GLOBALIZATION AND WATER RESOURCES MANAGEMENT:
THE CHANGING VALUE OF WATER

AUGUST 6-8 AWRA/IWLRI-UNIVERSITY OF DUNDEE INTERNATIONAL SPECIALTY CONFERENCE 2001

PRACTICAL ISSUES OF HELP: EXAMPLES FROM THE THUKELA BASIN IN SOUTH AFRICA

Valerie Taylor, Roland Schulze, Graham Jewitt, Andrew Pike and Mark Horan[1]

ABSTRACT: The Thukela is a physiographically, climatologically, hydrologically and socio-economically diverse catchment on the east coast of South Africa. It is bounded in the west by the Ukhahlamba-Drakensberg Park, a declared World Heritage Site, with altitudes of over 3000 m and in the east by its estuary discharging into the Indian Ocean. It is hydrologically complex with high spatial and temporal variability and unpredictable seasonal climate, and with streams contaminated by high sediment concentrations and acid mine drainage. The catchment is characterised by a juxtapositioning of "first world" commercial agriculture and industrial economies and "third world" impoverished communities dependent upon subsistence farming in degraded areas. Environmental problems arise from large-scale degradation through overgrazing as well as mining and heavy industry water quality issues. Substantial inter-basin transfers out of the Thukela system to the north (the Johannesburg / Pretoria complex) and the south (to the Durban /Pietermaritzburg complex) exacerbate these problems. Consequently, the hydrological characteristics of downstream natural flow regimes have been altered. Nonetheless, further large reservoirs for inter-basin transfer have been proposed. Through a movement to the integrated approach to the management of water resources in South Africa's National Water Act of 1998 (NWA), the Thukela catchment is now a designated Water Management Area. The NWA will in time have to be implemented through a stakeholder driven Catchment Management Agency for the Thukela. This paper presents practical issues of Hydrology for the Environment, Life and Policy (HELP) that need to be addressed to embrace the spirit of the NWA.
KEY TERMS: inter-basin transfer; environmental flows; water use; catchment management strategy; capacity building

INTRODUCTION

The limited availability of water resources for different water use sectors presents one of the most contentious and challenging issues to the implementation of effective management and potential future development of South Africa's catchment areas. To this extent the new South African Water Act of 1988 (NWA, 1998) requires that water resource allocation be approached in a more equitable and conservative way than in the past, in order to sustain water resources for catchment development. This includes protection of the water resource base by the setting aside of a Reserve for basic human needs and for the ecological functioning of rivers. Even in relatively wet regions of South Africa there is a need for effective management strategies to reconcile water demand with water supply. In this paper the freshwater issues of the Thukela catchment, in KwaZulu-Natal are reviewed and discussed in terms of the demands imposed by both societal and environmental systems.

The Department of Water Affairs and Forestry (DWAF) has advocated catchment management as the best way to manage water resources to meet human needs in a sustainable way (DWAF, 1996). This basic premise has been embraced by the NWA which promotes integrated water resources management (water allocation plans, control, development, management, conservation, and protection and use of water resources) at a catchment scale (NWA, 1998). The implications of this concept are that land uses within catchments will also be regulated (WISA, 2000). The new legislation provides for the declaration of Streamflow Reduction Activities (SFRAs), defined as the water use by any activity that reduces streamflow when compared to runoff from natural vegetation (NWA, 1998). Presently (2001), forestry plantations are the only declared

[1] *Respectively, Research Hydrologist, Professor of Hydrology, Senior Lecturer, Research Hydrologist and GIS Programmer, University of Natal, School of Bioresources Engineering and Environmental Hydrology, Private Bag X01, Scottsville, Pietermaritzburg, KwaZulu-Natal, South Africa, Phone: (+27) 33 260 5427, Fax: (+27) 33 260 5818, email: taylorva@nu.ac.za.

SFRAs. While this is not a major land use within the Thuklea catchment, other land uses such as sugar-cane farming are currently being evaluated as SFRAs.

