Allocating contested water

A case study on the (non-) compliance with Environmental Water Allocations in the Sand sub-catchment, South Africa

M.Sc. Thesis by Jan Willem Agterkamp

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Picture on cover page:
Abstraction weir at Mutlumuvhi River for New Forest irrigation scheme

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Master thesis Irrigation and Water Engineering submitted in partial fulfillment of the degree of Master of Science in International Land and Water Management at Wageningen University, the Netherlands

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Summary

After abolishing apartheid a new water policy framework was drafted. One of the main elements of the new water framework is the Reserve. The focus of this research is on the Ecological Reserve. A comprehensive Reserve determination is currently underway and due for completion in November 2009.

Recently, South Africa is turning its attention to implementation of the new water legislation. However, implementing and meeting the Reserve is proven to be difficult. The new water policy faces a difficult transition period. Despite the new water policy framework, the water in the catchment is not managed according to new water legislation. There is a gap between actual water distribution and the desired distribution according to the new water legislation.

The focus of this research is on the Sand catchment, a sub catchment of the Inkomati catchment. The Sand catchment is a relatively dry catchment with limited water resources and a large semi-urban population. The main water user is the irrigation sector which is a relic from the homelands. Due to the limited water resources combined with a growing population there is a strong competition for water.

The Sand catchment is in water deficit, especially during times of low river flow. Several strategies have been put in place to solve the water deficit and to address the Reserve; 1) Inter Basin Transfer, 2) Operating Rules, and 3) water licensing.

In the near future the domestic demand in the Sand catchment will be supplied through the Inter Basin Transfer. The remaining water user is the irrigation sector (and forestry). Meeting the Reserve in the Sand catchment is only possible by limiting water abstraction of other water users.

One of the ways to limit the irrigation water abstraction is by implementing the Operating Rules. These rules require irrigators to release a defined percentage of the flow past their abstraction works. However, six years after its completion the abstraction weirs are still not operated in this manner. The irrigators continue to divert flows up to the maximum capacity of the canals. One of the main reasons for the non functioning Operating Rules is the lack of knowledge about the rules amongst among decision makers and that the current irrigation abstraction points do not allow the release of a proportional flow.

In conclusion, despite the policy reform the condition of the river(s) is not improving.

List of abbreviations

ANC	African National Congress
ARDC	Agriculture and Rural Development Corporation
AWARD	Association for Water And Rural Development
BWB	Bushbuckbridge Water Board
BHNR	Basic Human Need Reserve
BTP	Bosbokrand Transfer Pipeline
CMA	Catchment Management Agency
CMF	Catchment Management Forum
CMS	Catchment Management Strategy
DOA	Department of Agriculture[1]
DWAF	Department of Water Affairs and Forestry[2]
EFR	Environmental Flow Requirement
ER	Ecological Reserve
ESCOM	Electricity Supply Commission
GWCA	Government Water Control Areas
HDI	Historically Disadvantaged Individual
IBT	Inter Basin Transfer
ICMA	Inkomati Catchment Management Agency
IFR	Instream Flow Requirement
JIBS	Joint Incomati Basin Study
KNP	Kruger National Park
MAR	Mean Annual Runoff
MCCAW	Mpumalanga Coordinating Committee on Agricultural Water
NWA	National Water Act
NWRCS	National Water Resource Classification System
NWRS	National Water Resources Strategy
OR	Operating Rules
PtO	Permission to Occupy
SSP	Save the Sand Project
TIA	Tripartite Interim Agreement
WfW	Working for Water
WMA	Water Management Area
WSA	Water Service Act
WSAU	Water Services Authority
WRC	Water Research Commission
WSP	Water Service Provider
WTW	Water Treatment Work

[1] After the 2009 elections the name of the department changed to Department of Agriculture, Forestry and Fisheries.
[2] After the 2009 elections the name of the department changed to Department of Water and Environmental Affairs.

Acknowledgments

As the title of this report already suggests this report is about allocating contested water in South Africa. The seven months of this research were characterised by contestation as well, not only of water but more of valuable time. Time and priorities were allocated between research, friends, family, the coming wedding, a youth camp and a bit of sleep in between. Finally, the journey is walked and a new phase will start. The road was long and sometimes lonely, but above all it was a challenging and exciting road.

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1 Introduction

1.1 The research

South Africa's water management faces many challenges towards achieving food security, poverty reduction, social equity, economic growth and environmental sustainability. The main reasons are the climatological characteristics combined with its notorious history; people were forced to move to resource scares areas. As a result there is a mismatch between human settlement and resource abundance.

South Africa's water situation is clearly one of water deficit. More than half of South Africa's Water Management Areas are in water deficit [DWAF, 2004b: A1]. After the end of the apartheid era, the national government gave priority to readdress the inequities of the past; this led to the formulation of the National Water Act (NWA). The NWA seeks to resolve the race and gender inequities of the past in the arena of water management and wants to contribute to poverty mitigation. The NWA [1998] makes the government responsible for overall water resource management as public trustee. The NWA has far reaching goals for effective water resource management control for all stakeholders. The principles of the NWA are sustainability, equity and efficiency, the latter is related to productivity. These keywords are the essence of IWRM which is related to the four Dublin principles [Brown, 2006: Swatuk, 2005].

The NWA addresses the principle of sustainability through, among others, the Reserve. The Reserve consists of two elements: the Basic Human Need Reserve (BHNR) and the Ecological Reserve (ER). According to the new water legislation the Reserve is the only right to water. Water is allocated to the Reserve before it can be allocated to any other purpose (see chapter 4).

Internationally South Africa is considered a forerunner in ensuring that sustainability is addressed in policy and the development of methodologies to determine environmental requirements. More recently South Africa has turned its attention to implementation and whilst great strides have been made, there are cases where meeting the requirements of the Reserve remains quite challenging [Pollard *et al.*, 2009b].

According to the NWA water should be managed within its natural boundaries; the catchment. This research is set up as a case study in the Sand catchment. The Sand catchment is part of the Sabie catchment, which is part of the Inkomati catchment in the Limpopo and Mpumalanga province in the Northeast of South Africa. The Sand catchment is characterised by an arid climate, frequent droughts, and high population density. The available water resources in the basin are heavily utilised. There is not enough water to meet current needs, let alone future needs. The aim of this research is to understand the water practices and to find out what the obstacles are for the safeguarding of the Reserve.

1.2 Background of the research

Contemporary poverty and inequality must be viewed within the historical context [Levin *et al.*, 1997]. In order to understand current land and water use, one must also understand the regional history. Therefore a description of the regional history is provided in this section. For a description of South Africa's (current and previous) water legislation see chapter 4.

Apartheid

There are huge disparities in distribution of wealth in South Africa. During the apartheid era resources were assigned to the white population (minority). They became rich at the expense of the black population (majority). This pattern of inequality is still apparent in the current water management situation, for example: the majority of the Inkomati catchment population did (and still does) not have accesses to sufficient clean water.

One of the most far reaching acts for the black Africans was the Native Land Act of 1913 followed by the Native Trust and Land Act of 1936. This Native Land Act delimited the geographic boundaries in which Africans could own or lease land [Reed & de Wit, 2003]. In the 1940's 'Trust Lands' were established for 'natives'. Tribal areas were divided into residential and agricultural land and people were forced to move into homelands, creating over-crowded and impoverished areas in which investment and development were negligible [de Wet, 1995].

The population pressure in the overcrowded homelands caused pressure on the cultivable land which led to unsustainable farming practices e.g. overstocking, which led to several problems, e.g. soil erosion. The problems posed by erosion appeared to be enormous. Soil conservation became necessary in which experts and the State played a leading role. The assumption was that the experts knew best, and that the land users should comply with their prescriptions. This is summarized by an erosion researcher; *"... The soil has already declared war on European civilisation, and no half measures can be permitted in coping with the situation. In his life-and-death struggle with Nature, the white man cannot show much consideration towards underlings"* [Jacks & Whyte, 1939]. Thus the government should not shirk its obvious duty and should take whatever steps may be necessary to save the land while there is still time [de Wet, 1995].

What was needed, therefore, was more effective control if 'native agriculture' was to improve [de Wet, 1995]. In response to this, central government launched several programs to combat erosion and to 'save the soil'. These programs intended to increase the reserves' capacity to accommodate the African population [Fischer, 1998]. The increasing concerns about the condition of the soil in the reserves set in motion a "rescue operation" which came to known as 'betterment'. In 1936 betterment planning was launched as a government policy aimed at the conservation of rural areas [Westaway, 1997]. The betterment planning was promoted and enforced by the central government and characterized by a top down approach [Jacks & Whyte, 1939: Westaway, 1997].

In the beginning, betterment planning was driven by concerns about the conditions of the soil. But when the Nationalist government came into power in 1948 they took up the idea and combined it with the goal of segregation in the new policy of apartheid [Fischer, 1998: 129]. The government appointed the Tomlinson Commission, consisting of 10 white people, to make recommendations about the socio-economic development of the areas to achieve 'eisoortige ontwikkeling[3] [Fischer, 1998]. The Commissions' aim was to 'help the Bantu to develop an efficient and self supporting 'peasant farmers" class in their own areas'[de Wet, 1995].

The publication of the Commission's report and the implementation of some of its recommendations had major effect on settlements land use and irrigation development in black rural areas [Perret, 2002b]. It should be noted that one of the conclusions of the Commission was that viable farming was impossible in congested reserve conditions [de Wet, 1995].

The recommendations of the Commission were only partly implemented by the central government/ the government cut the budget for the first year by nearly two-thirds, with certain items falling away completely [de Wet, 1995]. One of the cornerstones of the Commissions' report was the establishment of viable agriculture by removing of the surplus population from

[3] Translation: separate development.

the land into rural villages. However, due to the governments' budget cut no industrial development was created in the homelands. This resulted in families living in poverty and dependence on wage labour [de Wet, 1995]. Related to irrigation the Commission recommend the following [Union of South Africa, 1955]:

- Irrigated holdings of 1.3 to 1.7ha were adequate to *provide a family with a living that would satisfy them, whereby the whole family would work on the holding*;
– *New schemes, which can be operated by simple diversion of weirs and furrows, be developed during the next 10 years*;
– *All schemes should be placed under proper control and supervision, with uniform regulations as regards water rates, credit facilities and conditions of settlement.*

In conclusion, the commission suggested that irrigated holdings of 1.3 to 1.7ha were adequate to provide a family with a living standard that would satisfy them, whereby the whole family would work on the plot [ARC-LNR, 1999].

In the former homelands most irrigation schemes were established after the publication of the report of the Tomlinson Commission, and followed most of its recommendations [ARC-LNR, 1999]. This was also the case for the irrigation schemes in the Sand catchment. To accommodate the ever increasing population in the Sand catchment, agricultural betterment schemes were implemented in the 1960s [Niehaus, 2002]. When the Trust took over the land in the native areas it was planned according to 'betterment' principles; planned settlements, pastures fenced, and demarcation of arable land [Fischer, 1998]. Betterment planning was intended to divide African rural areas into residential and agricultural land and to make bantustans agricultural productive [Levin *et al.*, 1997]. All land in the catchment was subdivided into new residential settlements, arable fields, and grazing camps. Officers of the Trust forcefully relocated households onto stands in eight village sections [Niehaus, 2002]. The land was allocated to households who lived in nearby villages: Dingleydale, Chochocho, Buffelshoek, New Forest, Orinoco and Tshungelani [ARC-LNR, 1999] (see Box 1.1).

In 1972, the homelands Lebowa (upper catchment) and Gazankulu (central catchment) were proclaimed in the Sand catchment. The homelands were granted some form of autonomy from central government [Perret, 2002b]. The creation of the homelands resulted in an artificial division between, the Sotho and Tsonga speaking people. the Tsonga-speaking people were relocated to Gazankulu (*"Greater Gaza"*) homeland in the driest eastern districts, Lebowa (*"Northern")* was reserved for the Pedi people [Pollard *et al.*, 2003]. Both homelands were administered separately, in line with apartheid territorial engineering aimed at keeping the Shangaan (Mhala) and the North Sotho (Mapulaneng) 'apart'[4] [James, 2003]. The homelands became dumping grounds for what the State regarded as surplus Africans who were

Box 1.1: Confusion about names

During my research I became confused by the different names used for the same village. Old maps and government documentation referred to a village with a different name than the name used by the local people. For example: Songeni village was referred to as Dingleydale village. The reason being that most of the names used on maps/ government maps were imposed by the apartheid government, the local people, however, still used the local town names.

Another trouble was the change of names of Provinces and cities. E.g. Northern Province became Limpopo (name of the most important river), Eastern Transvaal became Mpumalanga ("the place where the sun rises") and Pietersburg became Polokwane ("place of peace"). The aim to change these names was to make place/provincial names more African.

[4] Translation: separate or divided.

not engaged in active service to the white-controlled economy as migrant labor. Due to forced settlement the population of Gazankulu doubled to more than 500,000 people [Pollard *et al.*, 2003]. Most homelands were characterized by limited natural resources.

During the 1970s political and administrative independence of the homelands was encouraged. Gradually the services of the central government departments were withdrawn and were replaced by a homeland administration [ARC-LNR, 1999]. Homelands' parastatal corporations were created, e.g. Tracor in Transkei and ARDC in Venda, Gazankulu, Lebowa [Perret, 2002b].

Post apartheid

After abolishing apartheid in 1994 the mission of the State changed radically from serving mainly the well-organised white minority, to serving an entire nation of over 40 million citizens [van Koppen, 2008]. To address the past inequities and apartheids influence on water management a water law review was required and new water policy and legislation was written [de Lange, 2004]. This section describes the new water policy framework which was established after the first democratic elections in 1994 (see see chapter 4).

Constitution

Following the first democratic elections, in 1994, the new constitution was drafted by the Constitutional Assembly [Backeberg, 2005]. The constitution requires legislative measures for promoting sustainable socio-economic development and use of resources such as land and water [RSA, 1996: in Backeberg, 2005]. From the perspective of water, the most important aspects of the new Constitution are the Section 27 rights. According to this section the State must take reasonable legislative and other measures, within its available resources, to achieve the progressive realisation of each of these rights[5].

National Water Act

The management of water resources is regulated by the National Water Act (NWA) which came into effect in 1999. Public consultation was part of the writing process of the NWA [Hamann & O'Riordan, 2000]. The NWA serves to protect the quality of water resources and aims at the integrated management of the water resources [Pollard *et al.*, 1998]. The NWA deals with the management of water as a natural resource and deals with water in rivers, lakes and groundwater. The NWA recognizes that water is a natural resource that belongs to all people and that the national government, through the Minister of Water Affairs and Forestry, is acting as the public trustee for the people [NWA, 1998]. The national government is the custodian of the nation's water resource. According to the NWA the State is responsible for enforcing the public interest in its water sources. The NWA recognises water as a social (equity) and economic (productivity) good [Butterworth *et al.*, 2001]. Through the NWA the previous system of centralized water management is replaced with decentralized water management. Water is managed within its natural boundaries; the catchments.

The NWA shifts the emphasis from the traditional "supply management" approach towards "demand management", that is conservation of the nation's water resources by lessening the demand and providing for an innovative pricing system. The NWA abolishes the historical distinction between public and private water. According to the NWA a minimum water flow is reserved: the Reserve. Water is reserved for environmental purposes and basic human needs.

[5] National Water Act Amendment Bill: discussion & voting, Water Affairs And Forestry Portfolio Committee, October 26 1999. Source: www.pmg.org.za

Water Service Act

The Water Service Act (WSA) gets its mandate from (among others) section 27 of the Bill of Rights in the Constitution that states that everyone has the have access to sufficient food and water. The aim of the WSA is to provide a framework for water services by defining the different roles and responsibilities of the different government departments [Pollard *et al.*, 1998]. It is the South Africans governments' priority to alleviate poverty and to promote growth. This goal can only be reached through equitable access to water [DWAF, 2005b]. Therefore the WSA states that everybody must have access to basic water supply and sanitation services. The focus of the act is on meeting basic human needs for water supply. It is the responsibility of local government to provide basic water services, under the supervision of, and subject to monitoring by both national and provincial government [Pollard *et al.*, 1998]. The NWA and the WSA are closely related to each other. The main difference is that the WSA deals with water services, actual water use is controlled under the NWA [DWAF, 2003d].

National Water Resource Strategy

The National Water Resource Strategy (NWRS) is the implementation strategy for the NWA. This strategy sets the framework in which the water resources of South Africa will be managed now and in the future [DWAF, 2004a]. The NWRS sets out the "strategies, objectives, plans, guidelines and procedures of the Minister and the institutional arrangements relating to the protection, use, development, conservation, management and control of water resources" in order to meet the purpose of the National Water Act and to satisfy the water supply and sanitation standards defined in the Water Services Act of 1997 [Woodhouse & Hassan, 1999: 30]. An important aspect of the NWRS is to define the Reserve.

Catchment Management Agency

According to the NWA [1998] day-to-day water allocation and management tasks will be progressively delegated from DWAF to decentralized bodies that are constituted along hydrological boundaries, the Catchment Management Agency [du Toit & Pollard, 2008]. The country is divided in 19 major WMAs (see annex A). Each WMA should be managed by a Catchment Management Agency (CMA). The CMAs are placed directly under the Minister of Water Affairs and Forestry.

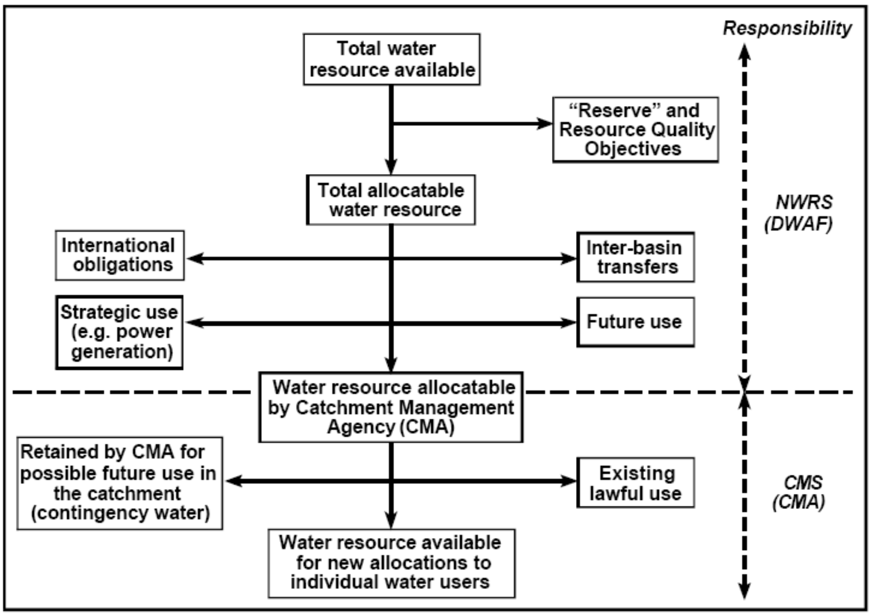


Figure 1.1: Schematic diagram showing the overall water use allocation responsibilities
Source: DWAF [2007a]

The purpose of establishing a CMA is to delegate water resource management from the government to the catchment level and to involve local communities, within the framework of the national water resource strategy [Pejan et al., 2007]. Through the CMA's the government tries to improve local participation in water management. The governments water management responsibilities are divided between the government and the CMA (see Figure 1.1). The initial functions of the CMA can be summarized as planning, co–coordinating, and promoting public participation in water management [Anderson, 2005].

Due to lack of funding and lack of staff the establishment of the CMAs has been very slow [Le Quesne, 2008]. Since the Inkomati CMA is the first established CMA in the country a lot is learned during the participatory process. It appears to be difficult to obtain legitimate representation from disadvantaged communities [Waalewijn *et al.*, 2005: Wester *et al.*, 2003]. Disadvantaged communities have weak networks with less knowledge and experience in water management [Anderson, 2005].

