of the ecological water requirements for different classes and the actual setting of ecological classes.

13 RECOMMENDATIONS

Existing unutilized water supplies and underutilized irrigation schemes in the Eastern Cape should be rehabilitated to their fullest extent possible while development plans are being formulated for the Mzimvubu River Basin.

In order to prevent a recurrence of the problems that have led to the under-utilization of existing irrigation projects in the Eastern Cape it is necessary to address the limiting factors before embarking on any large-scale irrigation or forestry developments in the Mzimvubu River Basin.

An updated determination of the land utilization potential of the Mzimvubu River Basin should be done at a reconnaissance level (desk study with limited field verification) to indicate the locations and extent of the areas that are suitable for forestry, the areas of high to moderate and low dryland cultivation potential, and the areas of high and moderate irrigation potential in each quaternary catchment. The findings of studies that were in progress at the time that this report was completed must be evaluated before new studies are done.

The hydrological model calibration and run-off simulation for the Mzimvubu River and its tributaries should be updated and improved to take account of the additional runoff data that has been gathered since the last update performed in 1994.

After the hydrology of the basin has been improved a programme should be initiated to determine the ecological Reserve for the Mzimvubu River, its tributaries and the estuary, together with any initiatives for the further utilization of the substantial land and water resources in the basin.

It is essential that future development planning be integrated at an early stage of the planning process. Assessments of possible future development and water use must take account of the competing land uses and the social preferences of the local communities and the likely conflicts that could arise.

The possibility of multi-purpose water resource development and water transfer projects must be considered from the outset.

Land use and water resource development projects in the basin must be closely integrated with plans for promoting and facilitating tourism to the Eastern Cape and the Wild Coast (including Port St. Johns), and vice versa.

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DIRECTORATE NATIONAL WATER RESOURCE PLANNING

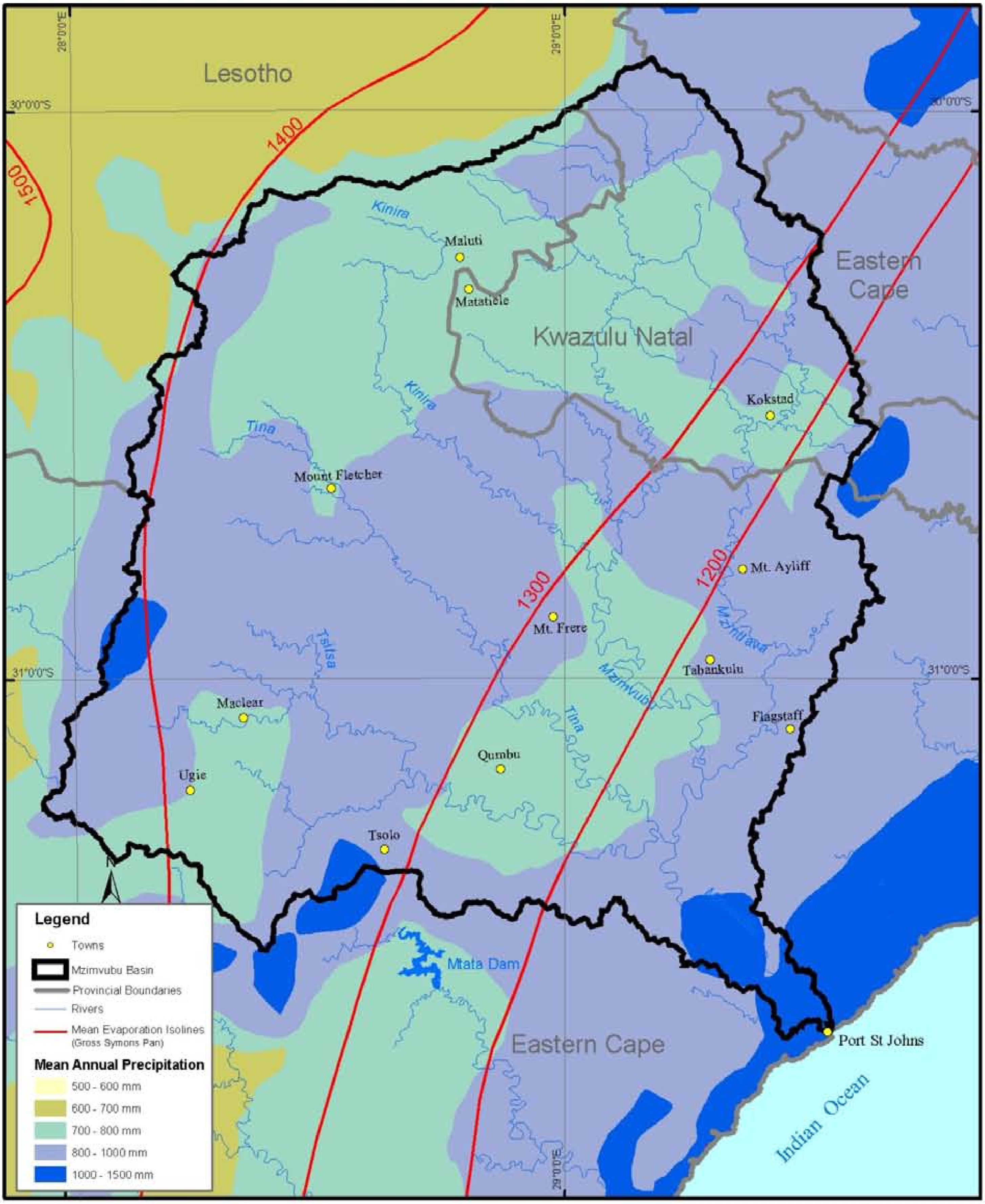
Eastern Cape : Mzimvubu River Basin
Water Utilization Options