The present political administration in South Africa has provided the opportunity to address some of the inequities associated with the water rights and water allocation that prevailed under the previous government. The NWA overhauled previous water legislation and provides for a transformation of the water management system from an essentially private system to a public rights system or licensing system (WISA, 2000). The new water policy treats all water within the hydrological cycle as a common resource (Gillham and Haynes, 2000) and, as such, is subject to water resources management that ensures equitable allocation. This concept is manifest in the extent to which stakeholders within catchments are now empowered to decide how to use their water.

The Thukela catchment is in the feasibility stage of the establishment of a Catchment Management Agency (CMA) to represent the catchment stakeholders. Once established, the Thukela CMA will be mandated under the NWA to identify pressing catchment issues and to formulate and adopt strategies to address them. This will require knowledge of how much water is available and an understanding of how to assure access to the water that is required (WISA, 2000). These uncertainties require to be explored for the Thukela catchment to re-assess the water allocations in terms of the NWA, particularly for the rural population. To achieve this, participation, information sharing as well as improved communication needs to be fostered between all stakeholders, including regional and municipal government, water users associations and local chiefs in predominantly rural areas. More explicitly, capacity-building measures which equip stakeholders with the expertise required to make informed catchment management decisions need to be instigated if the essence of co-operative governance enshrined in the NWA is to be achieved. The NWA embraces the concepts of a stakeholder-driven approach to catchment management planning and the Thukela catchment is poised to become the nation's first operational Water Management Area (WMA) in the context of Integrated Catchment Management (ICM). The physical, climatic, hydrological and socio-economical diversity within the Thukela catchment alone present considerable challenges for research of water resource issues. Therefore this paper presents the practical issues of the Thukela catchment as a HELP basin.

THUKELA CATCHMENT STUDY AREA

Physical Characteristics

The Thukela River is a principal river of KwaZulu-Natal province in South Africa and is ranked as the largest river by volume in the country. The total catchment area of 29 036 km^2 includes the larger portion of western KwaZulu-Natal, extending latitudinally from 27.41^o to 29.40^o S and longitudinally from 28.96^o to 31.44^o E (see Figure 1). The Thukela River has its source in the Drakensberg mountain range in the west, on the 3050-meter high Mont-aux-Sources plateau near the adjoining of the Lesotho and Free State province borders (DWAF, 2001). The river cascades down a steep escarpment then cuts through the Thukela Gorge and, joined by many tributaries, flows eastwards entering the low relief of the Thukela trough before cutting through a deeply incised valley until it reaches the Indian Ocean about 85 km north of the city of Durban, Africa's largest port (DWAF, 2001).

Ninety percent of the Thukela catchment is underlain by Triassic basalt over Permian / Carboniferous sandstones and shales with coal rich seams. Towards the east, older Devonian sandstones overlay Archaean basement complex granites and gneisses, with the sequence largely mirror-imaged near the coast as a result of monoclinal uplifting. The majority of soils within the catchment are highly erodable Mispah and Glenrosa, which together with steep slopes and meagre alluvial deposits restricts irrigation in the larger part of the Thukela catchment (DWAF, 2001). While natural groundwater occurs as springs and seeps, particularly in the mountainous areas, there is a scarcity of aquifers within the Thukela catchment, which restricts groundwater harvest potential in the catchment. Ground water quality is generally good, although this may be impacted in by coal mining operations in the northern area of the catchment (DWAF, 2001).

Hydrology and Climatology

The mean annual precipitation (MAP) of the Thukela catchment ranges from 2000 mm in the west (with the concentration of precipitation in mid summer, *i.e.* January) to as low as 550 mm in the drier central regions. The coefficient of variation (CV) of annual precipitation ranges from 15 to 25%. The number of rain-days with greater than 1 mm in January ranges from 8 to 19, whereas the number of events with greater than 10 mm per day ranges from 4 to 10 (Schulze, 1997). The mean annual temperature ranges between 12 to 14 ^{o}C in the west, to 20 to 22 ^{o}C at the coast (DWAF, 2001). Flows in January and February account for greater than 40% of the MAR, whereas flows from June to September account for less than 8% of the MAR (Schulze, 1997). The Thukela catchment produces around 8.5% of South Africa's annual streamflow from 2.5% of its area (Schulze, 1997). However, the CV of the catchment annual flow in the west ranges between 40 to 50%, whereas in the central valleys it is greater than 150%. The greater part of the catchment experiences variation in annual flows ranging between 60 to 100% (i.e. 4 to 6 times the CV of MAP (Schulze, 1997). For purposes of modeling the Thukela catchment hydrological dynamics, the catchment has an excellent spatial distribution of rain gauges with adequate records of

daily rainfall measurements. Daily streamflow measurements are also available, yet at a lower spatial distribution, particularly in the east.