Inkomati Catchment

The Inkomati catchment is situated in the north-eastern part of South Africa (see Figure 1.2). The international river system originates in South Africa, flowing partly through Swaziland, and reaches the Indian Ocean near Marracuene in Mozambique. South Africa is both an upstream and a downstream country of Swaziland. The Inkomati catchment consists of three major catchments (Inkomati, Crocodile and Sabie-Sand) and two minor catchments (Nwaswitsontso and Nwanedzi). The Komati and the Sabie join in Mozambique, so there is little hydrological connection between these three sub catchments in South Africa [Brown & Woodhouse, 2004]. The three sub catchments have historically been managed separately. The focus of this research will be on the Sand catchment which is a part of the Sabie-Sand catchment.

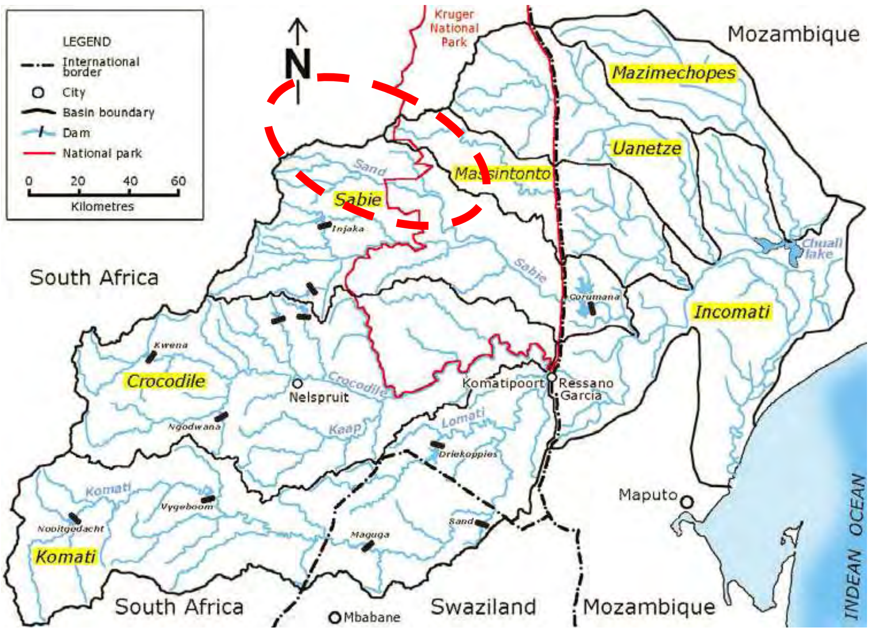


Figure 1.2: Inkomati Water Management Area with Sand Catchment highlighted
Source: Vaz & van der Zaag [2003]

Since the Inkomati is an international catchment, a number of international agreements are in place between the three countries that regulate their use of the water in the Inkomati Basin. After the Limpopo River, the Inkomati is the second most important water resource for Mozambique [Turton et al., 2004]. Mozambique is highly dependent on exogenous water that crosses the South African border. According to Waalewijn *et al.* [2005] the increasing demand for primary water downstream in Mozambique and the recognition of the environmental Reserve will continue to place high demands on the river system.

The water resources in the Inkomati catchment are managed by the Inkomati Catchment Management Agency (ICMA). The ICMA was the first CMA in the country. The CMA was established after 7 years of public participation and stakeholder negotiations. Politics had considerable influence in the establishment of the ICMA. For example, the ICMA proposal was shelved for 18 months, but because of the upcoming elections and the fact that there was still no CMA established in the country the process got a new impetus and the Advisory Committee was appointed [Brown, 2006]. The ICMA was formally launched on 30th March 2004.

The Inkomati Catchment Management Agency deals with the water management in the three sub-catchments in its area; the Komati, Crocodile, and Sabie rivers. Each of these rivers has a sub-catchment organization. It should be noted that there is no international obligation on the Sabie-Sand catchment to meet any water for Mozambique[6]. The major water consumers in the Inkomati catchment are the irrigation and forest plantation[7] sectors, followed by inter-basin water transfers[8].

The area of the Inkomati catchment is 31,230 km^2. The climate in the catchment varies from a warm to hot, humid climate in the Lowveld to a cooler, dry climate in the Highfield. The entire catchment lies within the summer (October–March) rainfall region, as a result 80 percent of all runoff occurs during the summer months. The average annual rainfall is about 730 mm [DWAF, 2001]. Because of the previously supply driven governmental water management, several large dams were build in the catchment [Vaz & van der Zaag, 2003]. Most of the storage dams in the catchment were designed to serve the needs of the white farmers [Woodhouse & Hassan, 1999]. The purpose of the dams is to store water, a second purpose, for some of the dams, is to generate hydropower. In addition to these large storage dams the catchment also contains numerous smaller dams.

The population in the catchment is about 1.5 million people [ICMA, 2008]. The population in the catchment is not evenly distributed but mainly concentrated in the areas of the former homelands. More than half of the population have poor access to water and sanitation facilities. The basin is characterised by water scarcity since the mid-1980s, this has become more severe in the last decades [Vaz & van der Zaag, 2003]. The water scarcity makes it even more challenging to improve the livelihood of all.

1.3 Problem definition

Ten years ago the National Water Act was gazetted, important changes were made; the riparian principle was abolished, the national government became the public trustee of all water resources, all right to use water was derived from the NWA, and a quantity of water of suitable quality was set aside as the Reserve for basic human needs and to protect aquatic ecosystems. Since 1998, numerous policies and plans were drawn up and investments were made to improve

[6] From internal DWAF email about drought in Sand catchment, 12 September 2000.

[7] Despite the negative effects to the reduction of the stream flow forestry contributes significantly to employment (Nkomo & van der Zaag, 2004).

[8] There are two major water transfers from the Upper Komati; 1) to the Mbuluzi River Basin in Swaziland (irrigation), and 2) to the Olifants River Basin (power generation). The coal mining operations pollutes the water to such an extent that clean water must be transferred from neighbouring catchments for the cooling towers of the thermal power station (de Lange, 2001). According to the Tripartite Interim Agreement between Mozambique, South Africa and Swaziland, this water transfer has a high priority (Nkomo & van der Zaag, 2004).

water management. However, in practice water use is still characterised by inequality and inefficiency. Progress is made but it proved to be a time consuming process to put policy in practice. The poor remain marginalised, and emerging farmers and poor rural communities have limited access to water resources [Butterworth *et al.*, 2001]. In addition the national water resources are seriously overstretched. Water demand exceeds or equals available water in more than 15 of the 19 WMAs [DWAF, 2004b].

South Africa defined the right to water as a Constitutional Right. This right is reflected in the National Water Act (NWA). One of the main elements of this act is the Reserve, the minimum quantity designed to ensure the availability of water for human needs and the environment [Butterworth *et al.*, 2001]. According to the NWA the Reserve (ER and BHNR) is the only right to water [NWA, 1998]. Water is allocated to the Reserve before it is allocated to any other purpose. The implementation (or delivery on the policy promises) of the Reserve combined with the above described challenges is a complex process.

This research will focus on the implementation (giving effect) of the Reserve in a specific area, the Sand catchment. The Sand catchment (X32) is a sub-catchment of the Sabie catchment (X3), which is part of the Inkomati WMA (X) in Limpopo and Mpumalanga province in the northeast of South Africa.

The Sand Catchment is characterised by an arid climate, frequency of drought and high population density. As a result the available water resources in the basin are heavily utilised and there is not enough water in the catchment to meet current needs, let alone future needs. The main water user in the Sand catchment is irrigation. There are more than 1000 irrigators each cultivating a small plot between 1 and 6ha, the infrastructure of the irrigation schemes is dilapidated. The irrigation peak demand is in March-April and in August-September when water availability is limited [Smits *et al.*, 2004]. Meeting the current irrigation water demand implies not meeting the ER most of the time. Current irrigation is therefore incompatible with meeting the Reserve [Smits *et al.*, 2004]. The irrigators use all the dry season baseflow often causing the Sand River to stop flowing completely [DWAF, 2009a].

Meeting the Reserve in the Sand catchment is only possible by limiting water abstraction of other water users. One of the ways to limit irrigation water abstraction is by implementing the Operating Rules. These rules require irrigators to release a defined percentage of the flow past their abstraction works. However, six years after its completion the abstraction weirs are still not operated in this manner.

According to the Operating Rules the four irrigation abstraction points are supposed to allow a proportion of the flow to pass the abstraction points down the river. However, in times of drought almost the entire river flow is diverted into the irrigation canals, and little or no water is returned downstream. This causes stress on the other water uses in the catchment, especially the Ecological Reserve requirements downstream and other downstream water users.

Another strategy to solve the water deficit and to address the Reserve is by transferring water from the Inyaka dam to the Sand catchment. The Inyaka Dam was constructed as the engineering solution for both the (domestic) water resources in the Sabie and Sand catchments. Water is transferred from the Sabie to the Sand catchment, through the Bosbokrand Transfer Pipeline (BTP). The transfer pipeline's initial purpose was to transfer raw water only when required, just after the winter of each year. Later on the purpose changed to transfer all the domestic water for the Sand catchment through the BTP. Where the domestic uses are not supplied directly from the BTP the abstractions from the rivers were planned to be compensated for by corresponding compensatory releases of water from the BTP. The compensatory release is necessary to meet the Ecological Reserve. However, municipalities attached new bulk infrastructure to the transfer pipeline resulting in all the water being used for domestic use. Hence, the pipeline does not deliver any water to the Sand River.

In conclusion, most of the water is being diverted to agricultural schemes in the upstream portion of the catchment while the Basic Human Needs Reserve (BHNR) and the Ecological Reserve (ER) in the downstream portion of the catchment are not met during periods of low flow.

The irrigation sector is not the only water use activity in the catchment that causes inequitable flow distribution. Since the irrigation sector is the major water user in the catchment they are chosen as the focus of this research.

1.4 Research objectives

The main objective of this research is *to understand the current water allocation and distribution in the Sand River catchment in South Africa and assess to what extent current water management practices impede satisfying the Ecological Reserve.*

Related to the main objective are several sub objectives; namely:
- To understand the desired water allocation in the Sand River catchment.
- To understand the current water management practices and resulting water distribution in the Sand River catchment.
- To assess to what extent the Ecological Reserve is being met in the Sand River catchment
- To identify the reasons (drivers) precluding meeting the Ecological Reserve.
- To identify the reasons for non-implementation of the Operating Rules for irrigation abstraction in the Sand River catchment.
- To understand what the different water users' perceptions are of the need to meet the Reserve and how this shapes their practices.
- To identify potential strategies that could contribute towards the meeting of the Ecological Reserve.

The social objective is to contribute to refining knowledge and provide for a deeper understanding of the implementation of the Reserve with a view to improve the water distribution and allocation to the people and the environment of the Sand catchment in South Africa.

1.5 Research question

The main research question is as follows:

How do current water management practices and water uses impede the meeting of the Environmental Water Requirements in the Sand sub-catchment of the Inkomati Catchment, South Africa?

In order to answer the main research question the following sub-questions are formulated:

1 – How is water allocated in the Sand River catchment?

2 – What are the water management practices and resulting water distribution practices in the Sand River catchment?

3 – To what extent is the Ecological Reserve met in the Sand River Catchment?

4 – What are the obstacles for meeting the Ecological Reserve?

5 – What are the perceptions of the different water users (irrigation, forestry, nature conservation, environment, and domestic water users) on the need to meet the Reserve and how does this shape their practices?

1.6 Relevance of the research

Through this research I tried to understand the actual water management practices in the Sand River catchment. The focus of the research is on the irrigation sector, the biggest water user, after the environment. A better understanding of irrigation water management practices is necessary to identify possible solutions for meeting the Ecological Reserve. This is based on the assumption that actual distribution and allocation of water is performed by water users, and not by officials of the government [Liebrand, 2007: 5]. By looking at the situation on the ground I tried to open the blackbox of water allocation and distribution. Despite numerous reports on the water resources in the catchment there is hardly any documentation on what is happening on the ground; e.g. how the systems are managed, operated and maintained. This thesis differs from other research in the Sand catchment because of its focus on the actual practices.

As described above, several plans were drawn up to meet the Reserve in the Sand River catchment. However, in practice most of the plans were not carried out as planned or not carried out at all. This report describes which factors prevented the implementation of these plans and what can be done to meet the objectives set by these plans. The research is not aimed at understanding perceptions of the Reserve or compliance with its objectives, although this did emerge as separate topic during the interviews. Through this research I tried to focus on the underlying causes that preclude the Ecological Reserve from being satisfied in the Sand River catchment.

1.7 Overview of the thesis

As described below the aim of this thesis research is the presentation of empirical evidence from the field. Therefore, the following chapters are predominantly descriptive in nature. The emphasis of the report is on what happened and what is happening on the ground.

After this introduction, the report opens with a presentation of the conceptual framework and methodology used in this research (2). The next chapter (3) gives a background of the research area, the Sand River catchment. Chapter 4 describes how water should be controlled according to the new water policy framework. The following chapter (5) describes the environmental water allocation in the Sand catchment. In contrast, chapter 6 describes the actual water distribution in the Sand catchment. Chapter 7 presents the outcome of the water distribution on the catchment's water balance. To solve the water deficit and to address the Reserve several strategies have been put in place, these strategies are presented in chapter 8. On the basis of all this, the last chapter (9) presents the conclusions and recommendations of the research. The description within most of the chapters is ordered according to a sectoral fashion[9].

[9] Examples of other approaches are: upstream – downstream, private – non private etc. I choose this approach because I found it the most suitable approach for the Sand catchment (all water users are organized per sector, stakeholder participation in the ICMA is organized per sector) and almost all the South African water resource reports are organized in this manner as well.

2 Conceptual framework and methodology

This section presents the conceptual framework of the research. The framework shows the conceptual perspective of the research. It provides the conceptual basis for the analysis of water management practices in the Sand catchment.

The conceptual framework makes a start with the notion that water management is a sociotechnical phenomenon (2.1). The main concept for this research is water management practices (2.2). This broad concept is described by using several other concepts; water control, water distribution and water allocation. Because of the influence of politics in South Africa's water management, this is conceptualised as well (2.3). This conceptual framework then delves into the concepts of stakeholder participation (2.4), and river catchments (2.5) as the unit of study. To close the conceptual framework some concluding remarks are given (2.52.6). The last section (2.72.7) of this chapter describes the methodology used in this research.

2.1 Water management is a sociotechnical phenomenon

The focus of this research is on actual water use: emphasis will be put on the situation on the ground, especially in the agricultural sector, e.g. the irrigation schemes (the biggest water user in the catchment). An irrigation system is a complex system. The system is not something that stands on its own. The system consists of different elements which are related to each other. Different approaches can be used in analyzing irrigation. Eggink and Ubels [1984] mentioned three approaches to the analysis of irrigation: 1) technical approach, 2) organizational approach, and 3) social approach. These approaches are limited by their focus on only one element. Several years later Mollinga promoted an interdisciplinary approach, as an answer to these limitations. He argues that an interdisciplinary investigation of irrigation requires insight into its technical, organizational, socio-economic and political aspects [Mollinga, 1997]. More elements were taken into account. His new approach is summarized in the term: sociotechnical system.

The sociotechnical approach focuses on the interrelations between water, water technologies, water users, the resulting agro-ecologies and water networks. The central concept in the sociotechnical approach is water control. The sociotechnical approach was developed to study water technologies as a form of mediation between society and natural resources, in which the social, the technical and the material are analyzed simultaneously as different but internally related dimensions of the same object [Bolding *et al.*, 2000]. This sociotechnical approach is subsequently simplified by Liebrand [2007]: both dimensions - social and technical - should been addressed simultaneously. The social and technical elements of an irrigation system are closely related to each other. Social elements are required for the political process; technical elements are required for the water control process (e.g. distribution). Irrigation management is not only practised by human actors but humans also mobilise sets of non-humans such as technological artifacts and physical materials [Mollinga, 1992: in Rap, 2004]. The social and technical elements must be handled together. Therefore both elements must be taken into account in order to analyze the water management practices of an irrigation system.

This reasoning is not only valid for a single irrigation scheme but can be extended to a catchment scale. Water management on a catchment scale is also complex. A catchment is even more complex than a single irrigation scheme; this complexity is partly due to uncertainty on a long-term perspective which is prerequisite for sustainable river management. The complexity or heterogeneity of the systems is summarised in the term sociotechnical system [Mollinga, 1997].

Our knowledge of these complex systems is imperfect: we do not know enough to manage these complex systems [Lee, 1999]. Therefore a special management approach is required; adaptive management. This approach is the opposite of old management approaches which viewed an ecosystem as a stable linear system and which attempted to reduce variability [Pollard *et al.*, 2009b]. Adaptive management includes the ability to change management practices based on new experiences and insights. Adaptive management refers thus to a systematic process for continually improving management policies and practices by learning from the outcomes of implemented management strategies [Pahl-Wostl, 2007]. Adaptive management can be summarized as learning by doing [Lee, 1999]. Adaptive management acknowledges that time and resources are too short to do more research to understand the full problem, but takes actions without full knowledge to address urgent problems such as, in this case, the declining eco system in the Sand catchment.

> **Box 2.1: History and irrigation**
>
> Apartheid policies shaped the catchment's landscape that we see today. This becomes clear in the history of the irrigation schemes in the Sand catchment. The irrigation schemes were developed and designed by the ruling part of the apartheid society. This society shaped the technical characteristics of the technologies that are present today.

Based on the above mentioned description it becomes clear that water management is a sociotechnical phenomenon. Water management is socially constructed and is therefore part of the socio-political relations within society. In South Africa the political history has a lot of influence on the current water management. Irrigation and water management infrastructure were developed and designed by the white minority. Current water management realities still reflect this inequity; however, the state is trying to improve the situation by use of, among others, the NWA.

2.2 Water management practices

The concept water management practices is the leading concept of this thesis research. The term “water management” is a very commonly used term and needs to be delimited for this research (see Figure 2.2). The term ‘practices’ is attached to emphasize the importance of what is happening on the ground.

This research focuses on the operation (plans and practice) of water management within the Sand catchment. Water management processes are complex and influenced by history (see Box 2.1), economics, politics, and power relations. The emphasis of this section is on water management practices of the irrigation sector, but it can be extended to the catchment scale.

By analysing the irrigation system and its practices the Uphoff matrix is used as a framework to guide the analysis. This matrix provides a useful comprehensive description of irrigation activities. Uphoff distinguishes three types of irrigation activities, under each type there are four activates [Uphoff, 1986: in Mollinga, 1997]:

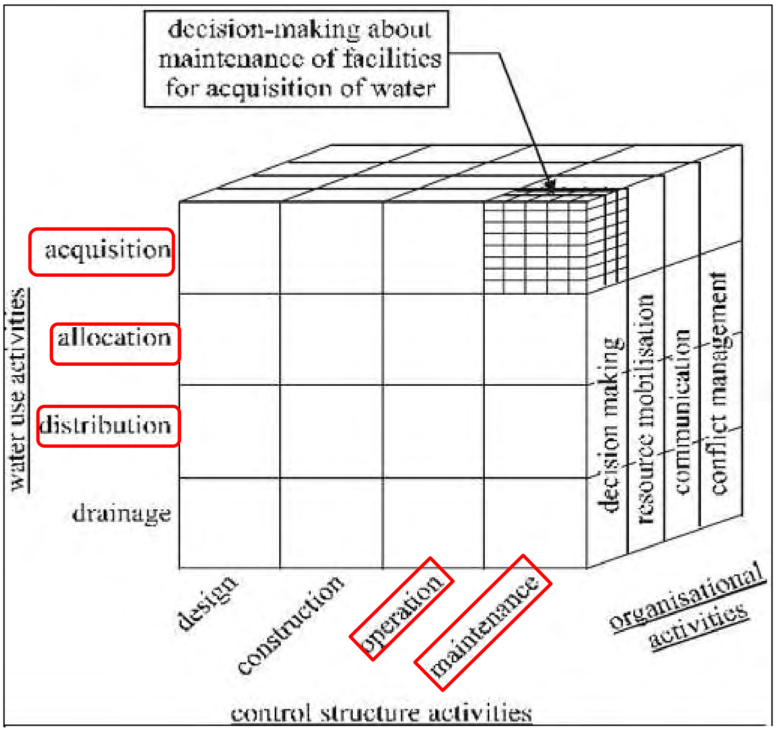


Figure 2.1: Uphoff's matrix of irrigation activities, focus activites highlited
Source: Uphoff [1986: in Mollinga, 1997]

- Water use activities (acquisition, allocation, distribution, and drainage),
- Control structure activities (design, construction, operation, and maintenance),
- Organisational activities (decision making, resource mobilization, communication, and conflict management).