EASTERN CAPE TOPOGRAPHY AND WATER MANAGEMENT AREAS

Projection: **Albers Projection**
Central Meridian: 26.5
1st Std Parallel: -30
2nd Std Parallel: -34
Latitude of Origin: 0

Scale: 0 10 20 40 60 Kilometers
1 : 3 000 000

Figure 1



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DIRECTORATE NATIONAL WATER RESOURCE PLANNING

Eastern Cape : Mzimvubu River Basin
Water Utilization Options

MEAN ANNUAL PRECIPITATION AND EVAPORATION

Projection: **Gauss Projection**
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2nd Std Parallel: 0
Latitude of Origin: 0

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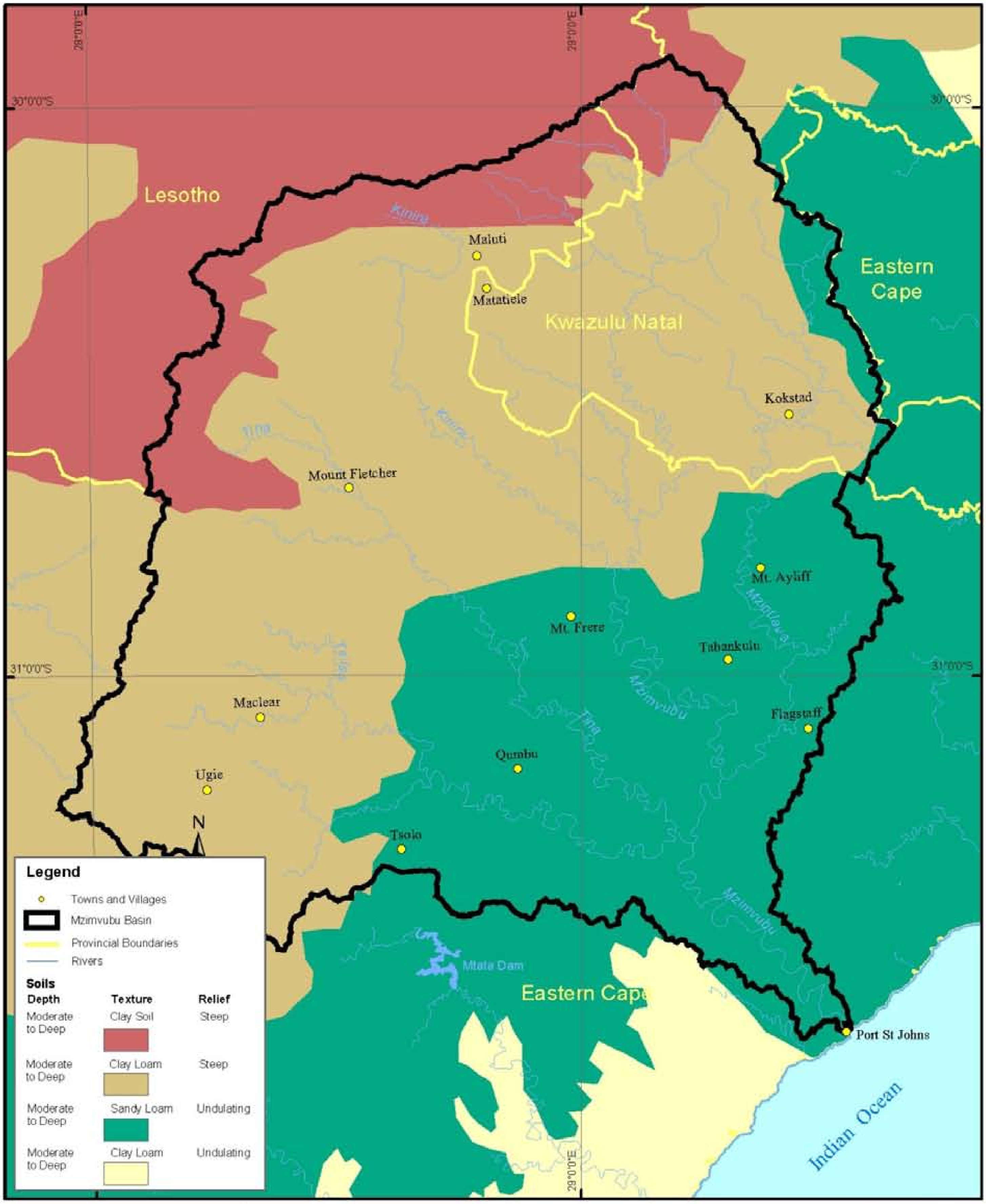
Figure 2