The catchment experiences maximum daily temperatures in January and minimum temperatures in July. The means of daily maximum temperature for January range between 20 ^{o}C in the west to 32 ^{o}C in the valleys, whereas the means of minimum temperature for July range between 0 ^{o}C in the west to 10 ^{o}C at the coast. Potential mean annual evaporation

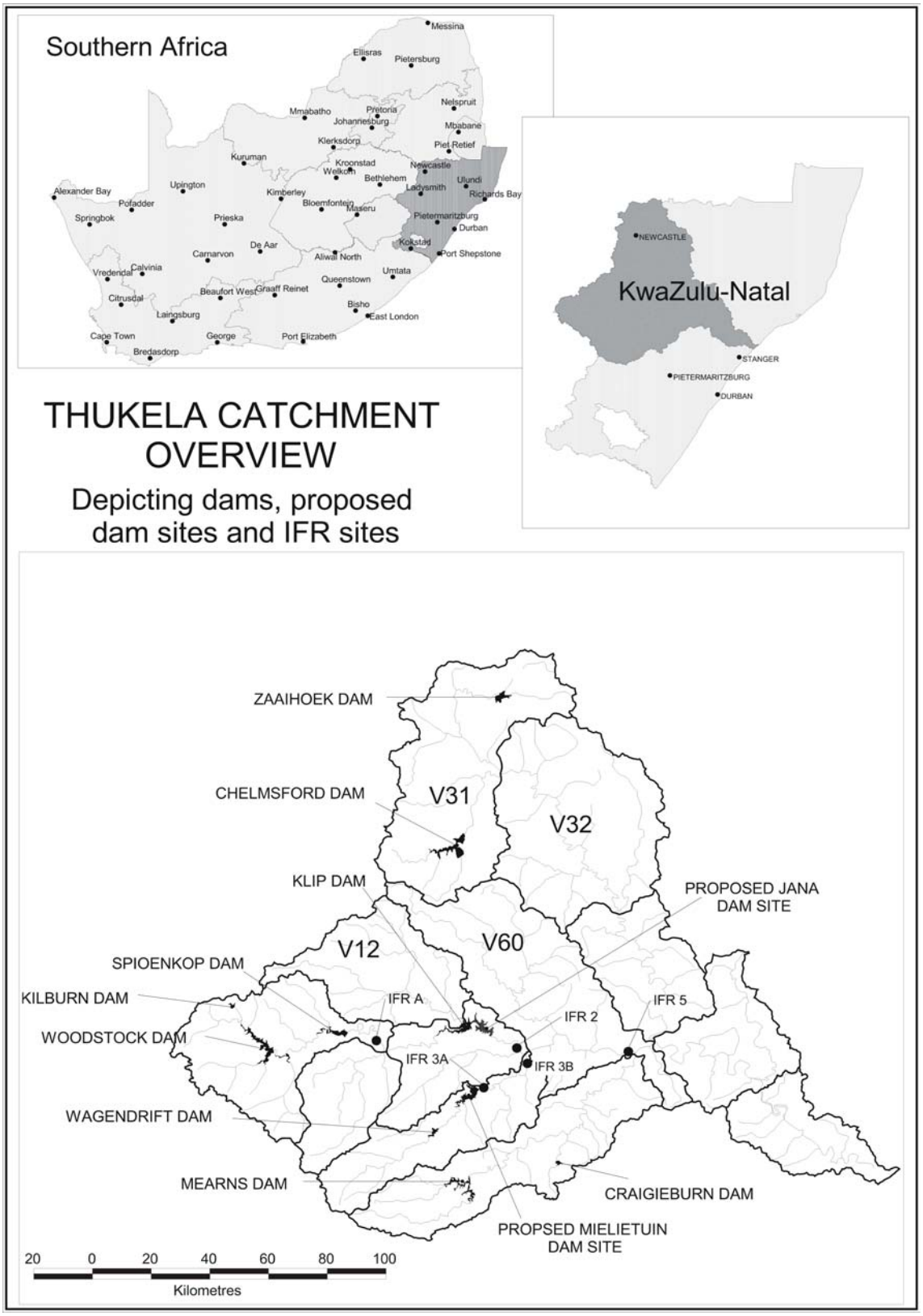

Figure 1. The Thukela Catchment Overview

ranges between 1600 to 2000 mm, with between 180 to 220 mm in January and between 100 to 110 mm in July (Schulze, 1997). The mean annual runoff (MAR) of the catchment is 4000 x $10^6 m^3$, which is equivalent to 17% of the mean catchment MAP.

Settlement, Land use and Economy

The Thukela catchment has an average population density of 54 people per square kilometer with over half of the catchment having a density of less than 10 people per square kilometer (DWAF, 2001). Much of the catchment is predominantly rural with little infrastructural development, but is nevertheless heavily settled. The least sparsely populated areas are in the Drakensberg Mountains in west, with higher density in the east. Greater density is associated with the major urban towns and the adjacent townships but generally there are less than 300 economically active workers per 1000 population.

A substantial portion of the Thukela catchment is unimproved grassland. The major land use is agriculture. Large tracts of land are owned by a relatively small number of commercial farmers with average farm sizes of greater than 700 hectares and frequently with access to river water for supplementary irrigation. The commercial agricultural sector comprises cultivation of wheat, maize and sugarcane (dryland and irrigated), beef and dairy pastures, vegetables and citrus as well as forestry. Most of the irrigation operation within the catchment is performed using sprinkler systems, however, center pivot irrigation is used in the large-scale commercial sector in the west. In the rural areas dryland subsistence agriculture and pastoralism are the dominant land uses since few of the rural communities have access to irrigation water. Heavy industry is associated with the major urban settlements and, in particular, coal mining is operated in the northern parts of the catchment. The catchment also supports eco-tourism in the west, where the Ukhahlamba-Drakensberg Park has been declared a World Heritage site and in the central valleys, where sites of interest