Uphoff's matrix of irrigation activities can be extended to other water users as well. Hence, this research adopts Uphoff's matrix for the water management in the whole scheme, not limited to irrigation only.

In this thesis the broad concept of water management practices is subdivided in three other concepts; water allocation, water distribution, and water control. These three concepts are tied together in the water management practices concept. To understand the differences between allocated water and actual water distribution the water control concept is used. The concept of practices provides the methodological means for analysing water control.

Water allocation

The process of water allocation can be analysed at different levels. In the case of an irrigation scheme these levels are the farm plot, the irrigation scheme and the catchment. This research focuses on two levels; the irrigation schemes and the catchment. Since the water users are not acting in isolation it is important to look at the catchment level as well.

The criteria for the allocation of water can be targeted via numerous forms of allocation, ranging from complete control by the government to a mixture of market and government allocation [Dinar *et al.*, 1997]. According to Dinar *et al*. [1997] there are a few major forms of water allocation; marginal cost pricing, user based allocation, water markets, and public (administrative) water allocation. In South Africa water is allocated by a public (administrative) water allocation process. The criteria for the water allocation process are prescribed by the government through the responsible bodies; DWAF and the CMAs. The structure of water allocation is influenced by the existing institutional and legal framework.

The government (through DWAF and the CMAs) is responsible for overall water resource management as public trustee. Through a stakeholder participation process the CMA decides what water resources can be used by the system as a whole, and allocates and distributes water within different parts of the system. An advantage of this form of water allocation is the intention to promote equity.

However, equity is a subjective term, it differs per situation, per culture, is influenced by people's perceptions etc. Equity lies in the eyes of the beholder. This raises the question, what is (social) equity, and equity to whom? This question is also raised by Syme *et al*. [1999]. According to him government policies constantly state that resources will be allocated 'equitably', however the definition of *what is* '*just*', or '*fair*' or '*equitable*' has received little attention. This is confirmed by Albrecht [1995: in Syme et al. 1995], who states that despite the importance of this issue internationally, there has been relatively little emphasis on the development of theory on the community's meaning of equity, fairness and justice in the context of natural resources allocation.

This research adopts Gleick's [1998: Wegerich, 2007] definition of equity. He defines equity as a measure of the fairness of the distribution and the process used to arrive at a particular social decision. Through the water allocation process the South African government intends to promote equity and to "redistribute" wealth. According to Dinar *et al*. [1997] allocation of equity deals with the distribution of the total wealth among the sectors and individuals of society. Equity objectives are particularly concerned with fairness of allocation across economically disparate groups, and may or may not be consistent with efficiency objectives. The equity perspective urges greater protections for excluded values and/or interests [Seetal & Quibell, 2005]. In South Africa, water use licensing will be the tool used to ensure equity in water use.

Water distribution

Distribute is defined by the Compact Oxford English Dictionary[10] as *hand or share out to a number of recipients.* Added to this is the distribution is defined as *1) the action of distributing, 2) the way in which something is distributed among a group or over an area*. This definition is applicable for water distribution as well. Based on this definition, water distribution in this research is defined as the process of scheduling and delivering the amount of water to each sector and each user. In a basin with multiple water users and multiple demands water distribution creates conflicts. In a stressed catchment (e.g. the Sand catchment) these conflicts appear throughout the whole water distribution process. The politics (and conflicts) of water distribution are different between the different water users and at the different levels within the water user. In an irrigation scheme, for example, the politics are different for the abstraction weirs, the main canal, and the secondary canals. The focus of this thesis is on day to day water distribution or day to day water management. This is where water resource distribution over farmers takes place [Mollinga, 2001]. A central issue in water distribution is (in)equity [Mollinga, 2001]. Uphoff *et al*. [1990] agrees to this definition by arguing that the norm of equity in water distribution is surprisingly strong.

Water control

The central activity in a sociotechnical (irrigation) system is water control [Liebrand, 2007: 8]. According to Mollinga [1997] irrigation management literature acknowledges that the operation of water control is done by people. Water control also refers to managerial control over the water distribution process, and other organisational processes in the irrigation system. Thus, water control is about the regulation and control of human behaviour, particularly with regard to the forms of cooperation necessary to make (irrigation) systems function [Mollinga, 1997].

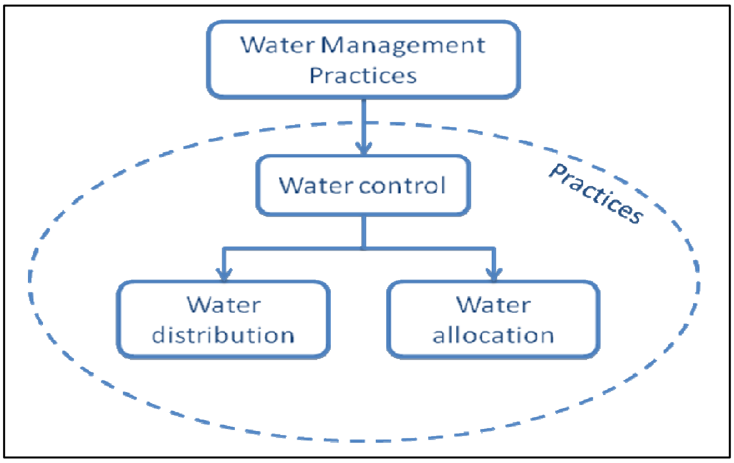


Figure 2.2: Water control in relation to water allocation and water distribution
Source: author, 2009

As the focus of this thesis is the irrigation sector in the Sand catchment, the water control concept is described in relation to irrigation management. Water control for agricultural production as a general concept includes: 1) irrigation, 2) drainage, and 3) flood control. This research will focus on one concept; irrigation. The central purpose of an irrigation system is to control the flow of water for agricultural crop production. Boelens and Zwarteveen [2005] underline the importance of water control. According to them the most important question in relation to water is not whether to price, privatize, sell or purchase, but rather who owns water access and who controls rights? In the irrigation literature water control is a commonly used term. In literature it is acknowledged that the operation of water control technologies is done by people, a form of collective actions is required to manage the system and that managerial control is required for the water distribution processes [Mollinga, 1997]. Having said this Mollinga formulated three dimensions of water control [Bolding *et al*., 2000]:

[10] Compact Oxford English Dictionary, available at www.askoxford.com accessed on 24 August 2009

1) Technical control, focus: the regulation of physical processes trough technical devices or shaping of the environment (e.g. controlling the flow of water by means of infrastructure)
2) Organisational control, focus: regulation of human behaviour (e.g. control of human behaviour, i.e. management),
3) Socio-political and economic control, focus: conditions of possibility for particular forms of technical and organisational control (e.g. control of social processes).

These three dimensions describe the features of a single object. These three dimensions shape the water control, are interrelated and bound together by power. A change in one of the dimensions leads to a change in the other two dimensions. For example having the legal possibility (and social power) to take water is meaningless without the two other dimensions of water control. One should have the means to take water from a source and convey it to fields; the technical dimension must be present. In additional it is necessary to organize and manage not only the water allocation and the operation of the infrastructure, but also the mobilization of resources and the decision-making processes around these issues, this is the organisational dimension of water control [Boelens & Zwarteveen, 2005].This research focuses on the first two dimension of water control. The centre of this research will be on the situation on the ground; about the control, management and distribution of (irrigation) water. In this research I looked at water control within the irrigation schemes and the relation between water control in the schemes and the catchment and their relation to the Reserve.
An important element of the water control process is distribution. Water distribution is more complicated than the distribution of many other resources. This is partly because of the variable availability and fluid characteristics of the water and partly because of the difficulties of monitoring and controlling the water flow. Because of the complexity to control the water the water users can act in ways that diverge from distributional agreements as stipulated in state laws, regulations, infrastructural lay-outs and technologies [Boelens & Zwarteveen, 2005]. Because of the complexity and different ideas about water control a lot of bargaining and negotiation takes place, this makes water control a political process. Through water control power relations are constituted, negotiated and shaped.

Another prominent factor within the concept of water distribution is power. The concept of power is important in researching the (division) structures and technology. As stated above, power binds the three dimensions of water control together. Through water control power relations are constituted, negotiated and shaped. This is affirmed by Van der Ploeg [1991] who states that technology can never be neutral, but contains a certain code that reflects power relations in society. Since technology is not neutral and therefore is influenced by the people who make decisions about the design, building, maintenance and operation, the technology reflects social relations of power in society. This statement is validated by Mollinga [2003a: p. 40], he says about water control: “management institutions and technical artefacts can be understood as the embodiments of particular social relations of power, and, the other way around, socio-economic and political power in irrigation takes concrete shape in particular forms of organization and technologies”.

Boelens&Zwarteveen [2005] made an interesting remark about water control; “The struggle for control over water is a struggle for existence, and a struggle to define what existence means.” In South Africa this is certainly the case, the struggle for equal access to the water source is a struggle for existence for human beings as well as for nature.

Practices

According to Mollinga [1997] one can describe an irrigation scheme as a network consisting of interrelated heterogeneous elements. This is confirmed by Bolding [2004: 17] who conceptualises an irrigation scheme as a sociotechnical network or relations that ties one or more farmers, their labour and skills, a piece of land, crops, a furrow, water, and other resources, like financial capital, together into some working order. Summarizing, networks are relations between actors [Schippers, 2008]. Following this argument, people are the most crucial part of the irrigation network. This research focuses on the practices of these people.

The concept of practices provides a framework for analysing the sociotechnical structure. According to Mollinga [2003b] practices are what people do, in a structured, and structuring fashion. These practices are related to the dynamic physical environment in which actors operate (e.g. the difference in water availability throughout the agronomic calendar [van den Dries, 2002: in Schippers, 2008]. Giddens [1984: in Mollinga, 2003b] adds to this that further feature of practices is that they have regular patterns. They consist of routines, and are structured by rules

For the study of water practices a concept of human agency is required. Mollinga [2003b] defines human agency as the basic idea about what motivates people's behaviour. Thus, peoples (e.g. irrigators) actual patterns of behaviour and social and material interaction with regard to water control determine what irrigation practice is like.

Practices are acted out in arenas or domains of interaction with boundaries defined by technology, social relations, and by time and space [Bolding *et al.*, 2000]. The domain of social interaction for irrigators is quite clear; the irrigation scheme.

Regarding practices of irrigation management, the following practices can be listed: water use activities, control structure activities, and organisational activities. These activities match with the matrix of Uphoff which is adopted in this research. Because of time constraints the research is limited to only a few activities out of the twelve activities as presented by Uphoff (see Figure 2.1). The water use activities are limited to water allocation, water distribution and water acquisition. For a description of the concepts of water allocation and distribution see above. In this research water acquisition is regarded as water abstraction from the surface source by creating and operating physical structures (e.g. storage dams and abstraction weirs) [Uphoff, 1986: in Mollinga, 1997], and abstraction of surface water by means of pumps. Because of the lack of available information on the design and construction of the irrigation schemes these two control structure activities are not described in detail. Since there is hardly any communication, decision making etc in the irrigation schemes (each irrigator manages his irrigation activities independent from other irrigators) the research is not focussed on the organizational activities.

2.3 Water is politics

Water is a 'contested resource' [Wester *et al.*, 2003] for this reason water issues are at the top of many national and international political agendas. Since water is politics it is never neutral, this standpoint is put forward by several authors:

- Schoch [2007]: Water is scarce and essential for life, health and welfare; it has become a contested terrain and therefore a political issue.
- Wester *et al*. [2003]: The question who will represent groups of stakeholder in river basin management is a highly political one.
- Schwartz & Schouten [2007] make almost the same statement about drinking water service: "The combination of water as a merit good, a private good, an economic good, and a good subject to market failure makes that the provision of water services is prominently on the political agenda in many countries, making it a 'political good'. While their statement is about drinking water service, the statement is also applicable for other water uses.

Politics can also be seen in everyday practices of water resource use. A distinction between different political levels is made by Mollinga [2001], he came up with a distinction in three levels: 1) official state and inter-state politics regarding water (or hydropolitics)[11], 2) the politics of water resources policy (policy formulation and implementation[12] as politically contested terrain)[13], and 3) the everyday politics of water use[14]. The three levels are linked to each other and a change in one of the levels will influence the other two levels. At each level different actors and different questions play a role. This research deals with all three levels, however it primarily focuses on the third level; the everyday politics of water use. Political analysis at this level look at the way the local social relations of power shape and are shaped by water resource use practices [cf. Mollinga, 2001]. A definition of politics applicable in the everyday politics of water use is given by Kerkvliet [1990: in Mollinga, 2003b], who defines politics as *the debate, conflicts, decisions, and cooperation among individuals, groups and organizations regarding the control, allocation, and use of resources and the values and ideas underlying these activities.* Based on this definition Mollinga [2003b] argues that water control is a political process of contested resource use.

Water management (in South Africa) is regulated by several laws, policies and institutions. These were the result of a long process of negotiation and discussions. The outcomes are the result of political practices. All policy making discourse is partial in that it is made by coalitions [Swatuk, 2005]. During the process of forming coalitions and making agreements a lot of political power is shown. After abolishing apartheid it became the government's goal to improve the livelihood of all the South Africans. And special attention was given to the development of the historically disadvantaged people. According to Turton [2005] development is about prioritization, wealth creation and the extraction of natural resources, which is a political process because it determines who gets what, when, where and how.

The keywords of the National Water Act are sustainability, equity and efficiency, the latter is related to productivity. These keywords are the essence of Integrated Water Resource Management. IWRM is not simply a policy or method, but a site where power - political, social and cultural - is exercised through discourse, knowledge creation and social practice. Therefore power is an important concept in IWRM. IWRM has two major dimensions; an upper level as a strategic planning model, and a second level as a model of operationalization [Lankford, 2008]. A problem observed in developing countries where IWRM is being promulgated is that operationalization is taking time and is not necessarily leading to intended results [Biswas, 2004]. It is proven to be difficult to implement the IWRM principle in developing countries. It is beyond this research to judge whether South Africa is still a developing country but it is evident that South Africa is facing the same problems. One of the reasons is that the sophisticated models and experiences in the first world combined with the Dublin Principles, cannot be transferred to fit different situations in Sub-Saharan Africa [Lankford, 2008].

Allan [2003] identifies five water management paradigms, from pre-modern to modernity. According to Allan, there is a shift since the year 2000 to the fifth paradigm; modernity. The fifth paradigm is based on the notion that water allocation and management are political processes. In recent years, water users are more aware of the social and political forces that are influencing water management. An example of the political influence in South African water management is the

[11] Examples of state politics are the top priority of the Reserve, the importance of the Inter Basin Transfers and defining the 19 Water Management Areas.

[12] Policy formulation and implementation can be combined by the term "governance". Governance sounds like the word government and can be confused with that term, but governments are not the only entities that control and manage human affairs. Governance means setting policy to guide an activity and then making sure that the money, people and institutions to do the work are in place. It also means making sure that people are accountable for the work they do, monitoring what happens and making new plans to carry the work forward. Source: White Paper on Environmental Management Policy, Department of Environment Affairs and Tourism, 1997.

[13] Examples of water resource politics are the Catchment Management Strategy and the Operating Rules.

[14] Examples of the everyday politics are water abstraction and water use.

legacy from the past; each homeland had its own policies and plans leaving a legacy of fragmented infrastructure and institutional arrangements.

As described in the previous chapters, water is becoming scarcer in South Africa, especially in the Sand catchment. When water becomes scarcer the (political) competition about (access to) the water source will increase. Molle and Mollinga [2003] made a distinction between different dimensions of water scarcity:

1) Physical scarcity (absolute scarcity, water source is limited by nature e.g. arid areas),
2) Economic scarcity (difficulties in capturing water through insufficient human and financial resources),
3) Managerial scarcity (scarcity because of lack of maintenance and management),
4) Institutional scarcity (a society's failure to deal with rising supply/demand imbalances)
5) Political scarcity (when people are excluded from accessing an available water source because they are in a situation of political subordination).

In the history of South Africa the small scale farmers (black) and the population of the homelands were facing political scarcity to the water resources. Water scarcity is a socially constructed notion. This is in accordance with the UNDP [2006: in Krishnan, 2007] who argued that water scarcity is often the result of inadequate management of water resources. [Mehta, 2000: in Krishnan, 2007] even went further by stating that water scarcity is not natural, but largely due to anthropogenic interventions in the realm of land and water management and use. He also argues that access to and control over land and water resources is highly unequal. This is surely the case in South Africa where the per capita water consumption of a black person is less than a twentieth of the typical white [Hamann & O'Riordan, 2000]. Thus inequity (in access to water) is shaped in social power relations.

Research of Krishnan [2007] showed how an emphasis on structural measures to abate water scarcity detracts attention from unequal access to the existing water supplies. Her conclusion, based on the Indian context, is also valid in South Africa under apartheid when DWAFs approach to water resource management was supply driven.

2.4 Stakeholder participation

Participation always had an ambiguous meaning. Participation is defined by many different definitions and is used in many contradicting ways [Boelens, 2001]. Therefore it is necessary to explain the concept of participation. First of all the concept 'participation' will be described after that the concept will be linked with the concept 'stakeholder'.

In response to the problems in irrigation systems there have been calls for an increase of user participation in irrigation water management to improve performance [Mollinga, 2001]. From the 1970s onwards participation has been a leading strategy in managing natural resources like the water management sector. Although there is a call for an increase of participation of local users groups Bewket and Sterk [2002] argue that participation as such is not important but the level of participation matters. Arnstein [1969] made a ladder of participation to distinguish between different steps of participation. Her ladder of participation has been a basis for many policy makers and activists for decades. Her ladder distinguishes between 8 steps of participation, which can be classified in three groups:

1) Non-participation: manipulation and therapy;
2) Degrees of tokenism: informing, consultation and placation; and
3) Degrees of citizen power: partnership, delegated power and citizen control.

In his 'Extended Ladder of Participation' Bruns [2003: in Wegerich *et al.*, 2008] build Arnstein's ladder of participation. For him the key questions were '*who decides?*' and '*who has input into the decision?*' Wegerich and Bruins [2008] comment on the ladder of participation because little attention is paid to the quality and quantity of involvement within the group. For example, WUAs can favour large landholders by using a proportionality approach for voting rights. In addition most of the farming household have only one member in a WUA this could strengthen the position of the man in the household. In addition, Arnstein's approach has the assumption that the power transfer will improve the quality and the quantity of the service, whether this would be the case is questionable [Wegerich *et al.*, 2008].

To improve irrigation performance in response to problems in existing schemes, scientist called for an increase of user participation in irrigation water management, since the 1970s [Mollinga, 2001]. However, during apartheid there was no stakeholder participation in water resource management, especially not by the Historically Disadvantaged Individuals. One of the goals of the new government, however, is to increase stakeholder participation, therefore two new decentralized water institutions are established the CMA and the WUA.

One of the principles of the NWA is: "Participation by stakeholders in decision making about water resources". According to the Act peoples participation is crucial in water resource management. This brings me to the concept of stakeholder. Renard [2004] made some remarks on the concept of stakeholder which are important to realize: stakeholders are not only local people, stakeholders are not only organisations and formal groups, and stakeholders are not only the users of natural resources. It is important to define the meaning of the word "stakeholder" first. According to the Oxford Dictionary a stakeholder is: 1) an independent party with whom money or counters wagered are deposited, 2) a person with an interest or concern in something. Bruce [2001, cited in Simpungwe, 2006] defines 'stakeholders' as individuals or groups who possess some form of legitimate investment on natural resource management outcomes and thus stand to lose or gain from management processes of the resource. Rolling and Wagemakers [1998, p7, cited in Simpungwe, 2006] identify stakeholders simply as natural resource users and managers. For this research I stick to the stakeholder definition of Bruce.