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Eastern Cape : Mzimvubu River Basin
Water Utilization Options

Soils

Projection: Gauss Projection
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2nd Std Parallel: 0
Latitude of Origin: 0

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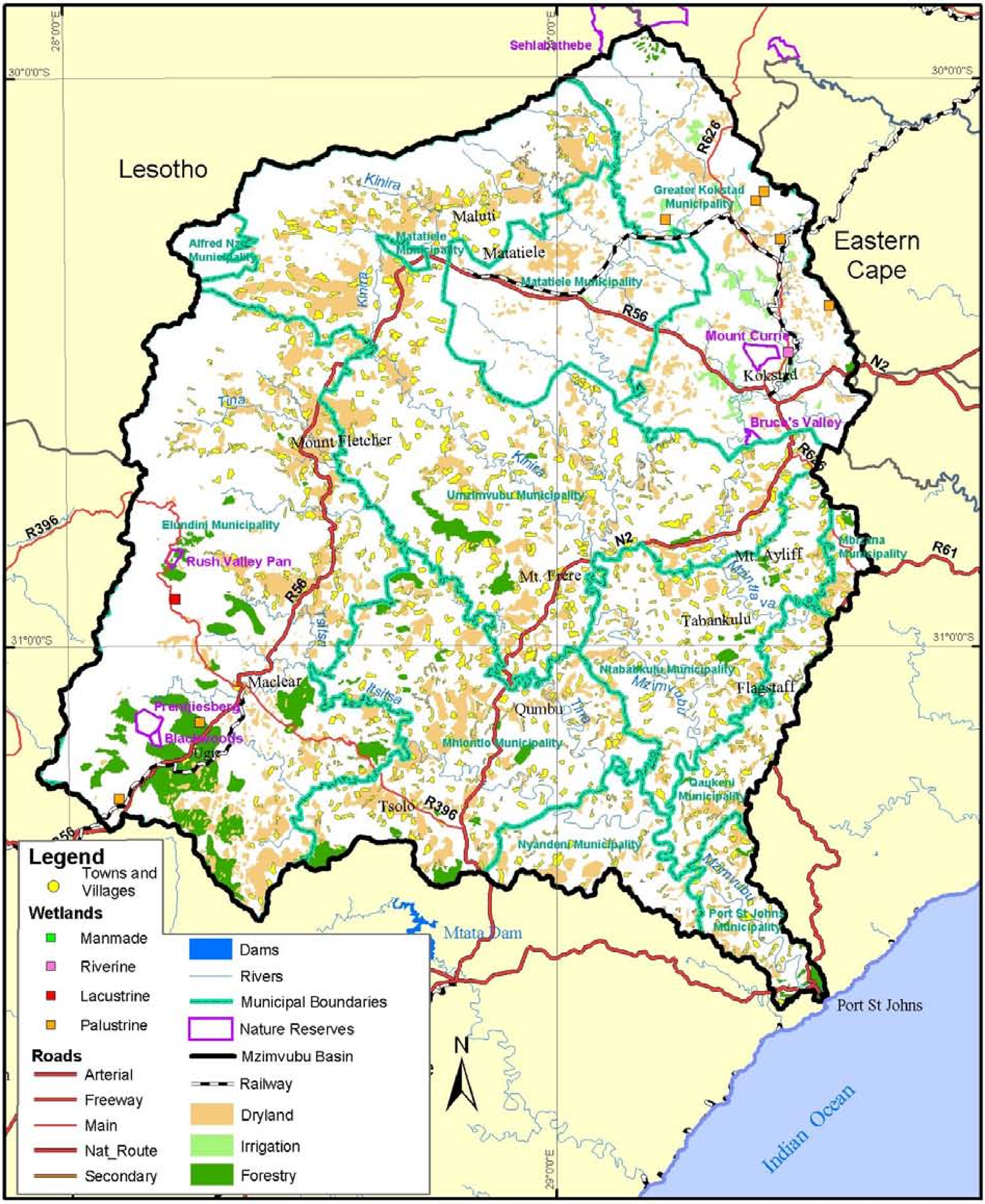
1 : 1 000 000

Figure 3



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DIRECTORATE NATIONAL WATER RESOURCE PLANNING

Eastern Cape : Mzimvubu River Basin
Water Utilization Options

LANDUSE

Projection:
Gauss Projection
Central Meridian: 29
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2nd Std Parallel: 0
Latitude of Origin: 0