include battlefield sites of the Anglo-Boer and Zulu-Boer wars. At the coast there is a viable crustaceans fishing industry, which is highly dependent on the preservation of a littoral sand bar formed by the sediment deposition offshore from the Thukela Estuary mouth. Population pressure on natural resources, especially water, is expected to increase. In particular, subsistence farming and overgrazing in areas of poor and relatively unproductive land has resulted in large tracts of degraded land, which requires rehabilitation.
Per capita income levels in the catchment are generally low, with the average at R5 500 per annum compared to the national average of R9520 (DWAF, 2001). The lowest average incomes are in rural areas where large numbers of subsistence farmers have many dependents. Table 1 indicates the distribution of income as well as selected socio-economic factors for selected tertiary catchments in the Thukela catchment.

Table 1. Selected socio-economic indicators for selected tertiary catchments in the Thukela catchment (after DWAF, 2001)

	Households	**Average annual per capita income (Rand)**	**% Households with electricity**	**% Households with piped water**
Thukela catchment	274 000	5 500	43	36
Specific catchments				
V32	52 000	5 800	57	39
V60	35 000	5 100	17	19
V31	39 000	8 000	86	85
V12	31 250	7 200	63	62

WATER INFRASTRUCURE, INTERBASIN TRANSFERS AND THE THUKELA WATER PROJECT

There are a number of storage dams within the catchment which have been constructed in order to regulate the variable flow described above, to compensate for periods of hydrological drought, to provide flood attenuation and to supply to industrial areas outside of the catchment. The major existing dams in the catchment (Figure 1) and their full supply capacities are shown in Table 2.

Table 2. Major dams in the Thukela catchment and full supply capacities

Dam	Full supply capacity ($10^6 m^3$)
Spioenkop (on the Thukela)	274.3
Wagendrift (on the Bushmans)	58.5
Chelmsford (on the Ngagne)	199.1
Craigieburn (on the Mynamvubu)	23.5
Woodstock (on the Thukela)	380.8
Kilburn (on the Thukela)	35.7

Water engineering within the Thukela catchment is substantial, particularly in the west where there are both large farming co-operatives requiring a reliable irrigation supply and inter-basin transfers. Inter-basin transfers augment both the water supplies of the neighbouring Mgeni catchment and the industrial Gauteng Region, South Africa's economic heartland.