Various perspectives are used to legitimize the need for participation. Boelens [2001] gives a list of nine interlinked perspectives, ranging from domestication to democratic right perspective. In this research the focus will be on the empowerment perspective. This perspective is often used in the South African context as an argument for stakeholder participation. In an ideal stakeholder participation process all stakeholders are equal, in practise this is not the case. Stakeholder participation is an essential element in the negotiations that are by definition political. Historically disadvantaged groups have limited knowledge[15] and limited negotiation skills. Hence, powerful groups are likely to exert more influence over the course of stakeholder process (or negotiations) and the implementation of agreements than disadvantaged groups [Edmunds & Wollenberg, 2001]. Thus stakeholder participation should be combined with capacity building (empowerment) of disadvantaged groups. Participation as empowerment means that the socio-political struggle of certain groups is supported. An important objective of this perspective is the increase of the local capacity for negotiation and claim-making power[Boelens, 2001].
An important comment on stakeholder participation is made by Edmunds & Wollenberg [2001: 244]. According to them *negotiations* (or stakeholder participation) *will achieve more just and equitable outcomes for disadvantaged groups if they are approach strategically, rather than trying to create neutral platforms where all stakeholders can discuss all issues - irrespective of their historical relations and the full range of their present political activities - with the goal of reaching rational, mutually intelligible and universally recognized agreements.*

[15] Limited knowledge about complex water resource management.

2.5 River catchment

In literature the terms river basin, watershed and catchments are often mixed up. According to Anderson [2005] the term watershed is used predominantly in North American literature while, catchment is used in South Africa, Australia and New Zealand. As catchment is commonly used in South Africa, this term will also be used in this. Several different definitions of a catchment are used by different organisations, researchers etc. Most of the definitions are concerned with the physical aspect of the catchment. An examples of the definition of a catchment is given by South Africa's White Paper on National Water Policy which defines a catchment as *the entire land area from which water flows into a river; catchments can be divided into smaller "sub-catchments" which are usually the area which drains a tributary to the main river or a part of the main river* [DWAF, 1997b]. Another definition is given by Anderson [2005]; an area of land bounded by topographic features of height that drains waters, through a stream and its tributaries to a shared destination. Both definitions are limited to the physical aspects and do not take into account the human element. For this reason I prefer the definition by Dourojeanni [2001] who states that "*A river basin is an area which is defined by nature itself, essentially by the limits of the run-off areas of surface water converging towards a single watercourse. The river basin, its natural resources and its inhabitants have physical, biological, economic, social and cultural qualities which endow them with their own special characteristics*".

Traditionally water policy makers used administrative boundaries (see Box 2.2). Nowadays there is general agreement among policy makers, researchers, and water managers that Integrated Water Resource Management (IWRM), on which the NWA is based, must be done at the catchment level [Merrey, 2003]. The IWRM philosophy regards the catchment as the "natural" unit for organizing water management [Waalewijn *et al.*, 2005]. However, after an extensive research on river basin management, Wester [2008] showed that the argument that river basins are the natural units for water management is deeply political.

According to Barham [2001] the gradual shift to watershed and thence to ecosystem thinking represents a larger social reflection upon the limits of natural systems that must be respected if they are to be sustained. She further argues that watershed thinking can be an opportunity to strengthen our ability to work together. But it is also possible that the existing inequalities will simply be passed along, or worse, reinforced.

The Department of Water Affairs defines IWRM as "a philosophy, a process and a management strategy to achieve sustainable use of resources by all stakeholders at catchment, regional, national and international levels, while maintaining the characteristics and integrity of water resources at the catchment scale within agreed limits" [DWAF, 2003c]. This definition is put into practice by the South African government. According to the government water is the primary resource that will ultimately limit development in South Africa, efficient management and allocation of water resources is a national imperative [DWAF, 1996]. Therefore the government manages water as a national resource rather than a catchment resource. Through Inter Basin Transfers (IBT) water is transferred between catchments (see Annex A). Most of the water transfers augment the water supply to the Gauteng area [Turton & Meissner, 2000]. For the overall development of South Africa the IBTs are very important. The local economies are heavily reliant on water that has been imported from other river basins by means of IBT. According to Turton [2005] exogenous water, supplied by

Box 2.2: Catchments in apartheid history

Traditionally water policy makers used administrative boundaries. In the 1970s, however, DWAF already took the basin as unit of planning, but unlike much of the later global debates, with the purpose to move water in and out of those basins and out of other countries

Source: van Koppen [2008]

means of IBT, is the lifeblood of the South African economy, which would simply collapse if this source of supply were no longer secured, raising water resource management to a strategic issue of great national importance.

Water resource development in the Sand catchment has led to water overexploitation. This process is has been termed basin closure. According to the International Water Management Institute a basin is closed when all the accessible water resources in a river basin are already in use or have been allocated to users [Seckler, 1996]. An interesting comment about basin closure is made by Lankford and Beale [2006]: when demand exceeds a river's supply along its reach, the river switches in behaviour - it no longer supplies surplus water to autonomous points of demand but becomes a contested channel with infrastructure that divides and defines the distribution of a scarce resource.

This research adopts the concept of a river basin because of the linkages between different aspects in the catchment which influence the water management in the closed Sand catchment. It is vitally important to look at the broader (catchment) picture and not to focus on one isolated aspect. For example, by looking at the irrigation scheme only, the major water losses in the irrigation scheme might seem like a waste of water. By increasing the efficiency of the irrigation scheme the return flows will decrease. This might result in problems downstream of the irrigated area. A good example of the dependency on return flow is the city of Maputo in Mozambique. Part of the water used in Maputo comprises the return flow from irrigation in Swaziland along the Umbeluzi river [Nkomo & van der Zaag, 2004]. By looking at the whole catchment it becomes evident that these return flows recharge the river. Therefore a loss to one system can be a gain to a downstream system by looking at water use at the catchment scale.

2.6 Concluding remarks on conceptual framework

The main concept of this research is water management practices, linked to these are water allocation and water distribution. Water allocation and distribution plans do not just come about as the result of a methodical application of rational scientific data processed by engineers and planners [Bolding *et al.*, 2000]. In practice these practices and decisions are influenced by power relations between stakeholders in which different actors strategically manipulate information and other resources to pursue particular goals and objectives. To get a better understanding of these practices the focus of this research is on these practices.

For a comprehensive understanding of the irrigation sector a framework that integrates technical and social science perspectives is required, as argued by [Mollinga, 2003b]. By using Uphoff's framework both dimensions will be addressed in this research. This framework helped to understand the difference between water allocation and water distribution. Combined with the water control concept it shows that once allocated a share of water, one need the technical, organisational and socio-political means to transform this allocation into distribution[16].

While analysing the water management practices one should be aware that water management in the Sand catchment is a complex process. Because of the complex interaction (change of government) with exceptional droughts, urbanisation and rural poverty water management in the Sand catchment is characterized by complexity.

2.7 Research methodology

This section describes the methodology used in this research; it describes the data collection and analysis phase. The section is closed with a description of the limitations of the research.

[16] Personal communication A. Bolding, 24 August 2009, Wageningen

This thesis research is set up as a case study. The everyday practices are studied in its boundaries; the Sand catchment. The case study method is an approach to studying a phenomenon through a thorough analysis of an individual case [Kumar, 2005]. The aim of this qualitative research is the presentation of empirical evidence from the field. The research activities are in line with the purpose of collecting and presenting information from the field. Initially, the research was planned to be on the irrigation sector only. Once in the field, it became clear that to understand the practices it was necessary to expand the research to the other water users as well. The focus of the research, however, is still on the irrigation sector.

Data collection

Before the fieldwork phase commenced, data was collected for an extensive literature review. The review gave me an understanding of the current knowledge about the research topic subject and the South African context. During the field work phase a large variety of documents was collected.

As an introduction to the fieldwork a conference on environmental water allocations in Port Elizabeth was attended. This international conference helped me to get a better understanding of the relevance of the environmental flows. During the conference the challenges of implementing environmental flows were discussed. Experiences of several researchers were exchanged.

Interviews were one of the main elements of the fieldwork. Semi structured interviews were adopted, mainly one-on one interviews. The 40 people interviewed were chosen to represent all the water users, regulators etc in the catchment (see Table 2.1). Since the focus of this research is on the actual situation on the ground, most interviewees were with local people who abstract, use, manage and control the water. In some cases the initial interviews were followed up with a second interview if issues were unclear or gaps emerged. To improve the validity of the research, several persons were interviewed in relation to the same subject. Hence, almost all the information was triangulated by several sources.

The interviews with the irrigation staff were mainly held in the DoA field office. After these interviews the irrigation scheme was visited to explain the discussed practices in the field. In order to obtain observation data, field visits were conducted. During these observations the water users (e.g. irrigators) were interviewed for a deeper understanding of their practices. Almost all the surface abstraction pints (except the domestic abstraction pumps in the game reserves) were visited. Most of the water users (irrigators + domestic pump operators) were observed while performing their water management practices. The interviews of the irrigation stakeholders were structured by using Uphoff's matrix of irrigation activities. The matrix provides a comprehensive description of irrigation activities. The matrix provided a framework to structure the interviews.

Table 2.1: Interviewed stakeholders

Regulators	Water users	Operation & Maintenance	Other interested and affected parties
National DWAF	Irrigation management Committees + farmers	Domestic pump operators	Teba development/ MABEDI project
Regional DWAF	DWAF - Forestry	Dam operators	AWARD
Regional DoA	Community members	Water bailiffs	Researchers
ICMA	Sabi Sand Wildtuin	Maintenance team	Consultants

Source: author, 2009

Data collection and analysis

All interviews were transcribed. The transcripts of the interviews were grouped according to a thematic classification. This means there were groups of transcripts relating to the Reserve, to maintenance, to ownership etc. The grouped transcripts were analyzed by use of a data sheet created by the author. Meetings and field notes were also transcribed and added into the above mentioned data sheet.

A powerful tool for analyzing data (interviews and literature) was the system diagram. Numerous system diagrams were drawn and discussed with several stakeholders to get a better understanding of the water management in the catchment. In the last week of my field work phase the catchments' system diagram was presented to, and discussed with, a group of key stakeholders.

Limitations of the Research

During the fieldwork phase it was often difficult to obtain information on actual practices. There was often no information available on the actual situation; e.g. water abstraction, number of farmers and irrigation scheduling. During the report writing phase, however, I had access to numerous reports, policies, government documents, plans, letters, pictures, models etc. The main reasons being, collecting information from all the stakeholders, knowing the right people and knowing where to find what. While writing the report, the writing process was limited by an overload of (often contradicting) information. Triangulation of data and sources was necessary in order to rebut contradicting information. The necessary triangulation was sometimes confusing since different perceptions upon reality exist. This is confirmed by Schoch [2007] who did research about South Africa's Reserve as well.

Due to time constraints the research was limited to active water users. No attention could be given to non functioning irrigation schemes. The interviews amongst the farmers were also limited to active farmers. Hence, there is no input from dormant farmers on, for example, reasons for the land being fallow.

It was regularly difficult to plan interviews with senior government officials and other key stakeholders. There is a small number of very committed staff at DWAF and ICMA, they are already overloaded.

Another limitation of the research was the language; translation in Shangaan and Sotho was required. During my field work I worked with a number of translators. Unfortunately they were not acquainted with irrigation and water management knowledge.

The main water user in the Sand catchment is the irrigation sector. This research is limited to only the water management practices of this sector. For a better understanding of the irrigators, however, it is necessary to look at the broader picture e.g. agricultural practices, challenges, markets and economic benefits.

An important component of the Environmental Reserve is water quality. However, this aspect fell beyond the scope of my research. The research was limited to the quantity aspect of the Reserve. But having water of the right quality is just as important as having enough water. Talking about the Reserve, the research is also limited to the abstraction of surface water. Groundwater, which is an important domestic water source, is not taken into account.

3 The research area – Sand catchment

3.1 Introduction

This chapter describes the characteristics of the research area the Sand catchment. The chapter starts with a description of the catchments boundaries (3.2), followed by soil and topography (3.3) and climate (3.4). This is followed by a short description of the population (3.5) and its landuse (3.6). next the available water resources are described in section 3.7. And a description of the main water related stakeholders (3.8) closes the chapter.

3.2 Catchment boundaries

The Sand River, some 125 km in length, is the main tributary of the Sabie River, which forms part of the Inkomati catchment. The area of the Sand catchment (see Figure 3.1) is 1,910 km^2 and is bounded by the Mankeli Hills in the south, the Orpen road in the north and the Drakensberg escarpment in the west.

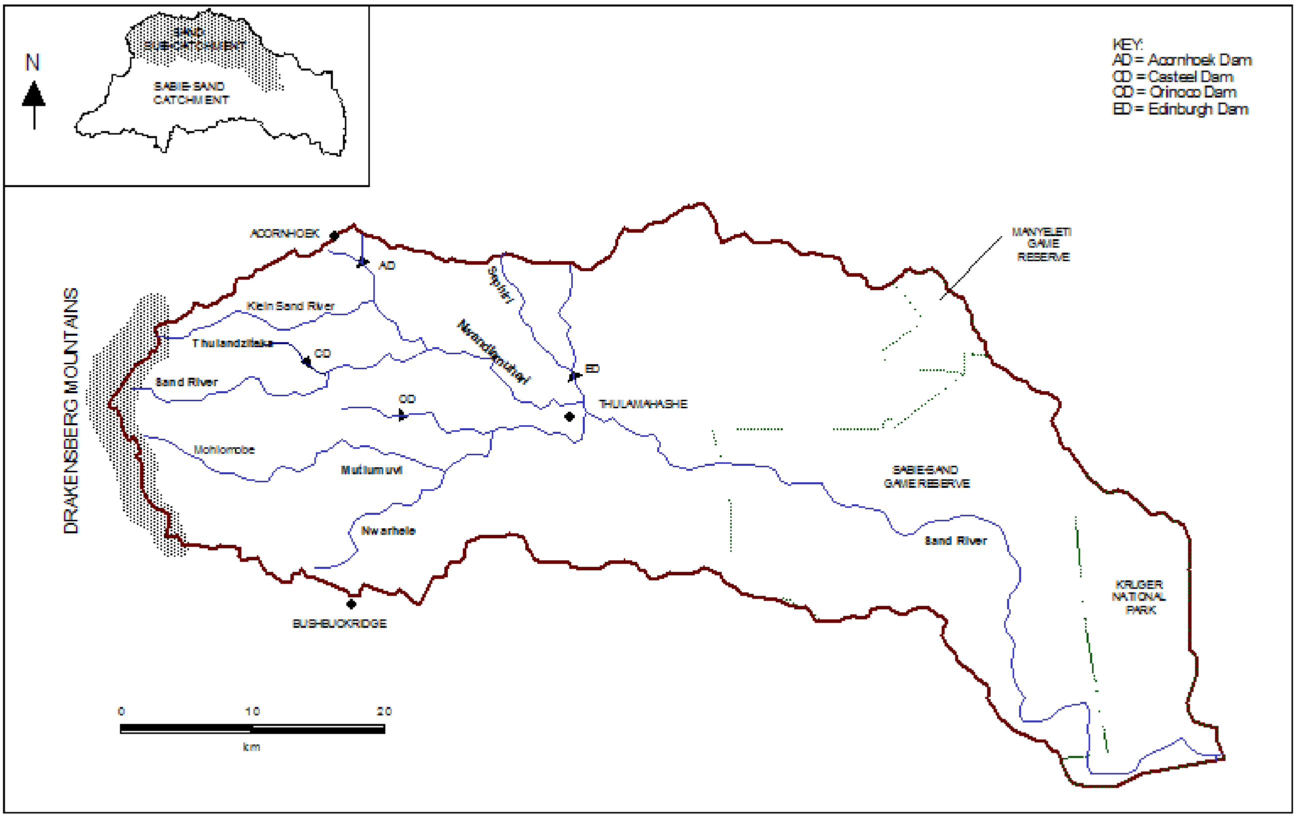


Figure 3.1: The Sand River catchment, indicating the catchment boundary, major rivers, existing dams and game reserve boundaries.
Source: Pollard *et al.* [1998]

Most of the catchment falls in the Central Lowveld area (150-800m altitude). The Sand catchment can be subdivided in three smaller catchments; the upper, central and lower catchment; they all have their own specific characteristics like climate, landuse, population etc.

3.3 Soils and topography

The topography of the catchment is characterised by a steep slope from west to east, from 1800m in altitude to 400m. The upstream catchment is characterised by steep hills, the central and lower catchment are relatively flat areas. The soils are mostly derived from granite, soils derived from granite are coarse and sandy, low in nutrients and water drains easily in these soils [Pollard *et al.*, 1998]. The soils in the eastern part are rocky, in the central area the soils are more nutrient poor and in the east the soils are poor sandy. These sandy soils are vulnerable for erosion.

The topsoils in the irrigation schemes are about 300mm thick structureless coarse sand to loamy coarse sand. The subsoil is sandy clay loam. The soils are gentle sloping between 0.1 and 0.3%, from elevation 560 m down to 400 m [ARC-LNR, 1999].

3.4 Climate

Because of the differences in altitude in the catchment, there are also differences in the climatological characteristics. The topography of the catchment is reflected in the weather situation. The rainfall decreases from west to east, while temperature and evapotranspiration increase from west to east. Because of the high temperatures in summer, the potential evapotranspiration (from 1850 mm in the west to 2200 mm in the east) is much higher than the precipitation [Pollard *et al.*, 2005]. From west to east the climate becomes hotter and drier. The mean annual precipitation varies from about 2000 mm/year in the west to about 550 mm/year in the east. 75% of the rain falls between October and March. The catchment has warm to hot summers and mild winters. The average annual temperature is 22°C. The climate in the catchment is semi arid. An arid climate is characterised by low erratic rainfall up to 700mm/year and periodic droughts [Pollard *et al.*, 1998]. Because of the erratic rainfall, droughts are common in the catchment, every 3.5 year in the northern portion of the catchment [Pollard *et al.*, 2002]. Another negative consequence of erratic rainfall is flooding. Heavy rainfall in the upper catchment results in floods downstream, also downstream of the Sand catchment. The sandy soils in the catchment are vulnerable to erosion during periods of high rainfall.

3.5 Population

The population living in the Sand catchment is estimated to be 337,000 in 1998 and is expected to grow to 447,000 in 2010 [Pollard *et al.*, 1998]. The average household size is 6.2 persons [Pollard *et al.*, 2002]. The current distribution of the population is influenced by the physical geography and the political history. Most of the people live in one of the 71 peri-urban or rural villages in the flat central area. The upper catchment used to be part of the former Lebowa government is state owned and is under commercial afforestation, not many people live there. The lower catchment consists mainly of private and state owned conservation areas; as a consequence very few people live in this area. The estimated population density for the whole catchment is 176 people/km^2. But because of the population concentration in the central area, the population density for this area is much higher; 340 people/km^2 [Pollard *et al.*, 1998]. Bushbuckridge is one of the most densely populated areas of the country [Shackleton, 2005].

Most of the people in the catchment live in sparse density residential areas without sufficient domestic water supply system and no sanitation system. The sanitation backlog in the Bushbuckridge municipality is the highest in the province. Some of the houses have a yard tap; however, most of the people need to walk to communal standpipes to collect their water. Borehole and surface water are the main sources of water for most villages in the area. Half of the households in Bushbuckridge have access to public standpipes, 16% to yard taps and 14% have house to house connections [Perez de Mendiguren & Mabelane, 2001].

History had an important effect on where and how people live in the catchment. Before 1850 the area was populated by Sotho speakers. Because of a war in Portuguese- East Africa (nowadays Mozambique) around the year 1850 Tsonga speaking immigrants and refugees moved to the area. Around 1900 both groups lived harmoniously together. Because of the threat of malaria there was a small interest by white farmers to move to the area. Therefore by 1920, only two irrigations systems had been established in the Inkomati catchment. In 1935 some land was owned by companies and white farmers. From the 1940's apartheid policies shaped the land use patterns in the catchment. Because of the high unemployment rate and the burgeoning population, the homeland government developed several infeasible job creation schemes involving agriculture, conservation and forestry.