Scale
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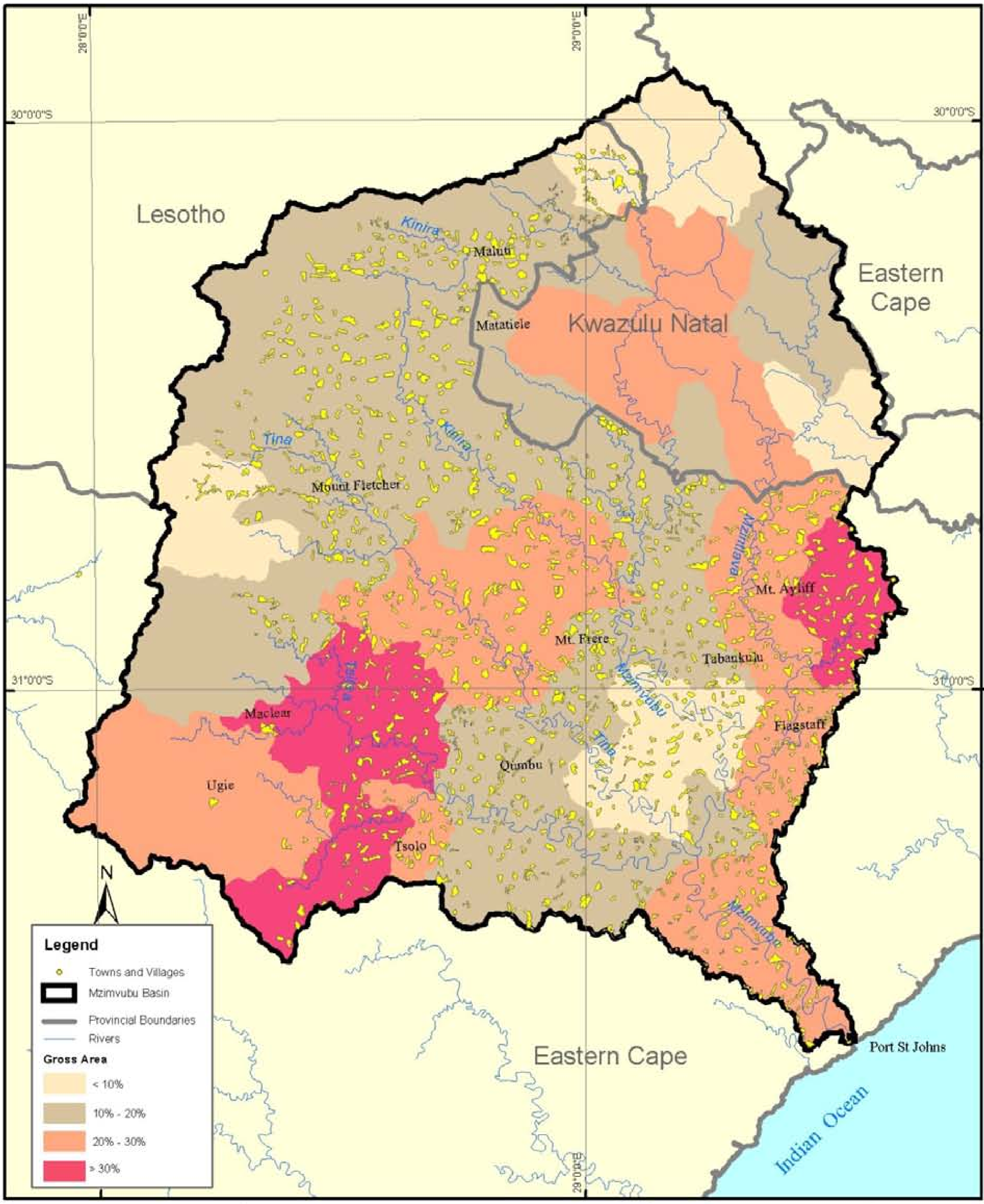
1 : 1 000 000

Figure 4



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DIRECTORATE NATIONAL WATER RESOURCE PLANNING

Eastern Cape : Mzimvubu River Basin
Water Utilization Options

FORESTRY POTENTIAL

Projection: **Gauss Projection**
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2nd Std Parallel: 0
Latitude of Origin: 0