The Thukela-Vaal transfer scheme is capable of supplying 630.72 x $10^6 m^3.annum^{-1}$ via the Drakensberg Pumped Storage (DPS) scheme yet several options to further augment the water supply in the neighbouring Vaal system have been considered by the DWAF, including increased transfers from the Thukela River via the existing DPS. The Vaal Augmentation Planning Study (VAPS) identified a southern tributary scheme comprising the proposed Mielietuin Dam on the Bushmans River and the proposed Jana Dam on the Thukela River (see Figure 1) with a piped conveyance linking these dams to the existing DPS. The range of full supply capacities are 1 468 to 2 483 x $10^6 m^3$ and 284 to 426 x $10^6 m^3$ for the proposed Mielietuin and Jana Dams respectively. A feasibility study, the Thukela Water Project (TWP), was initiated to investigate all aspects of the proposed increased transfers from the Upper Thukela Basin. The physical development associated with the TWP is extensive. Therefore, the DWAF view the project first at a strategic level in terms of national issues, second at a regional level with consideration given to socio-economic implications and finally at a site specific level where environmental impacts are a concern (Mallory, 2001).

As stated by Mallory (2001), the TWP therefore addresses components of engineering, water resource assessment, economic evaluation, integrated environmental management, social impact assessment, and stakeholder participation. The potential social and cultural impact conflicts associated with the inter-basin transfers include, *e.g.* displaced communities, loss of heritage, loss of sites of traditional resources for livelihood and sustenance. The impact of transferring water to neighboring catchments also transfers a resource, which would otherwise be available for potential development in the donor catchment. However, the NWA recognises that there are limits to the development of large dams and inter-basin transfers and promotes more conservative practices with which to address the problem of reconciling water demand with water supply.

WATER USE IN RURAL AREAS

Conversely, there is little infrastructure for water supply to rural areas and as shown in Table 1, the majority of communities in the central and eastern areas of the catchment have no piped water within their homes. Some rural communities have access to potable water from standpipes, however, many rural people still rely on river water for the basic human health requirements of drinking, washing and for small-scale irrigation of crops. The NWA highlights the importance of setting aside a basic human health reserve, which has priority over any other water use. Together with an ecological reserve, defined by the NWA as the quantity and pattern of flows required to protect the ecological functioning of rivers and the resource base itself, these reserves must be met before the water allocation and issues of licences to any other water users. An announcement by the Minister of Water Affairs in October 2000 requiring 6 kilo-litres of free water to be supplied to the poor reinforces the objectives of the NWA. However, the delivery of free water to the poor presents infrastructural, institutional and economic challenges to water service providers, concerning the practical means to implement this policy decision (Shepherd, 2001).

Additionally, the vagaries of climate limit secure food production by subsistence farmers who have little or no access to water for supplementary irrigation. Proposed small-scale rural water abstraction schemes, a key objective of the NWA, require research to assess the impacts of strategies of socio-economic development for the rural areas within the catchment. Research, initiated by the Department for International Development, is currently (2001) underway in the Thukela catchment to identify socio-economic indicators of poverty and to link those indicators with water resource assessments in a geo-referenced structure, thereby identifying those communities where poverty is related to water stress.

ENVIRONMENTAL ISSUES

The integrity of terrestrial, aquatic and riparian ecosystems in the Thuklea catchment are threatened by both the economically developed and developing water use sectors. The inter-basin transfers have already altered the natural flow regime considerably and resulted in modified freshwater and estuarine habitats. Such alterations could be further exacerbated by the implementation of the TWP. The aquatic instream flow requirements for the Thukela River were assessed in 1995 and subsequently refined in 1997 and 1998 (DWAF, 1999) by an Instream Flow Requirement (IFR) workshop using a technique known as the Building Block Methodology. The workshop participants defined and determined the management class of representative reaches, in terms of the NWA, and focussed on five unique sites (see Figure 1) at which flow characteristics to maintain the integrity of the aquatic ecosystem were evaluated. The five IFR sites are downstream of either or both of the proposed Jana and Mielietuin Dam sites. Additionally, nine critical reaches have been identified as being of significant hydro-eco-geomorphological interest.