In 1997 there was a conflict over which province Bushbridge would fall under, there were blockades, rallies etc. After a long dispute it was decided in 2006 to let it fall under Mpumalanga Province. The catchment is part of the Bushbuckridge Local Municipality, which forms part of the Ehlanzeni district municipality.

The major employment sectors include commercial activities, tourism, forestry, agriculture, and civil service posts such as local government, teachers and nurses. The agricultural sector employs about 1.6% of the population [Pollard *et al.*, 1998]. The population of the catchment is characterised by high unemployment. 60% of the people over the age of 15 of Bushbuckridge municipality is unemployed [Bushbuckridge local municipality, 2005]. Due to the lack of employment opportunities 50% of adult males and 14% of adult females engage in migratory labour [Pollard *et al.*, 2002].

It is important to note that most young people in the catchment are not interested in agriculture. This is confirmed by Pollard *et al*. [2008b], she argues that youth attach little value to the land and there is an increasing shift toward a consumerist ideal (Pollard, 2008). Hence, most of the farmers are elders.

3.6 Land use

The existing pattern of land use in the Sand catchment reflects the policies of the apartheid period; enforced removal of black residents and the creation of betterment schemes. Land in the Sand catchment is still mainly State owned and is granted to users through traditional authorities and regulations [Perret, 2002b]. The main landuse types in the catchment are rangelands, conservation areas, residential, forestry, and annual dryland farming. These major landuse types will be briefly described below;

Picture 3.1: Rangeland
Source: author, 2009

Rangeland: 40% of the catchment area, mainly in the central area (see Picture 3.1). Rangeland is used for livestock grazing and harvesting of natural resources. Cattle are grazed on communal land, main species are: cattle, goats and poultry [Pollard *et al.*, 1998]. The harvested natural resources from the rangelands are used for food, fuel wood, building materials and medicines.

Conservation area: 36% of the catchment area, mainly in the lower area. There are three major game reserves in the catchment: Kruger National Park (KNP), Manyeleti Game Reserve and Sabie-Sand Game Reserve. The establishment of private game reserves is catalysed by the marginal profitability of commercial farming in the catchment [Pollard *et al.*, 2003]. Tourism industries are closely related to conservation areas. In the KNP several dams and boreholes are constructed for the water need of the tourists and the animals [Asmal, 2004]. Tourists are mostly flown straight in and out of the reserves and do not have a lot of direct contact with the remainder of the catchment [Pollard *et al.*, 2005]. Tourism is one of the main sources of income in the catchment. For example, more than 1500 households families are supported by job opportunities provided by the tourist industry within the Sabie Sand Wildtuin [Jackson & Swart, 2003].

Residential: 10% of the catchment area, mainly in the central area.

Forestry: 6% of the catchment area, mainly in the upper area. Forestry is a major water user; 19% of the mean annual runoff in the Sand catchment is used by forestry [Woodhouse & Hassan, 1999]. In the early 1900's the indigenous forests and grasslands were replaced by three plantations; Welgevonden, Hebron and Onverwacht. The aim for establishing these plantations was to provide labour to the population of the Lebowa homeland [Pollard *et al.*, 2008a]. Trees were grown on these plantations for timber and pulp production. The lack of a natural source of fast growing timber trees led to the introduction of alien species. As a result most of the mono culture forest is planted with exotic species such as pine (mainly Pinus patula) and eucalyptus (mainly Eucalyptus saligna). On the one hand the forestry sector gives economical benefit to the region. But on the other hand, afforestation leads to a reduction in surface stream flow because the planted exotic trees consume more water compared to the indigenous forest. The plantations in the upper areas have reduced the natural flow in the Sand River systems by about 31% [Le Maitre *et al.*, 2002]. Another problem related to the plantation of exotic species is that these trees spread the negative effect far beyond the afforested area by invading adjacent areas [Le Maitre *et al.*, 2002]. To combat the spreading of the water consuming exotic trees, the government introduced the Working for Water program (WfW), most of this program is paid by a post-apartheid 'Poverty Relief Fund' [Asmal, 2004]. A strategic plan was drawn to convert the State owned forest to conservation in the newly formed Blyde River Canyon National Park and all alien trees were to be removed by 2006 [Pollard *et al.*, 2008a].

Dryland farming: 4% of the catchment area. The most important crops are maize, pumpkins and beans [Pollard *et al.*, 1998]. The dryland crops are planted during the rainy season. Many families in the catchment depend on dryland farming for their food security. A great risk for their food security is the erratic rainfall and drought.

The irrigation sector is not a large land user (1,4%) in the catchment, but due to its high water use, this type of landuse will be described. Irrigation is the largest single water user of water in the catchment. There are three large irrigation schemes in the catchment, namely Champagne (permanent crops), Dingleydale (annual crops) and New Forest (annual crops). These schemes were initiated by the homeland governments. The main purpose for building these systems was to provide employment for the local population and the schemes were not designed to be self-sufficient [Pollard *et al.*, 1998]. The most common irrigation type at Dingleydale and New Forest is short furrow irrigation. Both schemes are operated by numerous small farmers, each cultivating a small plot between 1 and 6 ha. There are an estimated 1000 farmers involved in these schemes (see Table 6.1). Most of the systems are in a bad shape and are very wasteful. Irrigators mostly access the water in the catchment as run-of-river, diverting it via weirs into canals.

Farming systems

The focus of this research is on the irrigation sector. Therefore, this sector will be described in more detail. This section describes the farming systems of the irrigation farmers, crops, markets, cultivation method etc.

Champagne farm is currently the only functioning irrigation scheme with permanent crops. The main fruit crops at the farm are oranges (Valencia and Navel) and to a lesser extent mangoes and litchis[17]. Most citrus trees are more than 50 years old. The lifespan of a productive citrus tree should not be more than 30years[18].

Dingleydale and New Forest irrigation schemes are cultivated with annual crops. Both schemes are traditionally grain and vegetable production areas[ARC-LNR, 1999]. Currently a wide variety of grain crops and vegetables are grown. The small scale farmers produce mainly green maize, groundnuts, cabbages, sweet potatoes, onions and other vegetables [DWAF, 2007b]. The dominant summer crop is maize, the dominant winter crop are tomatoes [ARC-LNR, 1999]. The driving forces behind crop choice are 1) the use of products for home consumption, and 2) selling of products on

[17] From interview Champagne farm manager, 29 April 2009, Champagne Farm.
[18] From interview Community Property Association member, 3 March 2009, Champagne Farm.

the market for an income. Besides the crops grown in the schemes, small orchards above the canals are planted with mango trees. There are also other fruit crops; e.g. guava, papaya and banana. These fruits are mainly for home consumption.

Picture 3.2: Roadside stall
Source: author, 2009

The main irrigation type at Dingleydale and New Forest the schemes is short furrow irrigation. Before the start of the irrigation period, the farmer prepares his plot by ploughing followed by disking the soil on the contour[19].

The harvested crops are a source of vegetables and fruits to the farmers' families. The surplus is sold to the community on the local markets. There is no formal fresh produce market near the two schemes and the chain stores in neighbouring towns do not buy produce from the schemes. Most farmers sell their produce at the roadside. There are several roadside stall along all the main roads surrounding the schemes (see Picture 3.2). Due to the limited purchasing power at the local market the profit from the crops are generally low [DWAF, 2007b]. To make the situation even worse most farmers produce the same crops at the same time. The produced crops come onto the market at the same time, thus lowering the price.

It should be noted that the main winter crop in the irrigation schemes is tomato. The tomato jam factory in Hoedspruit (just outside the catchment) used to be a major market for tomato farmers of the schemes. For several years the tomato jam factory is closed down already. However, the farmers still produce a lot of jam tomatoes[20]. The farmers are reluctant to change to other varieties or crops, even if they do not make a lot of profit and have high spraying cost.

Based on several field visits and numerous discussions with farmers and other stakeholders an overview of challenges for the farmers in the irrigation sector is given in Table 3.1. The combination of these challenges results in a considerable number of plots in the schemes lying fallow.

Table 3.1: Main challenges for the irrigators

Category	Challenge
Water	Periodic water shortage
	Water logging
Production	Use of low quality seed
	Inadequate weed control
	Incorrect planning practices
	Insufficient governmental extension service
Infrastructure	Dilapidated infrastructure
	Lack of maintenance
	No proper fence around the irrigation scheme, cattle damaging the canals and eating the crops

[19] Trough the recent Masibuyele eMasimini DoA programme the irrigation schemes received 11 tractors (6 tractors at Dingleydale and 5 tractors at New Forest) and farmers received maize seed and organic fertilizers. These tractors are available for agricultural work within the schemes. The irrigation management committees planned to charge the farmers for the use of the tractors. The committees wanted to save money to fix the broken canal sections. DoA, however, emphasized that the tractors are a gift from the government, thus the farmers should use the tractors for free. DoA pays the salary of the tractor drivers and provides free diesel.
[20] Based on field observations and discussions with irrigation farmers.

Financial	Lack of cash flow to buy inputs / pay for transport
	No access to credit facilities to buy inputs
Marketing	Difficult to buy farm inputs
	Difficult to sell products, no formal markets nearby
	Lack of transport to markets
Soil	Acidity in top soils and sub soils (minor areas)
Social	Dependency of farmer on the government for maintenance of the infrastructure and the availability of agricultural inputs
	Large number of plot holders are not interested in farming

Source, author, 2009

3.7 Water resources

This section describes the main points of the water resource situation of the Sand catchment. For a more detailed description on water availability and water use see chapter 7.

The tributaries of the Sand River which originate in the high rainfall areas in the Drakensberg are perennial rivers. The tributaries which originate on the plains are non-perennial [AWARD, 2008a]. Nearly 50% of the water running to the Sand River is generated in this mountainous area, which covers about 25% of the catchment [Pollard *et al.*, 2008a]. The Sand river is highly seasonal, the river shows summer peak flows (February) and low lowest flow at the end of the dry season (October) [Weeks *et al.*, 1996]. The water quality of the Sand River is generally good. The main problem related to water quality is sedimentation [DWAF, 2000a].

The bulk of the water use in the Sand catchment is dependent on the unregulated flow of the rivers in the catchments, except for some augmentation dams. Four storage dams are built to store surface water and four abstraction weirs were build to divert water (see Figure 3.1). The weirs are often operated in an ad-hoc manner with little regard to the needs of the affected communities or to DWAF policies in this regard [DWAF, 2004a]. An example: during the 2002 drought irrigators abstracted all the water at the New Forest weir, while downstream the Thulamahashe abstraction pump was unable to draw water for domestic use [Jackson & Swart, 2003].

Most of the existing water resources are already utilised. The introduction of a new water user is only possible by an increase in groundwater use, a reduction in other sectors or transfers from outside the catchment as confirmed by Butterworth *et al.* [2001]. In 1994, DWAF stated that: *"Existing development in the Sabie River catchment is already causing serious water shortages in both the Sand River and Sabie River sub-catchments and future development and population growth will aggravate these water shortages. Unless the water supplies are augmented, the basic water requirements of the population in the largely underdeveloped region will not be met and the natural riverine environments of the Sand and Sabie River will be irreparably damaged"* [DWAF, 1994: 1]. Therefore plans were drawn to transfer water from the Sabie to the Sand Catchment. A storage dam was built on the Marite River, a major tributary of the Sabie. The dam is situated on the farm Inyaka and is called the Inyaka Dam [DWAF, 2003b] (see section 8.2).

Because of water scarcity, environmental concerns and the drought in 1992 (the worst in recorded history) the management of Kruger National Park (KNP) became concerned about the maintenance of the minimum flows in the Sabie River. The Sabie River has a high ecological status and is important to the ecosystem in the park. The management of KNP realized the park's vulnerability to upstream developments, including land use changes, for example: forestry plantations and population increase. In response to these concerns the Sabie River Working Group was set up by staff of the Kruger National Park (KNP). The Sabie River Working Group can be seen as the precursor of the catchment-based management agency. The working group brought the different water users in the catchment together, mainly irrigation boards and homeland administrative officials [Woodhouse & Hassan, 1999]. One of the agreements made in the Sabie River Working Group was that a minimum flow of 0.6 m^3/s will be maintained in the Sabie as it enters the KNP [Woodhouse & Hassan, 1999]. Plans were drawn to make a catchment management plan for the Sand catchment. The name for this project is the Save the Sand Project which is co-ordinated by AWARD, a locally-based NGO.

3.8 Water stakeholders

This section describes briefly the key stakeholders involved in water management in the Sand catchment. This section is not aimed at giving an extensive description of the stakeholders, but rather on mentioning the aspects relevant for this research. For a description of the practices of these stakeholders see chapter 5.

Government - Department of Agriculture

The Department of Agriculture has a responsibility for scheme members as agricultural producers [Chancellor, 2003]. The catchments' agriculture is controlled by several levels in the department;

- Province: The provincial DoA is located in Nelspruit is responsible for sustainable resource management in Mpumalanga province. Although water is one of the key agricultural inputs it is not formally considered in the planning[21].
- District: The Ehlanzeni district office is located in Thulamahashe and is responsible for all DoA farmer support activities in the district. The maintenance unit is controlled from this office.
- Field: Several field offices are located in the catchment (Bushbuckridge, Dingleydale and New Forest. The DoA extension officers and water bailiffs are based in these offices. Currently there are three extension officers at the schemes. Unfortunately, they have little resources and they only provide advice and some training. There used to be a DoA training facility to train farmers at Dingleydale.

The ARC research institute originated in 1961 within the DoA[22]. The Agricultural Research Council (ARC) is the principal agricultural research institution in the country. The irrigation sector became a major activity of the institute, they are involved in feasibility studies, planning and design. As part of the Save the Sand program ARC wrote a rehabilitation proposal for Dingleydale and New Forest in 1999.

DoA through its Comprehensive Agricultural Support Programme is planning to increase its support to the irrigators in the catchment [DWAF, 2007b].

Government - Department of Water Affairs and Forestry

The Department of Water Affairs has a responsibility towards water managers/users and members of a WUA [Chancellor, 2003]. The catchments' water is managed by several levels in the department:

- National: The national office is located in Pretoria and is responsible implementing the NWA [Brown, 2006], joint management of international catchments, policy formulation and regulation[Reed & de Wit, 2003], development of a national water resource strategy [James, 2003], and for the comprehensive Reserve determination[23] etc. The writing process of the Operating Rules was supervised from this office.
- Regional; the relevant regional office is located Nelspruit. The proto ICMA originated from this office. The regional office is responsible for implementation of the passive control at the weirs [DWAF, 2004a]. Recently a Compliance Monitoring & Enforcement unit has been established at the regional office signalling the increased regulatory intentions of the Department [Pollard *et al.*, 2009a]. It should be noted that until March 2008 there was only one person responsible for compliance monitoring in the whole country.

[21] From interview Senior DoA official, 15 April 2009, Nelspruit.
[22] For more information on ARC see www.arc.agric.za
[23] From interview senior DWAF official, 15 April 2009 Nelspruit.

After the abolishing of apartheid DWAF became responsible for domestic water supply (see section 6.4). Later on DWAF handed over this responsibility to the Water Service Providers. The transfer of responsibility for water provision started in 2001 [USAID, 2005].

Government – Inkomati Catchment Management Agency

The ICMA is located in Nelspruit and is responsible for water use in the Inkomati catchment. the ICMA should write a Catchment Management Strategy (see section 4.3). Until the ICMA was established the Minster of DWAF acted as the CMA for the water management area [DWAF, 2002b]. The ICMA board was appointed in September 2005.

Government – Sand catchment Water User Association

The second tier in local water management institution, besides the CMA's, are Water User Associations (WUA). A WUA will operate on a restricted local level and are in effect cooperative associations of individual water users who wish to undertake related water activities for a mutual benefit [DWAF, 2003b]. Both New Forest and Dingleydale irrigation schemes have in the past submitted their application for the registration of a WUA. Because the irrigation schemes were too small to become independent WUAs their applications were not granted [Teba development, 2009]. The irrigation schemes needed to be incorporated into a larger WUA. This is in line with the plans of the ICMA to establish one WUA with all the water users in the Sand catchment, including farmers and private game reserves[24]. This process started in the middle of 2008. The WUA is expected to be established in 2010 – 2011. It should be noted that under the NWA, only WUAs can apply for an irrigation water use license and may be granted the right to use water under specified conditions.

Government – Tribal Authorities

There are three tribal authorities in Dingleydale namely Moreipusho, Moletele and Sehlare and one tribal authority in New Forest, the Amashanga [Teba development, 2009]. The tribal authorities are not very influential in the catchment anymore. As in many former homeland areas, power disputes have arisen between emerging local government and the tribal authorities. Conflict arise in many areas, one particular area of conflicts is land allocation rights, traditionally this right was exercised by the Tribal Authority but local government is trying to influence this process [Pollard *et al.*, 1998].

Government - Municipalities

The Bohlabela District Municipality is a newly formed municipality, established in December 2000 through the municipal demarcation process. The District Municipality comprises of Bushbuckridge Local Municipality, Maruleng Local Municipality and the District Management Area the Kruger National Park. After the transfer of Bushbuckridge from Limpopo to Mpumalanga in March 2006 the name Bohlabela is changed into Ehlanzeni District Municipality. From 1st July 2003, municipalities became the Water Service Authority with a regulatory responsibility for domestic water supply and sanitation services [Brown, 2006].

Farmers

The water management of the irrigation farmers is organised on different levels; irrigation management committees and dam committees. Irrigation management committees: two committees are present in the catchment: Dingleydale Irrigation Scheme Water User Association (DISWUA) and the New Forest Management Committee. The management committees are elected by the farmers for a period of five years. The management committees of Dingleydale and New Forest were established in 2005 and 2000 respectively. Both committees were assisted by consultants who assisted them to write the constitution. Reporting to the New Forest management committee are four ward committees, Edinburgh, New Forest A, New Forest B, and Orinoco C. The ward committees

[24] Personal communication ICMA official, 15 May 2009.

are responsible for the distribution of water and the maintenance of a section of the irrigation scheme. Both committees also have a technical committee, a human resources committee, and a natural resources committee[25]. Reporting to both management committees are the dam committees. Dam committees: farmers using the same storage reservoir are organised in dam committees. A committee consist of seven members and is headed by a chairman. The committee is elected by the farmers in its command area for a period of five years. During irrigation, dam committee members are in the field to inspect water use, and to make sure that the farmers irrigate at the agreed time and period.

Community members

Community members are a much broader group than irrigation farmers only. As described elsewhere in the report, access to sufficient clean domestic water is limited to a large part of the community. The main sources of income of the community are pensions and migratory labour. During apartheid the farmers in the homelands were confined to restricted areas that were usually far from markets. As a result migrant labour became the central economic activity in these areas, and agriculture merely served to supplement the incomes earned on the mines and from domestic work [Schirmer, 2007].

Bushbuckridge Water

The Bushbuckridge Water Board has been established in 1997. Board members were appointed about 14 days before the signing of the Water Service Bill into the WSA. Bushbuckridge Water Board is the bulk water supplier for Ehlanzeni District and Mbombela Local Municipalities. These municipalities supply retail water to the end users. The main customer of the Water board is Bushbuckridge Local Municipality. The financial viability is, therefore, dependent on these municipalities paying for the water provided by the Water Board. However, the municipalities are dependent on their ability to recover the costs from the end consumers and cost recovery in these areas is very low[26]. This might be the reason why Bushbuckridge Local Municipality is hardly paying for its water, which in turn makes the Water Board totally dependent on financial subsidies from DWAF[27]. Since the focus of this report is on water management, the economical viability of the stakeholders is outside the scope of this research. Several water treatment operators mentioned their difficulties in operating their treatment plants. Due to the lack of finances there was not always enough money to buy chemicals to purify the raw water. Since treatment plants cannot function without chemicals they were forced to temporarily close their plant. In the last April 2009 this happened at the treatment plant in Thulamahashe and even at the large Inyaka Regional Water Works[28]. It should be noted that Bushbuckridge Water does not know how many people they serve [Pollard *et al.*, 2009a].