Scale: 10 5 0 10 20 Kilometers
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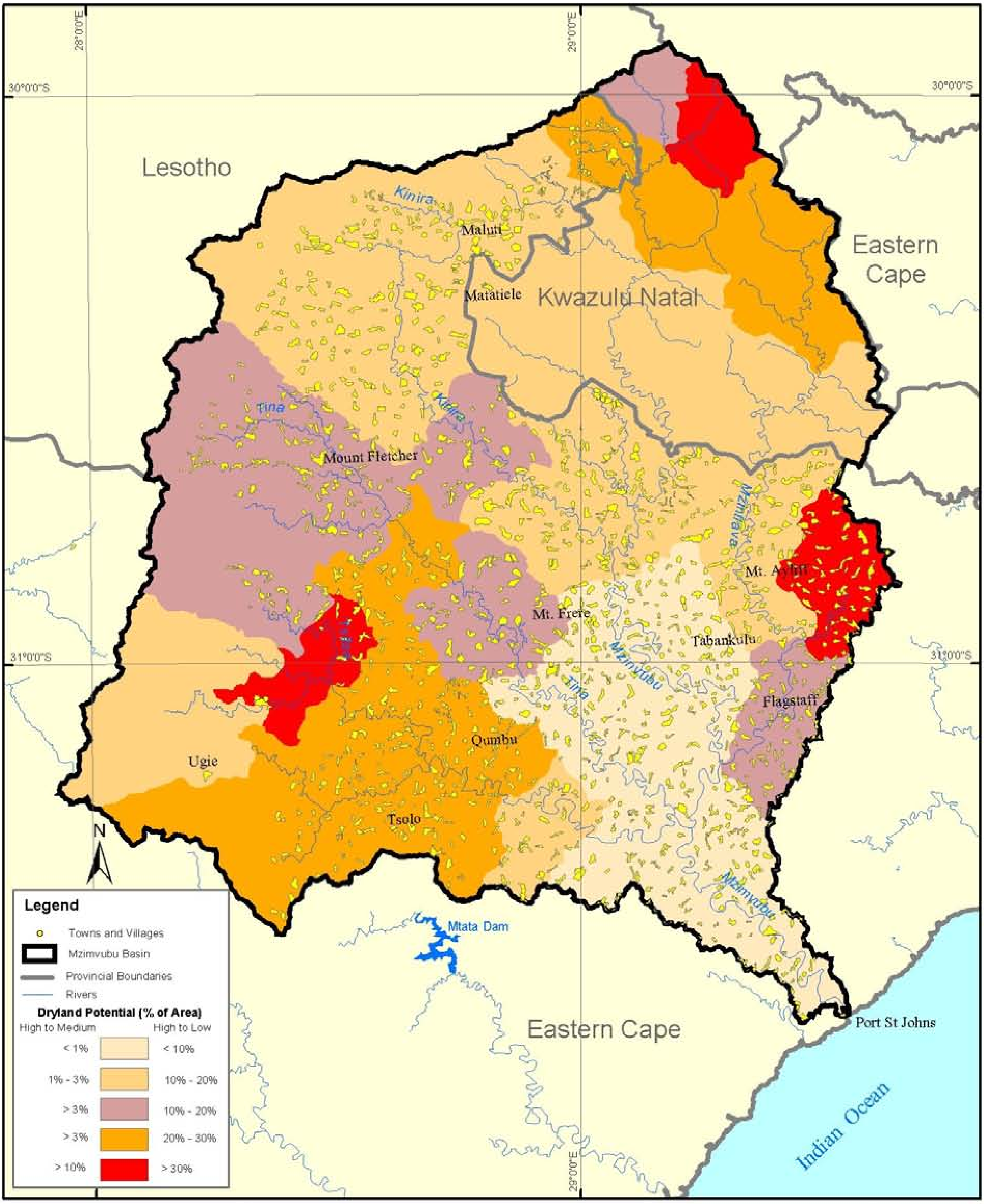
Figure 5



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Eastern Cape : Mzimvubu River Basin
Water Utilization Options

Dryland Potential

Projection:
Gauss Projection
Central Meridian: 29
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2nd Std Parallel: 0
Latitude of Origin: 0

Scale:
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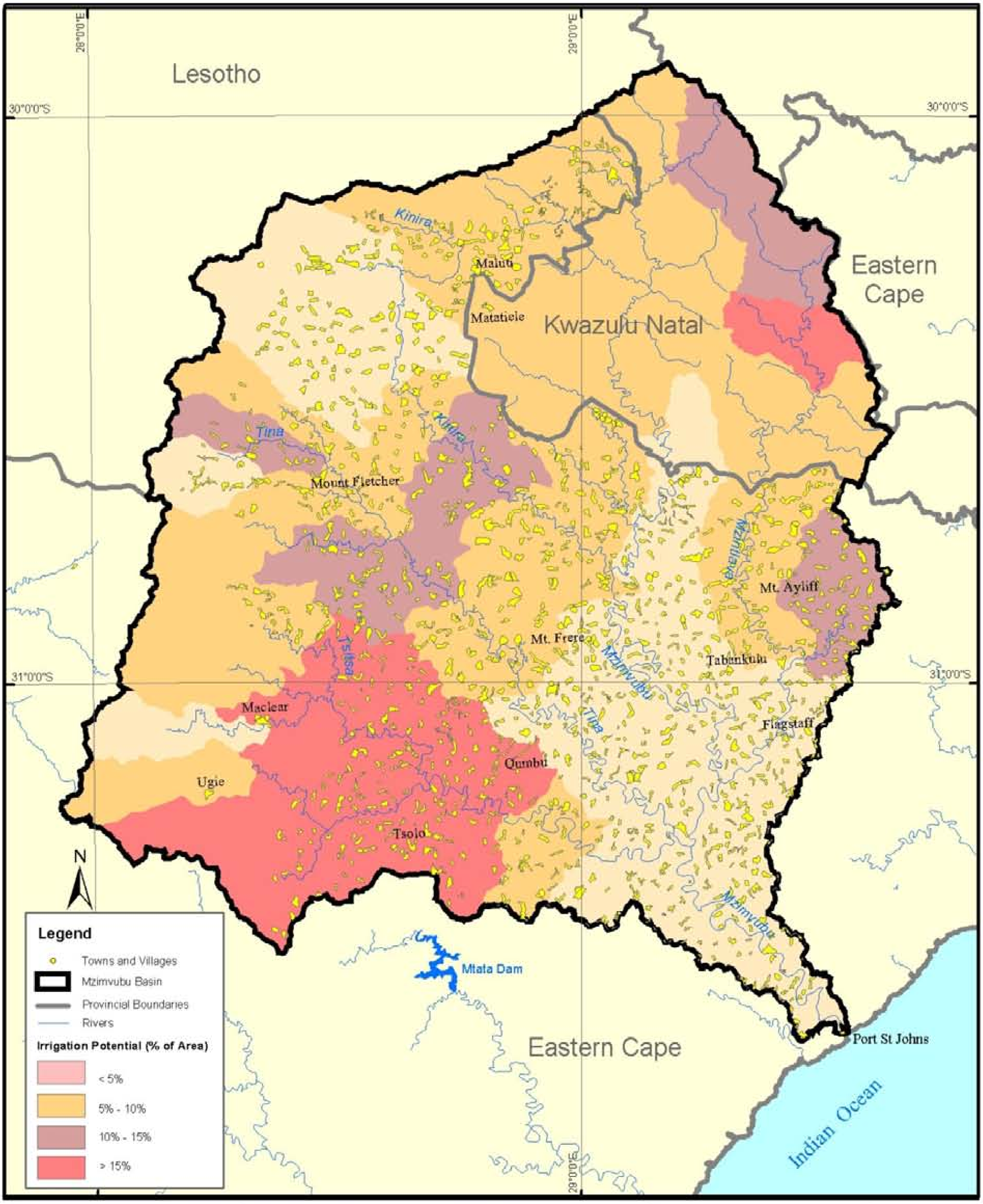
1 : 1 000 000