It is considered that the diversity of habitat at these critical reaches is indicative of the health of the river. Therefore, the impacts of the proposed TWP on the streamflow and sediment deposition at these sites are of particular interest. Sediment transport research is also pertinent to the impacts of the TWP since the Thukela estuary is one of the few open river mouths along the South African coast. This characteristic of the estuary sustains the habitat that ranks the Thukela system as important for both birds and fish, and supports the local fishing economy. A major concern is that proposed catchment development to further impound the Thukela and Bushmans Rivers will result in sediment deposition within the proposed dams and reduced sediment transport downstream. Additionally, ecosystem goods and services provided by the Thukela River are at risk from SFRAs, as well as other activities that alter river water quality. Alien riparian vegetation represents a threat to ecosystems and water resources in the catchment since it is assumed to use more water than the indigenous vegetation with which it competes. Hydrological research is, therefore, required to assess the impacts of the various land uses within the catchment on river health and ecosystem response. In any event, research of the natural hydrograph and daily streamflows is required to ascertain appropriate reservoir release rules that incorporate some semblance of the natural flow regime.

DISCUSSION AND CONCLUSIONS

Hydrologically, socio-economically, environmentally and managerially the Thukela catchment stands at the threshold of having to enact a series of new water management practices. South Africa's new legislation places emphasis, *inter alia*, on the equitable allocation of water, the environment, streamflow reduction activities, the efficient use of water, water as a tradeable commodity and integrated catchment management. The catchment therefore, provides an opportunity to study new water policy and management issues for which hydrological processes and modeling studies are needed. Catchment managers, working closely with stakeholders will need to make decisions on a scientifically transparent basis. This requires better understanding of the interconnectedness of hydrological, environmental, social and economic processes together with more realistic modeling of systems, better data and information and enhanced future prognosis. The Thukela catchment, therefore, presents a challenge for user-driven research to be undertaken under the auspices, guidance and support of the HELP initiative.

ACKNOWLEDGEMENTS

Mark Horan, GIS Programmer, University of Natal, School of Bioresources Engineering and Environmental Hydrology, Private Bag X01, Scottsville, Pietermaritzburg, KwaZulu-Natal, SouthAfrica provided technical support for this study.

REFERENCES

DWAF, 1996. The philosophy and practices of integrated catchment management: Implications for water resources management in South Africa. Department of Water Affairs and Forestry and Water Research Commission. Pretoria, RSA, Report TT81/96: 1-58 plus appendices.

DWAF, 1999. Thukela IFR Study: Summary Report of the IFR Study 1995 – present. Department of Water Affairs and Forestry, Pretoria, RSA.

DWAF, 2001. Thukela Water Management Area: Draft Situational Assessment. Report prepared by A.J. Wilson and Associates International cc, Managing Consultants, February 2001 to Department of Water Affairs and Forestry, KZN Regional Office, Durban, RSA.

Gillham S. and Haynes, M., 2000. Demand Management, a possible alternative to augmentation?: A South African Case Study. Umgeni Water, Pietermaritzburg, RSA.

Mallory S., 2001. The Thukela Water Project. Civil Engineering, June 2001, Magazine of South African Institution of Civil Engineering. SAICE/SAISI, Midrand, RSA.

National Water Act, 1998. RSA Government Gazette No.36 of 1998: 26 August 1998, No. 19182. Cape Town, RSA.

Schulze, R.E., 1997. *South African Atlas of Agrohydrology and –Climatology*. Water Research Commission, Pretoria, RSA. Report TT82/96: 1-273.

Shepherd, M., 2001. Free Water – Necessity is the mother of innovation: a practical approach by local authorities. Civil Engineering, June 2001, Magazine of South African Institution of Civil Engineering. SAICE/SAISI, Midrand, RSA.

WISA, 2000. Water Institute of Southern Africa (WISA) Divisions of River Basin Management, and Management and Institutional Affairs, 2000. Catchment management in South Africa: Turning policy into practice. Report on the outcome of a symposium and workshops, 15 and 16 February 2000, Pretoria, RSA.