Environmental sector

The environmental sector in the catchment is represented by the downstream Kruger National Park, the Sabie Sand Wildtuin and several environmental NGOs. Since the Sabie Sand Wildtuin is almost entirely located in the Sand catchment, this stakeholder will be described in more detail.
- Sabie Sand Wildtuin: The Sabie Sand Wildtuin is a private game reserve adjacent to Kruger National Park. The fences between the game reserve and Kruger were removed in 1993. The game reserve is an association of about 150 private land owners who collectively manage the Wildtuin[29].

[25] From interview irrigation management committees, 9, 11 March 2009, Dingleydale and New Forest.
[26] National Assembly, internal question paper 31 March 2006, question to the Minister of Water Affairs and Forestry.
[27] Report of the Portfolio Committee on Water Affairs and Forestry on oversight of 2004/2005 Annual Reports and oral presentations of Water Boards, dated 17 May 2006.
[28] From interviews with several Water Treatment Works operators, 29 April, 12, 13, 21 May 2009, Sand catchment.
[29] From interview Sabie Sand Wildtuin Ecologist, 9 April 2009, Kasteel.

The Sabie Sand Wildtuin handles bookings and manages a common environmental management programme [Carruthers, 2007]. There are about 20 commercial lodges in the park. More than 1500 families are supported by job opportunities provided by the tourist industry within the game reserve. In comparison, Dingleydale and New Forest irrigation scheme together provide employment to over 300 full time farmers and between 1000 and 1500 seasonal labourers [DWAF, 2007b]. The perennial nature of the Sand River attracts a wide variety of large mammals to the river system and tourists from all over the world come to enjoy the wildlife in the game reserve. Hence, the Sand River is the lifeblood of the Sabi Sand Wildtuin and a lack of flow could seriously impair on the diversity that the river system can support. The game reserve is disappointed in the lack of commitment by the government to solve the water deficit. Because of this the Sabi Sand Wildtuin is preparing a court case to take legal action against DWAF and DoA (see section 8.3).
- Kruger National Park: Only a very small portion of Kruger National Park is part of the Sand catchment. The park was established in 1926 and is part of the recently proclaimed Greater Limpopo Transfrontier Park. The new established conservation area covers 36,000 km2 in three countries; South Africa, Mozambique and Zimbabwe.

Non Governmental Organisations

Several NGO's are active in the different fields in the Sand catchment, from health or water to environmental NGO's. This report only describes the two relevant NGO's for this research; AWARD and the MABEDI project ran by several NGO's.
- The Association for Water And Rural Development works on water supply in the broader context of managing water resources and their wise use, with a focus on learning about water security issues in the Sand catchment[30]. Award has emerged from Johannesburg's Witwatersrand University.
- The Maruleng and Bushbuckridge Economic Development Initiative (MABEDI) is a four year project. The project is funded by the Business Trust of South Africa and the Department of Local Government, and commenced in 2006. The aim of the project is to work with resource poor farmers and to uplift these small scale farmers through various linkage components including; infrastructure, input linkages and market linkages[31]. The project works in two municipalities Maruleng (Sabie catchment) and Bushbuckridge (Sand catchment). The agricultural part of the project is coordinated by two NGO's, namely Teba development and Lima. In cooperation with the irrigation management committees Teba development wrote a proposal to rehabilitate the irrigation infrastructure.

Consultants

Numerous consultants are involved in the water sector in the Sand catchment. This report only describes a few consultants relevant for this research;
- EVN Consultancy designed the irrigation infrastructure in 1959. For Limpopo Province they did a mapping and degradation study of the irrigation infrastructure[32]. EVN designed the Bosbokrand Transfer Pipeline and the accompanying bulk supply schemes (see Picture 3.3).
- Charles Sellick & Associates drafted the Operating Rules and decision support models for management of surface water resources in the Sabie Sand catchment.

Picture 3.3: Construction signboard
Source: author, 2009

[30] For more information on AWARD see www.award.org.za
[31] From interview Managing director Lima development, 26 March 2009, Bushbuckridge.
[32] The engineer responsible for this project left EVN in 2007, EVN was not able to find this report.

4 Water control and the Reserve – desired situation

4.1 Introduction

As briefly described in chapter 1 the South African water legislation changed drastically after the first democratic election in 1994. This chapter analyses how the previous water legislation (upto and including the apartheid era) secured, or did not secure, the water needs of the black smallholders and the environment (section 4.2). Under the new water legislation a new water user is recognized; the environment. The focus of my thesis is about securing the environmental water requirement. The chapter analysis how and why the new water legislation (post apartheid) changed the focus to HDIs and the environment (section 4.3). This section describes the legal stipulation, the institutional setting and the obstacles for implementing the new water legislation. A more detailed description of the obstacles for implementation will be given in the following chapters. In this chapter I will also address how the new policy framework envisages the allocation of water for the environment. In addition, this chapter provides a broad description of the Reserve. For a more detailed description of the environment as a water user in the Sand catchment see chapter 5. It should be noted that all water reforms in South Africa occurred during or immediately after an extended drought period. Political changes also influenced the new water legislation: unification in 1910 led to the 1912 Water Act, the election of the National Party in 1948 led to the 1956 Water Act and the election of the African National Congress in 1994 led to the National Water Act in 1998 [Backeberg, 2005].

4.2 Previous water legislation: water for a few

In 1910 the Union of South Africa was established. Two years later, in 1912 the first Water Act was proclaimed; the Irrigation and Conservation of Waters Act. The focus of this act was on irrigation [Perret, 2002b: Turton *et al.*, 2004]. Because of the rapid urbanisation and industrial development a new Water Act was established in 1956. The Water Act of 1956 divided water resources into three different categories: river, ground and dam. Water regulation was different for the different water resources [Tvedt *et al.*, 2006]. The focus of the 1956 Water Act was also on irrigation, although other water uses, such as domestic, urban and industrial, also received recognition[33]. The 1956 Water Act focussed on the economic heavyweights in the country; agriculture, mining and industry. The important role of agriculture in the 1956 Water Act was related to the historical political power base of the National party [Reed & de Wit, 2003].

Both Water Acts were based on the Roman-Dutch and English riparian rights principles; the owners of property adjoining a river (riparian land) have the exclusive right to use the water of that river [Woodhouse, 1997]. The water rights were valid in perpetuity [de Lange, 2004]. Despite certain legal restrictions the riparian owner could in effect do and take as much as he/she needed [Perret, 2002b]. According to the 1956 Water Act access to the water resources was limited to those who owned land: "*the sole and exclusive use and enjoyment of private water belongs to the owner of the land on which such water is found*" [RSA, 1956]. But the apartheid policy excluded black people from owning or renting land outside the reserves [Perret, 2002b]. The combination of the racially based Land Measures Act and the Water Act of 1912 and 1956 dispossessed Africans from their water sources. Black farmers could also not become a member of an Irrigation Boards because the 1956 Water Act limited membership of Irrigation Boards to those with title deed to the land [de Lange, 2004]. Hence, the 1956 Water Act, along with a number of other pieces of water-related legislation had appropriated almost all of the readily available water and allocated it to the so called first- world component of the country [Turton & Quinn, 2000]. This is confirmed in the White Paper on National Water Policy: *until 1994 the considerable technical expertise of DWAF, was directed towards servicing the water needs of the apartheid state, resulting in an inaccessible centralised bureaucracy in which the needs of the people*

[33] National Water Act Amendment Bill: discussion & voting, Water Affairs And Forestry Portfolio Committee, October 26 1999. Source: www.pmg.org.za

on the ground, particularly the black majority, were not taken into account [DWAF, 1997b]. The State was mainly interested in the development of the white minority. From 1917 till 1994, the government provided technical support and very soft loans or grants to newly created Irrigation Boards. In many cases this support included dam construction. After 1946, private farmers could also obtain subsidies [van Koppen, 2008]. The water resource approach of the government was supply driven large dams and bulk infrastructure was build. Increasingly complex inter-basin networks of pumping stations, reservoirs, canals, pipes and tunnels were being build to linked several catchment.

In the 1970s the industrial sector developed significantly, this resulted in a change of the water philosophy: water was more and more seen as an economic good, about the same time state funding was reduced and agriculture slowly lost its favoured position [van Koppen, 2008].

As mentioned above the 1956 Water Act was founded on the riparian principle combined with the principle of private use and ownership. Since the homeland areas were considered to be 'communally' owned and controlled by tribal authorities the Water Act did not apply to these areas. This is confirmed by Woodhouse [1997] who states that it is reasonably certain that the 1956 Water Act was not concerned with water rights in bantustan areas. In practice water resource allocation within homeland areas was delegated by DWAF to the homeland administrations' departments of agriculture through a block allocation by DWAF [Woodhouse & Hassan, 1999: 26]. The homeland governments were responsible for water resources in the Sand catchment. The former Gazankulu homeland managed water within the Department of Public Works in Thulamahashe. The former Lebowa homeland managed water within the Department of Agriculture in Bushbuckridge [Pollard *et al.*, 1998].

Outside the homelands water was managed through a combination of Government Water Control Areas (GWCA), irrigation districts and a few other organisations. DWAF was the responsible authority. In practice, water resource management in each catchment became dominated by a small number of forestry or irrigation interests [Woodhouse & Hassan, 1999].

In the last decades of the apartheid government it became more and more clear that South Africa was in water deficit. During 1970 it was predicted that the country's water requirements would exceed the maximum yield potential by 2000 [Commissioner of Inquiry into Water Affairs, 1970]. The previous government dealt with this by water resource development and building of large dams, catalyzed by DWAF's supply driven approach to water resource management. Almost all the readily available water was appropriated and all that was left was the water that was difficult to mobilize. The majority of the country's inhabitants did not have undisturbed and equal access to clean water. The situation for the Historically Disadvantaged Individuals (HDI) became even more worse in the 1970s. Due to the increased industrialisation water was regarded as an "economic good". Subsequently HDIs requests for financial supports were rejected by the new criteria of "lack of economic viability'. Additional to this the environment became recognized as a new water user in the 1970s. New water claims by HDIs had now to face a new user with stronger rights, the environment [DWA, 1986]. Pienaar and van der Schyff [2007] estimated that in 1996 approximately 16 million people did not have access to clean water for domestic use and 21 million people did not have sufficient water for sanitation. In the Inkomati Catchment more than 50% of the population has poor access to drinking water and sanitation facilities [DWAF, 2000a].

Both water Acts did not seriously deal with environmental issues, equity issues and downstream requirements[34]. This meant that the flow in every tributary could be fully utilised, leaving nothing for downstream users and all surplus water could be dammed, provided it was used beneficially by the user. Besides the water acts other laws negatively influenced the sustainability of the water resources

[34] Partitioning Water Use in South Africa, Academy Symposium 2003, Australian Academy of Technological Sciences and Engineering. http://www.atse.org.au/index.php?sectionid=634

in the catchment as well. For example, the Forestry Act allowed the planting of commercial forests in sensitive runoff areas, under a permit system with virtually no cognisance of ecological and environmental issues. In the several acts no attention was given to sustainable management of the environment and both water acts did not recognize the role of the environment as a water user. This situation lasted until 1970 when the environment became recognized as a water user in its own right [van Koppen, 2008]. But it still took until the late 1980s when government policy shifted from not recognising aquatic ecosystems at all, and considering every drop of water that reached the sea to be wasted, to the view that aquatic ecosystems had legitimate water requirements. However, by then the environment was regarded as a competing water user. Environmental water could only be allocated provided that this did not compromise other water users to any great degree and did not constrain economic development [Reed & de Wit, 2003]. The environmental water needs were estimated to require 13% of the nation's water demand [DWA, 1986]. It still took a couple of years before the role of the environment was officially recognized. The first recognition of the link between protection of the aquatic environment and sustainability of water resources was made in the early 1990's in the South African Water Quality Guidelines (DWAF 1996).

The water policy until 1997 can be summarised by a statement from Armitage and Nieuwoudt [1999: 52] according to who *"The water policy until 1997 was based largely on (a) supply augmentation to arising water scarcity problems, (b) water allocation as a strictly government function; and (c) water resources management through the centrally controlled bureaucratic function by the Minister of the DWAF"*.

4.3 New policy framework: Some, for all, for ever

After abolishing apartheid in 1994 the mission of the State changed radically from serving mainly the well-organised white minority, to serving an entire nation of over 40 million citizens [van Koppen, 2008]. As a result poverty alleviation and redressing the past inequities were the main priorities of the South African government under the ruling ANC party. One of the first actions of the new government was the abolishment of the racially based Land Measures Act. The Land Measures Act restricted black persons from owning or occupying land. Through this acts black persons were prevented from having any water rights [DWAF, 2003b].

At the start of the new democracy in South Africa, the homeland administrations were dismantled and integrated in the rest of the country. The new government inherited the block allocation of water from the homeland governments. DoA became responsible for water allocation to prospective black irrigators, although DWAF became responsible for issuing permits for water abstraction [Woodhouse & Hassan, 1999].

To address the past inequities and apartheids influence on water management a water law review was required. The reformation of South African water law was also needed because of the rapid urbanisation and industrialisation combined with the arid climate. The existing water legislation did not provide the necessary tool to address the water scarcity adequately [de Lange, 2004]. The droughts of the 1990s raised public awareness of the increasing scarcity of the water resource[de Lange, 2004]. It became clear that the country's economy is dependent on its valuable water sources and that it is increasingly expensive to build more dams to store water [WorldBank, 2009].

Water Law Review

A national Water Law Review process was initiated to look at the existing law and how to change the law for a new democratic South Africa with equal access to water for all. It is outside the scope of this research to describe the water law review in detail, but some relevant issues will be mentioned below.

The first step of the process was the publication of a document called "You and Your Water Rights" it was widely distributed in 1995. This booklet set out some of the problems with the existing law and called for public comment and submission what a new water law should include.

The following step was the establishment of a panel to draft a set of Water Law Principle on which new water law could be based. The panel met at the Water Law Review Conference were the water law principles were defined. These principles form the basis of the new water laws [DWAF, 2005a]. During heated debates at the Water Law Review Conference the environment finally became a recognized water user and found its way into the Water Law Principles. The key principles defined the water resource as an indivisible national asset that included the entire hydrological cycle [de Lange, 2004]. In the years following this conference wide-ranging consultation took place with stakeholders, through provincial and national workshops, symposia and public hearings [Backeberg, 2005: Hamann & O'Riordan, 2000]. These workshops helped to create awareness and understanding of the new water policy and its implications for the water sector[de Lange, 2004]. At these different meetings the different stakeholders could comment and discuss the new water principles. During several debates stakeholders presented proposals for more acceptable alternatives. To involve the historical disadvantaged sectors in the workshops each of the provincial workshops was preceded by a preparatory workshop were the principles were explained more in detail [de Lange, 2004].

The stakes were especially high for the commercial irrigation sector that believed they stood to lose their livelihoods, and for the communities without proper access to domestic water [de Lange, 2004: 19]. Those (white commercial farmers) who traditionally had access to power founded their lobbying power almost completely eroded by the political transition. In a water scarce country like South Africa, the value of a farm is closely related to its secure and legal access to water [de Lange, 2004]. Losing its water right will be a losing its economical value, this will make it difficult for farmers to, for example, negotiate production loans for banks. The commercial farmers had little reason to believe that the new regime would be sympathetic to their case [de Lange, 2004]. The Minister of DWAF organised several meetings with the farmers, and other stakeholders as well, to discuss the new policy with them. The Minister tried to convince the commercial farmers that the proposed change is not intended to penalise farmers, but rather to set up a legal framework for the management of water which is fair to all, and which will facilitate the sustainable management of an extremely rare and precious resource[35].

An important aspect of the new approach to water management is the participation of all the stakeholders, especially the historically disadvantaged groups [Pollard & du Toit, 2005]. However, the population of the former homelands is not well organized to participate effectively in a consultation process on water [Waalewijn *et al.*, 2005]. DWAF should support capacity building initiatives for the historically disadvantaged individuals to involve them in a meaningful participatory decision making process of water reform and water allocation [DWAF, 2005b].

One of the main changes to the old water legislation is the transition from a private use rights allocation system to a public rights system [Pollard *et al.*, 1998]. The new water legislation grants rights to use water in terms of an administrative system; water licensing. According to the NWA [1998] all water use should be registered and licensed, except Schedule 1 use (see section 8.4). Under the new act only WUAs may apply for a license to use irrigation water. Once water use is registered or licensed water use charges must be paid as prescribed in the NWA.

During the Water Law Review period South Africa recognized the role of the environment in ensuring sustainability in water resource use, and in socio-economic development. Researchers showed that if one can take care of the environment by allocating good quality water to the environment the (socio-

[35] Speech by Prof K Asmal, Minister of Water Affairs and Forestry, at the Paarl farmers' association on the water law review, Simonsvlei winery, 16 April 1996.

economic) needs of the country and its inhabitants can be easily supplied or ensured by the environment[36]. It was acknowledged that healthy environment supplies essential goods and services that sustain healthy people's lives. Several environmentalist groups had influence in recognition of the environment as a water user [Pienaar & van der Schyff, 2007]. DWAF recognized the environment as a resource provider and stipulated that the water needs of the resource should be met first [DWAF, 2002a]. As a result the focus of water planning and management had to shift from development of the water resource to improving water use efficiency, including conservation and reuse, protection of water sources, and maintenance of aquatic environments [WorldBank, 2009: 35].

The new government changed the emphasis of the water policy form a supply driven approach to a sustainable approach. This is made clear by the first DWAF minister in the new government, Kader Asmal, who commented that, "*... we could not simply continue to build even more expensive infrastructure (dams and pipelines) with ever diminishing returns. We will have to find other ways of maximising our water supply"* [Buch & Dixon, 2008]. In response a new water legislation was written. This required a transformation of DWAFs approach to water resource management from supply driven a more holistic approach to water resource management[37]. The shift in functions of DWAF away from an engineering and operational focus towards more multi-disciplinary regulatory functions was already proposed by the White Paper on National Water Policy [DWAF, 1997b]. Several reasons for the shift in emphasis away from development of new water resources, towards management of existing water resources can be mentioned; 1) many of the prime dam sites in the country have already been developed, 2) increasing inability of the state to continue funding the high capital costs of new water infrastructure and water resources developments for government water schemes, as well as their ongoing operation and maintenance costs [DWAF, 2005b].

All together more than 1500 comments, amendments and suggestions were received during the law review period [Gleick, 1997]. Most stakeholders supported the idea to manage water in an integrated way, to recognize the economic value of water, and for protecting the fundamental resource base [Gleick, 1997]. There was almost unanimous support by all sectors for the concept of catchment management [de Lange, 2004]. The water law review and the writing process of the new water legislation profited from the visionary leadership of Minister Kader Asmal and Director General Mike Muller [de Lange, 2004].

Some of the provisions and conditions in the early drafts of the Bill were totally unacceptable by different stakeholder and were removed or adjusted as a result of the consultation process. For example: in the Draft Bill water allocations would be issued to the landowner. But this would create difficulties by woman in tribal areas where land allocations were mainly issued to men, although the woman are in fact the farmers. The final NWA provides that water is allocated to the water user, not to the land owner [de Lange, 2004].

By the end of the drafting process the Director General initiated implementation task teams to critically asses the implementability of the provisions of the National Water Bill [de Lange, 2004]. The Director General wanted to signal that he was serious about the implementation of the Bill and he wanted to ensure that the new water Bill would be practical to implement. This was the beginning of a process to restructure DWAF according to the implementation requirements of the NWA.

After three years of consultation and debate the National Water Bill was presented in Parliament. In his speech to present the National Water Bill the minister emphasized the need for equity and that the bill

[36] Personal communication senior WRC researcher.