Figure 6



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Eastern Cape : Mzimvubu River Basin
Water Utilization Options

IRRIGATION POTENTIAL

Projection:
Gauss Projection
Central Meridian: 29
1st Std Parallel: 0
2nd Std Parallel: 0
Latitude of Origin: 0

Scale:
10 5 0 10 20 Kilometers
1 : 1 000 000

Figure 7

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Eastern Cape : Mzimvubu River Basin
Water Utilization Options

Hydropower Possibilities

Projection:
Gauss Projection
Central Meridian: 29
1st Std Parallel: 0
2nd Std Parallel: 0
Latitude of Origin: 0

Scale:
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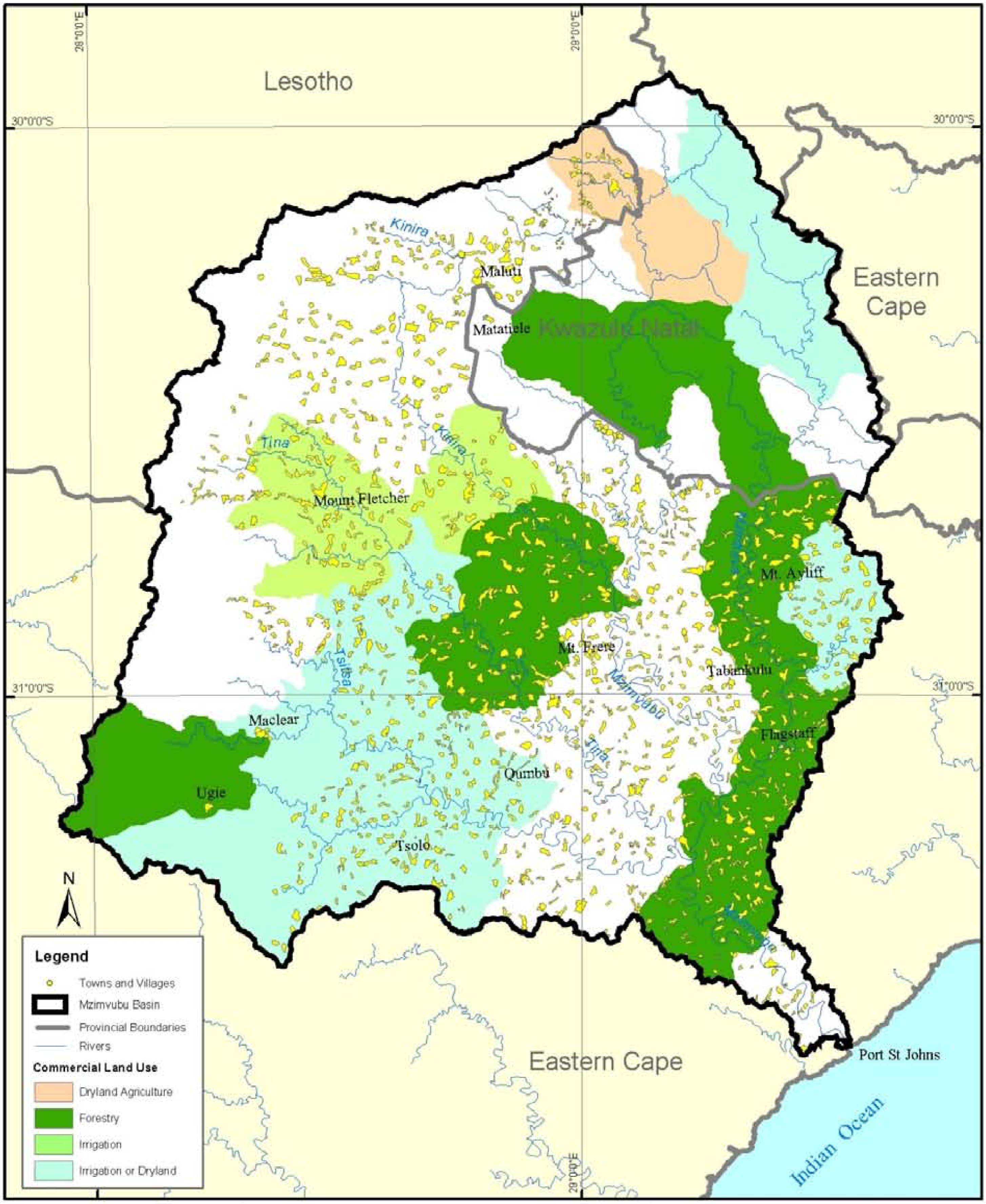
1 : 1 000 000

Figure 8



DEPARTMENT OF WATER AFFAIRS AND FORESTRY
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Eastern Cape : Mzimvubu River Basin
Water Utilization Options

Possible Predominant Commercial Land Use

Projection:
Gauss Projection
Central Meridian: 29
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2nd Std Parallel: 0
Latitude of Origin: 0

Scale:
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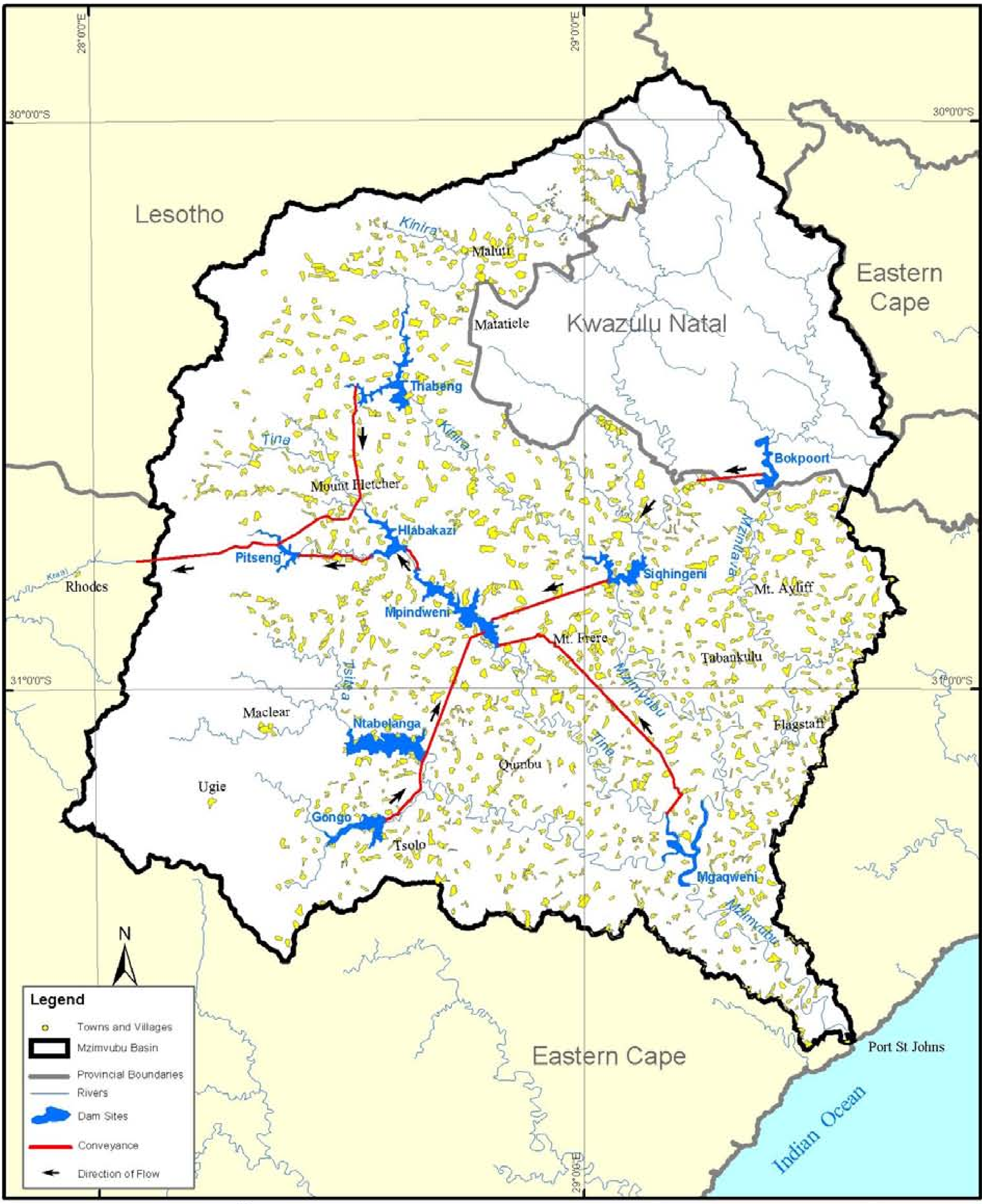
Figure 9



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DIRECTORATE NATIONAL WATER RESOURCE PLANNING

Eastern Cape : Mzimvubu River Basin
Water Utilization Options

Possible Dams and Northern Transfer from Mzimvubu River Basin to Orange River

Projection:
Gauss Projection
Central Meridian: 29
1st Std Parallel: 0
2nd Std Parallel: 0
Latitude of Origin: 0