[37] It should be noted, however, that the new government intends to spend approximately R 30 billion on the continuing construction and establishment of fifteen water resources infrastructure projects. From: speech by Ms. B. Sonjica, Minister of Water and Environmental Affairs. Budget Vote of 2009/10, 24 June 2009. Source: www.dwaf.gov.za

concerns everybody: *"Whether you are black or white, or whether you are rich or poor, our destinies are intertwined. We all face a water emergency by 2020 unless we act in concert, and now"*[38].After the presentation in the Parliament there was a last round of consultation and public submissions in the National Assembly and the National Council of Provinces of Parliament [de Lange, 2004]. It should be noted that the less organised small scale irrigation sector made no submission on the Draft Bill during the public hearings in the Parliament [de Lange, 2004]. The ANC had a majority in the Parliament and therefore in the committees of Parliament as well. So despite the extensive stakeholder participation process the vote on amendments of the Draft Bill in the Agriculture, Water Affairs and Forestry Portfolio Committee was carried by the ANC. Therefore, the final issues that could not be resolved through 3,5 years of consensus-seeking were decided politically [de Lange, 2004: 50].

The Minister signed the National Water Bill into law on 26 august 1998 and the Bill became an act: the National Water Act. By that time most sectors expressed support for the broad framework and several aspects of the bill [de Lange, 2004]. But the real test is when actual (compulsory) licensing occurs.

Legal stipulations

According to Schreiner *et al* [2002] the three main aims of South Africa's approach, introduced under the National Water Act and Water Services Act are to address the inequalities of racial and gender discrimination, link water management to economic development and poverty eradication, and ensure the ecological integrity of the resource. This matches with the keywords of these new laws: equity, efficiency, and sustainability. This approach is summarized in the slogan of the Ministry of Water Affairs and Forestry: "*some, for all, for ever*". This slogan is expressed in the before mentioned laws and has been translated into implementation plans and strategies at national, provincial and local level [Pollard & du Toit, 2005].

South Africa has defined the right to water as a Constitutional Right. Section 24 of the Bill of Rights in the constitution [RSA, 1996: 7] states that "*Everyone has the right-*

(a) to an environment that is not harmful to their health or well-being; and

(b) to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that-

(i) prevent pollution and ecological degradation;

(ii) promote conservation; and

(iii) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development."

Therefore, the constitution places a legal obligation on the government to realise the right to "sufficient water" [du Toit *et al.*, 2009b: 1]. This right is reflected in the NWA. The NWA [1998] defines this right as the Reserve. The Reserve is the only right to water and cannot be compromised. This is described in Principle 3 of the National Water Resource Strategy [2004b: A1], which states that, *"(t)here shall be no ownership of water but only a right (for environmental and basic human needs) or an authorisation for its use."*

The first chapter of the NWA [1998: 16] defines the Reserve as:

"The quantity and quality of water required

a) to satisfy basic human needs by securing basic water supply, as prescribed under the Water Services Act 1997 for people who are now or who will in the reasonable future

(i) be relying upon;

(ii) taking water from:

[38] Speech by Prof K Asmal, Minister of Water Affairs and Forestry, at the Parliament when he presented the National Water Bill, 9 February 1998.

(iii) being supplied from, the relevant water resource: and
b) to protect aquatic ecosystems in order to secure ecologically sustainable development and use of the relevant water resource."

This definition can be summarised as follows: the Reserve is identified as the specific water quantity and quality necessary to satisfy basic human needs and safeguard aquatic ecosystems [MacKay, 2000]. Hence, the Reserve is the reserved water for the environment and basic human needs. Through the Reserve, water for basic human needs and for the maintenance of aquatic ecosystems is effectively removed from the total body of water available for allocation to other uses [Pollard *et al.*, 2002]. In other words, the conditions of the Reserve must be met before any other authorisation to water use can be made [du Toit *et al.*, 2009a]. But it should be noted that the Reserve is not intended to protect the environment at the expense of all development. The water resource development goals in the NWA give a balanced approach to ensure that there is development and use of water resources, but at levels that are sustainable in the long term [DWAF, 2002a].

The Reserve consists of two elements: the Ecological Reserve (ER) and the Basic Human Need Reserve (BHNR). The CMA is responsible for securing the ER, the local government is responsible for the BHNR. The Minister of Water Affairs and Forestry, through the Directorate General, is required to determine the quantity and quality of the water necessary to meet both aspects of the Reserve for all, or part of any, significant water resources [NWA, 1998]. The Regional DWAF office is envisaged to be the regulator for the Reserve. They will review the monitoring undertaken by the CMA[39]. This reflects the shift of the function of DWAF, away from an engineering and operational focus towards more multi-disciplinary regulatory functions as proposed in the National Water Policy [DWAF, 1997b].

Ecological Reserve

The Ecological Reserve is the South African version of the well-known international water term Environmental Water Requirements. The Ecological Reserve (ER) relates to the water required to protect the aquatic ecosystems of the water resource, keeping it healthy and functioning. The White Paper on Water Policy describes the fundamental principles and objectives for the new water law. Principle 9 of the White Paper defines the ER: *"The quantity, quality and reliability of water required to maintain the ecological functions on which humans depend shall be reserved so that the human use of water does not individually or cumulatively compromise the long term sustainability of aquatic and associated ecosystems"* [DWAF, 1997b]. The ER is essential for the sustainability of the hydrological cycle. The ER is important for the downstream areas, which depend on the water that is still available in the river.

Environmental water allocation is often regarded as water to keep the river alive. But environmental flows are not only intended to maintain biodiversity and aquatic ecology. The Reserve contributes to human water needs by sustaining the ecosystem function that support human uses. Environmental flows are recognized as vital in ensuring the continuing provision of environmental goods and services upon which peoples' lives and livelihoods depend [Le Quesne *et al.*, 2007]. Environmental goods and services are an integral element of the Reserve determination. However defining an environmental good or service is a complex problem[40]. A lot of different definitions are used to define environmental goods and services. This thesis adopts the definition of FAO: "*Environmental goods and services refers to actions and products derived from human activity rather than benefits obtained directly from the natural environment. By a narrow, "end use" definition, includes pollution-reducing equipment and waste management; a wider, "production-oriented " definition includes environmentally-friendly*

[39] From interview senior DWAF official, 15 May 2009, Nelspruit.
[40] 5th WTO Ministerial Conference, Cancún. WWF Briefing Series www.wto.org

goods, such as organic produce or eco-certified wood, and services such as eco-tourism" [FAO, 2005].

It should be noted that the provision of environmental water allocations is not intended to mimic a pristine river. A regulated river system, by definition, cannot reproduce all aspects of natural flow while also providing for competing uses [Dyson, 2008].

The determination of the ER (water quantity and water quality) is a complex process. South Africa has been a leader in developing environmental flow techniques for determining the quantity and quality of water needed to provide a given level of habitat protection [WorldBank, 2009: 33]. For a description of this process see chapter 5. The ER is currently defined by DWAF as a series of flow duration curves[41], one for each month of the year [Mallory *et al.*, 2009].

The final figure of the ER can only be set after classification of the water sources. In order to define the Ecological Reserve DWAF drafted a National Water Resource Classification System. The national classification system is a set of guidelines and procedures for determining the desired characteristics of each significant water resource. By use of this classification system DWAF tries to harmonise the ecological sustainability of water resources with social and economic needs [WaterWheel, 2008]. DWAF currently has defined 3 classes for river health, from natural to heavily used/impacted. The classification of the desirable state depends on the trade off between the desirable state of the eco system and the economical benefit of the river. One of the last steps in the classification process is consultation with stakeholders. The people living in the catchment have to select the class; hence it is a political decision.

Once a management class has been selected by stakeholders it will be gazetted by the Minister and it will form the basis of the management plans. The management plan describes the proposed measures to reach the desired state of the water resources. Part of the management plans are the resource quality objectives, this establishes goals for resource protection.

The method used by DWAF to determine the Reserve has curtailment built into it[42]. The assurance of supply and level of curtailment is built into the definition of the requirement and determination process of the Reserve [DWAF, 2008b]. According to DWAFs forthcoming Water Classification System the Ecological Reserve requirement should reflect natural hydrological variation such that 'higher' flow curves are required during wet periods, while 'lower' flow curves are required during the dry season and drought periods. The method is based on exceedance curves, these curves are based on what percentage of time in the historical data has a certain flow rate been exceeded. This results in different Reserve requirements, with built in curtailments or assurance, for every month. Thus the Reserve determination results in a set of assurance rules that specify flow requirements at various frequencies of exceedance [Classification system in DWAF, 2008b].

<u>Basic Human Need Reserve</u>
Principle 8 of the White Paper on Water Policy defines the Basic Human Need Reserve (BHNR) as *"The water required to ensure that all people have access to sufficient water shall be reserved"* [DWAF, 1997b]. The BHNR is the catchment amount of water necessary to meet the entitlements to the basic needs of inhabitants of the catchment [Schoch, 2007]. The WSA recognizes the right of everyone to basic water supply and basic sanitation. The WSA does not, however, define what this

[41] A flow duration curve is a cumulative probability distribution of flows recorded or simulated at a site in a river basin over a long period. The flow duration curve shows the cumulative probability of a given flow quantity being met or exceeded. The area under the curve represents the MAR. The area under the threshold of the median flow may approximate the total annual baseflow, which occurs in natural conditions.
[42] From personal communication with senior ICMA official, 16 June 2009.

means, the quantity of water needed for BHNR is not specified. When the ANC came to power its basic policy platform was the Reconstruction and Development Programme. In this program the ANC stated its short term aim to provide all households with a clean safe water supply of 20-30 l/p/day within 200 metres distance from the residence [ANC, 1994]. Later on the government defined the BHNR as the minimum quantity of potable water of 25 litres per person per day or 6000 litres per household a month within 200 meters from the household, with 98% reliability and a 10 l/min flow rate to satisfy peak demands of a communal tap system [DWAF, 2000b]. The amount of 25 litres per day was strictly meant to be used for domestic purposes only. In order to meet the entitlements to basic needs of inhabitants in the catchment it is necessary to reserve not only the amount of water (BHNR) but also provide the means to deliver it to the people (infrastructure and institutions) [Schoch, 2007]. If there is insufficient infrastructure, the BHNR cannot be delivered to the people for whom it has been set aside. Meeting the BHNR is a challenge for the water managers of South Africa. Due to apartheid regime policies the majority of the country's inhabitants do not have undisturbed and equal access to clean water. Pienaar and van der Schyff [2007] estimated that in 1996 approximately 16 million people did not have access to clean water for domestic use and 21 million people did not have sufficient water for sanitation.

Other obligations

According to the NWA the Reserve receives priority allocation and therefore determines the amount of water available for other uses (Box 4.1). The NWA is not limited to water use for the Reserve only, the Act also describes other obligations like international agreements, the next highest priority of water use after the Reserve, and water use for strategic purposes (e.g. water for power generation). An example of an international agreement is the Tripartite Technical Committee which ensures cooperation between South Africa, Swaziland and Mozambique on the Incomati River. According to this agreement South Africa is obliged to deliver at least 2m^3/s (averaged over a three day period) at the border between South Africa and Mozambique[43]. The more recent Interim Inco Maputo Water Use Agreement, states that a minimum flow of 2.6 m^3/s is required at the border for environmental purposes [DWAF, 2009a]. South Africa is occasionally not meeting its international water obligations [DWAF, 2009a: ICMA, 2008].

Box 4.1 : Priorities for water use

The National Water Resource Strategy gives a general guide on priorities for water use;

- The Reserve (BHNR and ER)
- International agreements and obligations
- Water for social needs (poverty eradication e.g. primary domestic needs)
- Strategic uses (e.g. power generation)
- General economic use (e.g. irrigation and forestry)
- Water use not measurable in economic terms (e.g. recreation)

[DWAF, 2004b]

Institutional setting

An important step of the participatory approach is the progressive delegation and decentralisation of water resource management functions from DWAF to newly established institutions like the Catchment Management Agency (CMA) and the Catchment Management Forum (CMF) at catchment level. The extent of responsibilities will thus change over time as functions are delegated or assigned [DWAF, 2007a]. In order to ensure stakeholder participation the CMA is to be supported through the Catchment Management Forums [Pollard *et al.*, 2009a]. The CMA will have to perform many functions that are vital to the implementation of the National Water Act (NWA). Therefore the implementation of the NWA depends to a large extent on the creation and success of the CMA [Hamann & O'Riordan, 2000: 25]. The Catchment Management Forum is a voluntary organisation which will inform and support the CMA for a water region.

[43] South African Multi-stakeholder Initiative on the World Commission on Dams. The World Commission on Dams and South Africa. Substantive Report, Final, 26th November 2004.

The NWA requires that, as soon as reasonably practicable, a National Water Resources Strategy (NWRS) be established [Backeberg, 2005]. The NWRS prescribes that management of water resources in the catchment must be defined by a Catchment Management Strategy (CMS) (see Figure 4.1). The CMS is required to 'set out in the policies, strategies, objectives, plans, guidelines and procedures of the CMA for the protection, use, development, conservation, management and control of the water resources within its water management area' [Pollard *et al.*, 1998: 132]. The CMS must be in line with the National Water Resource Strategy and will be subject to review every five years[DWAF, 2003a]. The CMA may delegate the local implementation of the CMS through institutions such as WUAs. According to the CMS guidelines a catchment management strategy is a set of medium- to long-term action programmes to support the achievement of sustainability, equity and efficiency through integrated water resource management [DWAF, 2007a]. The CMS is guided by a catchment vision. The strategy must be written by the CMA in close cooperation with DWAF and the local stakeholders. Once a vision has been set for the water management area, two strategic documents should be written to achieve the vision: Resource Directed Measures and Source Directed Controls [DWAF, 2004b]. The Resource Directed Measures describe how to manage the water resource, Source Directed Measures describe how to access the water [Pollard *et al.*, 1998]. Both strategies contain measures to ensure the protection of the water resources by setting objectives for the desired condition of resources, as well as putting measures in place to control water use to limit impacts to acceptable levels [DWAF, 2007a: 69].

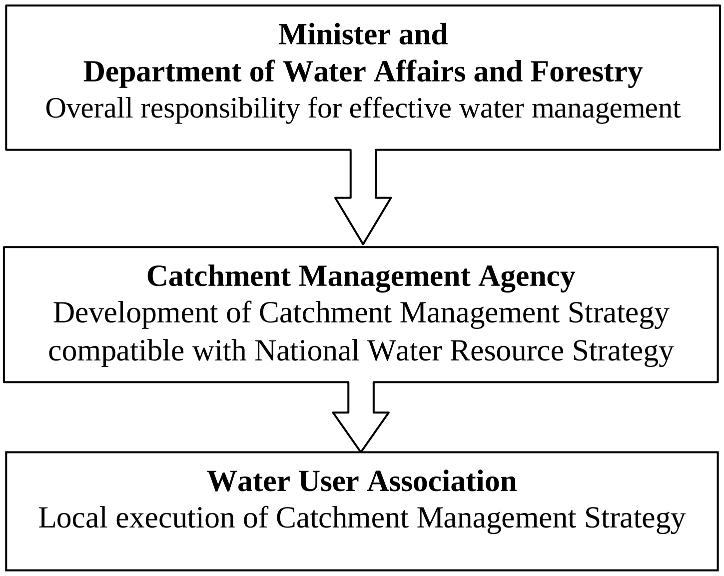


Figure 4.1: CMAs and WUAs in the national context of water resource management
Source: DWAF [2003a]

The NWA promotes the creation of WUAs. According to the Act a WUA "*operate at a restricted localised level, and are in effect co-operative associations of individual water users who wish to undertake water related activities for their mutual benefit*" [NWA, 1998: 100]. The WUAs will take over most irrigation management functions, for example: water allocation and distribution and financial management [Perret, 2002a]. The primary purpose of a WUA is to serve as an institutional mechanism for combining resources of interested parties rather than to effect water management [James A, 2003]. WUA's are intended to ensure the representation of major water users, thus extending beyond the agricultural sector [Pollard *et al.*, 2008c: 8].

After the introduction of the policy framework the situation slowly improved but the rights of the poor are still neglected. Poor people tend to lose when they have to compete with large-scale water users. The past inequity is still present in the area of water management: by 2000, 20 million human beings still lacked adequate sanitation services [Turton & Meissner, 2000]. And a considerable part of the population in the former homelands still does not have sufficient access to drinking water. By adopting the NWA the South African government will use the law as a tool in the transformation of society towards social and environmental justice [Schreiner *et al.*, 2002: 127]. By creating effective service delivery structures the government tries to bring this into practise. It is the government's priority to bring, for free, 25 l/cap/d within 200 m from the house to all citizens (higher consumption needs to be paid for).

Obstacles

The determination of the ER (water quantity, quality, timing, and duration) is a complex process. The ER depends on a large number of natural components and a wide range of hydrological conditions from zero flow to extreme floods [Asmal, 2004]. The Joint Incomati Basin Study (JIBS) in 2001 provided a first estimate of how much water should remain in the river. It observed that the amounts required are fairly high, and will constrain other water uses. The JIBS recommended further detailed studies to ascertain these values [Vaz & van der Zaag, 2003]. According to the proposal for the Inkomati CMA [DWAF, 2001], the ecological water requirement for the Sabie River through the Kruger National Park has been determined as 204,5 million m^3/year on average, this amount is almost the same as the annual runoff at the border with Mozambique. The ER is not a fixed number but will be expressed as a range of values. The ER depends on the class of the resource, a large number of natural components, and a wide range of hydrological conditions from zero flow to extreme floods. According to a World Wildlife Fund publication about environmental flows, defining acceptable environmental flow is not solely a question of specifying a minimum flow below which water levels should not be allowed to fall. It is also necessary to account for important flow variations within the system [Le Quesne *et al.*, 2007: 14]. Flow variations can be vital for among others supporting wetlands or flows for migrating fish species. Because of the complex determination of the ER several scientific methodologies have been developed and redefined over the past 15 years.

Because of the inter linked nature of groundwater and surface water resources, groundwater needs to be included in the Reserve determination process. Groundwater can contribute to the surface water flow, therefore the volume of groundwater that can be abstracted without impacting the ability of groundwater to sustain or contribute to the surface water Reserve has to be determined [DWAF, 2004b]. The ER is currently defined by DWAF as a series of flow duration curves, one for each month of the year [Mallory *et al.*, 2009]. Because of the complex and time consuming process of the Reserve determination it is expected that the Reserve will be a negotiated allocation.

The National Water Resource Strategy presents an indicative multi-year programme for the implementation of the NWA throughout the country. Given the size and the complexity of many of the activities (e.g. compulsory licensing and the establishment of CMAs) described, the programme is only indicative and should not be regarded as a rigid master plan [DWAF, 2004b]. According to the NWRS the government (DWAF/CMA) is intended to follow a phased approach for the implementation of the Reserve, in order to minimise possible negative impacts on existing users [DWAF, 2004b].

The NWRS recognizes the lack of financial and human resources to simultaneously implement all the activities in all 19 watermanagement areas. Therefore, some catchments are prioritised according to the needs and circumstance in the area [DWAF, 2004b]. To date, six CMAs - Inkomati, Mvoti-Mzimkulu, Gouritz, Olifants-Doorn, Thukela, and Usutu to Mhlathuze CMAs - have been established [WorldBank, 2009]. The indicated programme for the Inkomati catchment is the establishment of a CMA in 2003/2004 followed by a transition period until 2009/2010 to a fully functional agency. The WUA establishment process was planned to start in 2005/2006 and according to the plan staff and stores would be transferred together with a phase out subsidy in 2008/2009. It becomes clear from these dates that the implementation of the Act is a long term process. For example; the indicative programme for compulsory licensing has a time span of 21 years after the start of the program in 2003/2004. Almost the same period is required for the proposed expansion of the monitoring network. It becomes clear from the above that the implementation of the NWA has a huge impact on the human resources within DWAF. Besides the huge impact on human resources the implementation will also require extensive financial resources. The NWRS estimates the annual funding requirement for routine operational activities as R1800 million (2002 prices), this is R200million more than DWAFs budget allocation for financial year 2002/3 [DWAF, 2004b].

While adopting a land reform program and new water legislation the government also adopted liberalism as its economic and developmental guideline [Perret, 2002b]. Consequences of this are State withdrawal from former commitments and controls, decentralization and the transfer of power to local management and decision making structures. It will become clear in the following chapters that local management and government structures have not been prepared for this quick hand-over process.