Scale:
10 5 0 10 20 Kilometers
1 : 1 000 000

Figure 10

DEPARTMENT OF WATER AFFAIRS AND FORESTRY
DIRECTORATE NATIONAL WATER RESOURCE PLANNING

Eastern Cape : Mzimvubu River Basin
Water Utilization Options

Southern Piped Transfer from Mzimvubu River to Fish and Orange Rivers

Projection:
Albers Projection
Central Meridian: 26.5
1st Std Parallel: -30
2nd Std Parallel: -34
Latitude of Origin: 0

Scale:
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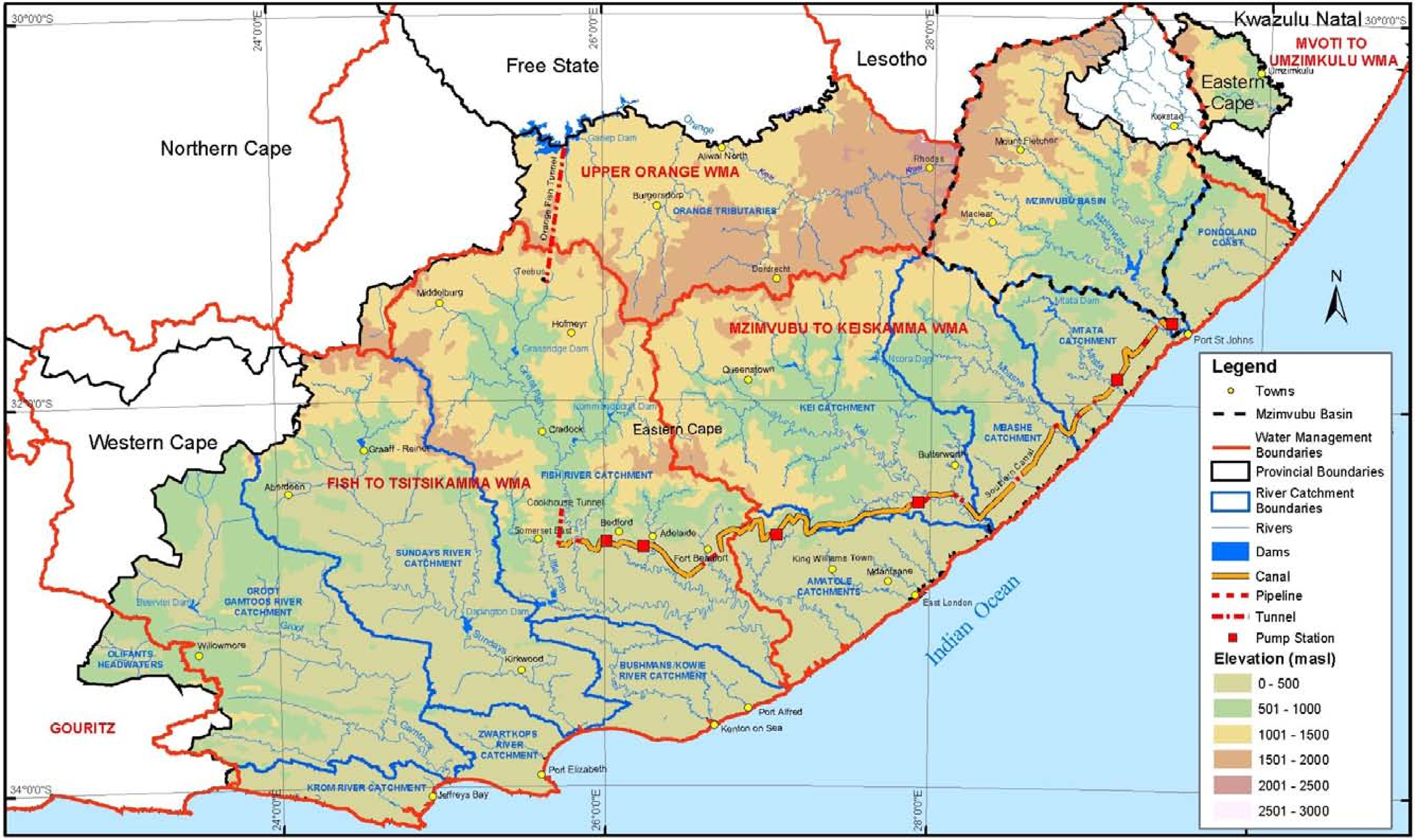
1 : 3 000 000

Figure 11



DEPARTMENT OF WATER AFFAIRS AND FORESTRY
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Eastern Cape : Mzimvubu River Basin
Water Utilization Options

SOUTHERN CANAL TRANSFER FROM MZIMVUBU RIVER TO FISH AND SUNDAYS RIVERS

Projection: Albers Projection
Central Meridian: 26.5
1st Std Parallel: -30
2nd Std Parallel: -34
Latitude of Origin: 0

Scale: 0 10 20 40 60 Kilometers
1 : 3 000 000

Figure 12