The new water legislation requires a shift in the water resource management approach. The transition period, from water allocation based on riparian rights to one based on negotiations over equitable and efficient sharing of the water resource, has proven to be difficult. One of the reasons is the opposition from groups who previously had extensive access to water resources [WorldBank, 2009]. The difficult transition period was explained by Ms Barbara Schreiner, DWAF Senior Executive Manager of Policy and Regulation in a parliamentary meeting in 2004 about the implementation of the NWA. She reported that although the Department had formulated many policies, legislation and strategies to protect water resources, they still faced many challenges before there could be equity in access to water. For example, free basic water delivery was enjoyed by only 57% of the population or 76% of those with access to infrastructure. Other challenges included transforming irrigation boards and government water schemes into water user associations (WUA), and the establishment of catchment management agencies (CMA) and water user associations[44]. But given the limited government resources it will be difficult to implement the extensive management, allocation and consultation required by the NWA [Hamann & O'Riordan, 2000]. This was confirmed by the Mr. R. Kasrils minister of DWAF in a speech at the opening of the international conference on environmental flows for river systems in 2002: *"Much has been learned in the road we have travelled – and much has still to be mastered as we struggle to bridge the divide between legal and scientific theory, and practical operational reality"*[DWAF, 2002a]. It is even argued by several researcher, among others Hamann and O'Riordan [2000], that by trying to implement a more sustainable and holistic management approach, the NWA may create a regime so full of bureaucracy that it results in failure. One example, of the newly created holistic management approach is the proposal submission of all 27 Irrigation Boards in the Inkomati water management area to transform into WUAs. All the proposals were rejected by DWAF on the grounds that they were insufficiently representative of different water users [Brown, 2006].

The management of water resources in the catchment is to be detailed in the CMS. The strategy is currently being written by Inhlakanipho Consultants for the ICMA. The strategy should be written in close consultation with DWAF and stakeholders and should be finalized within a few months. However, to date none of the interviewed stakeholders as well as DWAF have been involved in the writing process of the CMS (see below). Recently a rapid process has been put in place to draft the CMS by the end of June 2009 via a 'task force' of about 12 people [Pollard *et al.*, 2009a: 26]. Besides the lack of stakeholder participation in the collaborative writing process of the CMS, stakeholders are also not involved in forums since the forum is not functioning anymore in the Sand catchment [ICMA, 2008].

[44] Implementation of the National Water Act (1998): briefing, Parliamentary Water Affairs And Forestry Portfolio Committee, February 11 2004. Source: www.pmg.org.za

One of the key concepts of the NWA is stakeholder participation in water resource management. To increase stakeholder participation two new decentralized water institutions were established the CMA and the WUA. However, as argued by Wester [2008] increasing the capacity of water users to influence decision making is crucial in river basin management. Thus, stakeholder participation must be accompanied with stakeholder empowerment (see section 2.4). It is necessary to train the people so they can make informed decisions. Recently the ICMA appointed one official to ensure effective public participation and empowerment in the Sabie-Sand catchment [ICMA, 2008]. It has proven to be difficult to involve local stakeholders in water resource management. According to the guidelines for the development of the CMS stakeholders should be involved in writing the CMS [DWAF, 2007a]. But due to internal management problems at Inhlakanipho Consultants this is not happening. The internal problems at the consultancy consist of two senior program managers having other fulltime jobs outside the consultancy (preparation of elections for a new political party and a fulltime job as head of a department at one of the major conservation areas).

It is proven to be difficult to implement the BHNR in the former homelands[45]. Most homelands were located in infertile areas and became overcrowded concentrations of resource poor people with little or no economic opportunities [de Lange, 2004]. For example, in the 1980s the bantustans accounted for approximately 15% of potentially arable land, but over 44%of the total population lived in the homelands [The Transvaal, 1983]. The water resource situation in several homelands could be characterized as a severe water crisis [Levin *et al.*, 1997]. Because of the influence of apartheid history on homelands, the water scarcity in the homelands is characterized by Hamman & O'Riordan [2000] as being "socially constructed". This is confirmed in the preamble of the NWA; "*Recognizing that water is a scarce and unevenly distributed national resource*… (and) *water is a natural resource that belongs to all people, the discriminatory laws and practices of the past have prevented equal access to water, and use of water resources* [NWA, 1998].

It is argued by du Toit *et al.* [2009b] ,who did a research project about the legal status of environmental flows in the new policy framework, that if the State aims to fulfil its obligation to provide water as a right for present and future generations it will need to secure ecosystem sustainability. However, South Africa's implementation of the complex water legislation is in its (legal) infancy. While the guidelines and procedures for establishing the Ecological Reserve are provided under the NWA, the specific procedures of how to maintain it and ensure that violations are monitored and corrected, on an ecosystem-by-ecosystem basis, have yet to be properly legislated and made administratively feasible [du Toit et al., 2009a]. This is confirmed by DWAF's position paper on Water Allocation Reform according to which the National Water Act and National Water Policy provide the legislative and policy framework for water allocations, yet they do not provide detailed strategies and approaches to promote equity, sustainability and efficiency in water use, or a process to roll this out across the country [DWAF, 2005b: 3].

The response of DWAF can be seen in the light of its old engineering and operational focus. Since the new water legislation, however, DWAF's focus changed towards more multi-disciplinary regulatory functions. DWAF became a regulator and implementation agency[46]. The above raises the question whether it is possible to legally define the principles of the NWA, namely equity, sustainability and efficiency? DWAF, in its new role as regulator, should facilitate this process through the CMAs. Thus the definitions of the principles will be negotiated by the stakeholders in the CMAs. By negotiating

[45] The main problems related to the delivering of basic water services are; lack of infrastructure, dilapidated infrastructure, lack of payment, leakages, lack of available water resources and illegal connections.

[46] Research on the politics of irrigation reform process suggests that water bureaucracies (DWAF) are very creative in maintaining their construction and supply-driven orientation even in a seemingly fundamental institutional reform process (NWA). Source: Bolding *et al*. 2000.

these principles new questions will arise, e.g.; (how) can one compare the bench marks of each principle (see discussion in section 8.3).

4.4 Conclusion

The focus of South Africa's first water act of 1912 was on irrigation. The focus of its successor, the 1956 Water Act, was also on irrigation, although other water uses, such as domestic, urban and industrial, also received recognition[47]. The role of environment as a water user was not recognized. Both water acts were founded on the principle of private use and ownership. Since the homeland areas were considered to be 'communally' owned and controlled by tribal authorities the Water Act did not apply to these areas. The 1956 Water Act along with a number of other of water-related legislation created a white dominated resource ownership structure.

After the first democratic elections in 1994 a new Constitution was written. The right to water was defined as a Constitutional Right. This right is reflected in the NWA. The NWA [1998] defines this right as the Reserve. The Reserve consists of two elements: the Ecological Reserve (ER) and the Basic Human Need Reserve (BHNR). Under the previous law the environment was not recognized at all. During the law reform process the environment became a recognized user, a resource provider. Under the NWA [1998] the environment, the Reserve, enjoys an automatic (priority) allocation. All organs of state and water management institutions must give effect to the Reserve in exercising any power or performing any duty under the NWA. The implementation of the Act is complicated, there is unclarity about specific procedures, for example, procedures for monitoring and correction. Therefore, it is argued that the NWA is highly commendable but difficult to implement in a context of resource scarcity, severe backlogs in rural areas, competing users, needs for economic performance and job creation [Perret, 2002b].

Equitable access to water is critical to the government's aim to eradicate poverty and promoting economic growth [DWAF, 2005b]. However, after the introduction of the policy framework the situation slowly improved but there is still a neglect of the rights of the poor. There are still significant inequities in access to and use of South Africa's water resources, as well as inequities in the benefits that accrue from water use [DWAF, 2005b: 3]. The inequities are more striking in the former homelands. But despite the new water policy framework and more than 10 years of implementation the water resource situation in the former homelands is still inadequate.

Through the NWA stakeholder participation in water resource management is supported. As described in section 2.4 various perspectives are used to legitimize the need for participation. The focus of the new water policy framework is on the empowerment perspective. It is important to note that not the participation as such is not important but the level of participation matters, as argued by Bewket and Sterk [2002]. If the government sincerely intends to involve the stakeholders in water management decisions, the stakeholders should have some degree of citizen power, the third level in Arnstein's ladder of participation [Arnstein, 1969]. At the moment, however, the stakeholder participation is less advanced and only reaches the second step of the ladder; degrees of tokenism: informing, consultation and placation. Since the stakeholders are not involved in the decision making processes the historically disadvantaged groups are not empowered as well. This chapter closes with a remark from Kadar Asmal the former Minster of DWAF: *A lot of work has been done by researchers to define the Reserve, but surprisingly it is more difficult to make the concept work in everyday practice, where human survival outside the conservation areas competes with animal survival inside it* [Asmal, 2004: 17].

[47] National Water Act Amendment Bill: discussion & voting, Water Affairs And Forestry Portfolio Committee, October 26 1999. Source: www.pmg.org.za

5 Environmental water allocation – Sand catchment

5.1 Introduction

The previous chapter described environmental water allocation in South Africa in general. This chapter focuses on the situation in the Sand catchment. After a small introduction of the country's history on environmental water allocation it describes the Instream Flow Requirements in the Sand catchment in section 5.2. Followed with a description of the Reserve determination process (5.3). This chapter is closed with an overview of the current state and the way forward (5.4)

The vulnerability of the Lowvelds' environment to human intervention is shown by Pollard *et al.* [2008c]. According to her, some of the major rivers in the Lowveld, recorded as perennial rivers in the 1920s by Steven-Hamilton [1929], such as Letaba, Luvuvhu and Sand were transformed to intermittent systems by anthropogenic disturbance. The change in flow regime is also visible across the border. The flow regime of the Incomati in Mozambique has been altered significantly because of upstream (South Africa) abstractions [Vaz & van der Zaag, 2003]

According to the NWA the Reserve is the only right to water. This section describes one of the two elements of the Reserve: the Ecological Reserve (ER). The second element of the Reserve, the Basic Human Need Reserve is described in section 6.4.

Long before the NWA there was already some kind of recognition for the environment being a water user. The early environmental flow allocations were just simple hydrological ratios. The ratio increased from 1% in 1970 up to 10 to 15 percent to be assigned for the environment [World Bank, 2009]. Later on there was a realization that simple ratios were insufficient and that environmental flows needed to be based on the water requirements of aquatic ecosystems. This resulted in the first South African workshop on the development of an environmental flows method in 1987 [Ferrar, 1989]. South Africa subsequently became a pioneer in the development of methods for environmental water allocation, which considered the water requirements of the complete ecosystem [World Bank, 2009].

DWAF developed criteria for the Sand River. The main criteria that has been adopted for the Sand catchment is that the flow must not cease at the confluence with the Sabie River during the low flow season [DWAF, 1994]. One of the agreements made in the Sabie River Working Group was that a minimum flow of 0.6 m^3/s will be maintained in the Sabie as it enters Kruger National Park [Woodhouse & Hassan, 1999]. For a description of the Sabie River Working Group see section 3.7. A couple of years later DWAF became more aware of the

Box 5.1: Building Block Methodology

The Building Block Methodology (BBM) was developed as a method for determining IFRs. The methodology was developed during several workshops funded by DWAF and the Water Research Commission during the 1990s [FWR, 2000]. The BBM was initially applied by DWAF to rivers within South Africa where dams were being considered.

The BBM is a prescriptive approach for developing a flow regime for maintaining a river in a predetermined condition.

According to a World Bank [2009] report on environmental flows, BBM is based on three main assumptions:

1) Riverine biota can cope with naturally variable flow conditions, but atypical flow conditions constitute a disturbance and could cause fundamental changes;
2) Management of the most important components of the natural flow regime will contribute to the maintenance of natural biota and ecosystem functions; and
3) Flows that most strongly influence channel geomorphology should be included in the managed flow regime.

Through the BBM a flow regime is built in monthly blocks of water. Each volume of water is characterized with a description of the biological, hydraulic, or geomorphologic function it serves [World Bank, 2009].

vulnerability of the environment which must be protected to ensure sustainability. During a workshop in 1996 Instream Flow Requirements (IFR) were determined (see below). Currently, DWAF is busy with the Reserve determination, a process that will be completed in November 2009. In the absence of an exact quantification of the Reserve, IFRs are still being used.

5.2 Instream Flow Requirements

Instream Flow Requirements (IFR) comprise a flow regime (magnitude, timing and duration) that needs to be guaranteed in order to sustain the river ecology and the goods and services that it provides [Smits *et al.*, 2004]. The first IFRs within Kruger National Park were estimated by using the Building Block Method (see Box 5.1). This activity was essentially a technical exercise with limited stakeholder engagement, apart from SANParks itself. This reflects the focus of the IFR process on establishing just the environmental water needs and not extending to a wider assessment of stakeholder requirements for water [World Bank, 2009]. The ER, which can be regarded as successor of the IFR, entails a more holistic approach where by stakeholder participation is very important.

During a workshop in August 1996, the Instream Flow Requirements at various points in the Sabie-Sand catchment were determined. The IFR sites in the Sand were selected during this workshop as well. A couple of months before the workshop was scheduled a helicopter flight was planned to assist the team in selecting the suitable sites. The team planned to use a video for the Habitat Integrity determination. However, due to bad weather the helicopter flight was cancelled. As the site selection team was already in the field and due to severe time constraints, the sites preliminary selected had to be accepted by the team [Pollard, 1996].

At the workshop in 1996 the IFRs were determined by using the Building Block Methodology. This workshop brought together the developers of the BBM and the members of the Kruger National Park River Research Programme. A member of DWAF's Water Law Review Team attended the Sabie-Sand IFR workshop, to assess whether or not the BBM could meet legal requirements in terms of quantifying the water required for river maintenance [cf. FWR, 2000].

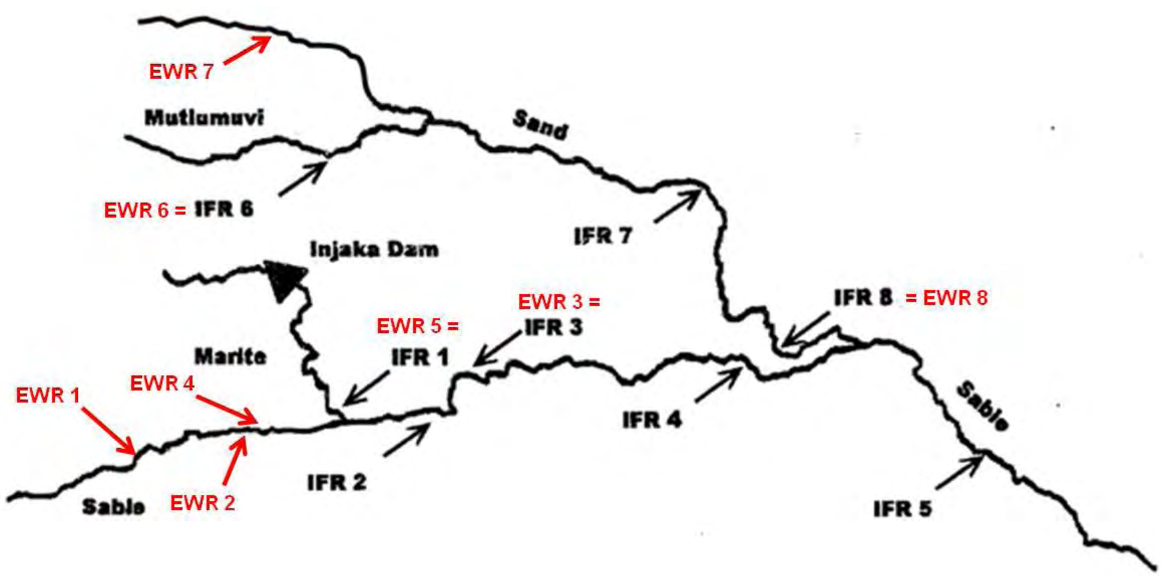


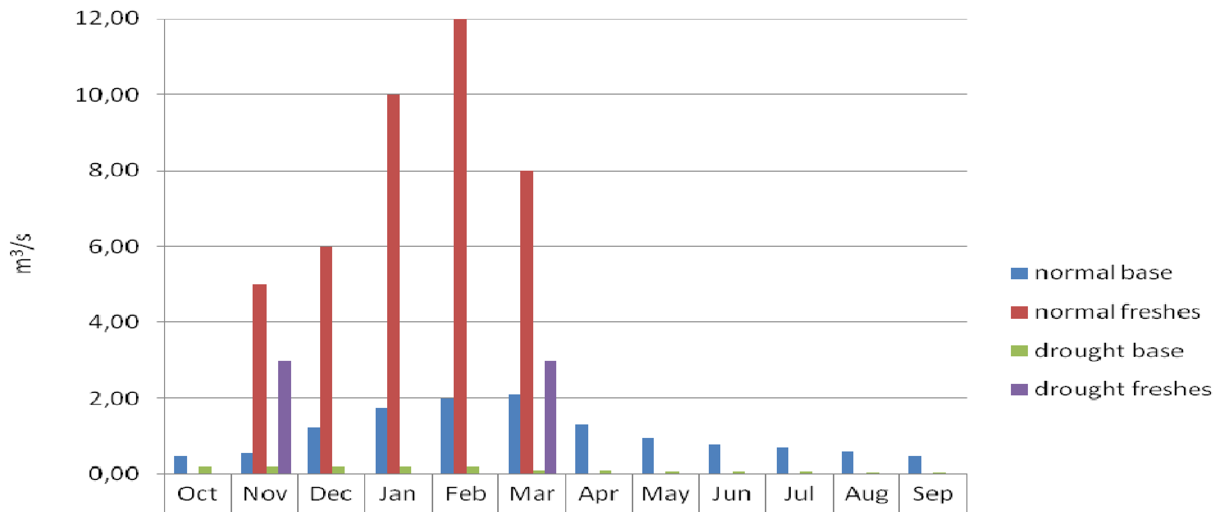
Figure 5.1: IFR and EWR sites in the Sabie-Sand catchment
Source: adapted from DWAF [1999]

The outcome of the workshop were specified IFRs at a number of selected sites in the Sabie-Sand catchment [DWAF, 1997a]. The IFR study concluded that the Sand River and riverine zone constitutes an important resource for local communities. For example, use of plants for medicinal, cultural, building and craft purposes, as well as consumption of fruit, use of fish for consumption. With the high unemployment rate in the catchment the water resources provide an important free source for fish and plants, which provide protein, minerals and vitamins [DWAF, 1998].

IFR (maintenance and drought) were determined for eight sites in the Sabie-Sand catchment (see Figure 5.1), of which three sites are in the Sand catchment. The three sites (IFR 6,7and 8) are situated downstream of each other: IFR 6 on the Mutlumuvhi River, downstream of Nwarhelele confluence, IFR 7 on the Sand River in the Sabie Sand Wildtuin, downstream of the Mutlumuvhi confluence and just downstream of the Exeter gauging station, and IFR 8 on the Lower Sand River in the Kruger National Park just upstream of the Sabie confluence.

The most advanced hydrology-based methods (e.g. IFR) effectively focus on estimating the ecologically acceptable proportions of baseflow (base) and quickflow (freshes), which could be allocated for freshwater ecosystem maintenance [Smakhtin *et al.*, 2004].

The IFR (maintenance) base flow recommended at the IFR workshop ranged from 0.5 to 2.1 m^3/s [DWAF, 1997a]. The IFR is divided in two categories: “maintenance IFR” and “drought IFR”. The criterion for a year being a dry year is when the river flow is smaller than 70% of the normal flow. The normal flow is based on a modelled flow duration curve. The IFR is composed of, among others, magnitudes, depths, volumes and return periods. In Figure 5.2 an overview of the recommended base flow and floods for IFR7 is given. Note: the normal high flow in February is 60 m^3/s, but to facilitate readability of the graph this is not shown.



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
normal base	0,50	0,55	1,25	1,75	2,00	2,10	1,30	0,95	0,80	0,70	0,60	0,50
normal freshes		5,00	6,00	10,00	60,00	8,00						
drought base	0,20	0,20	0,20	0,20	0,20	0,10	0,10	0,08	0,08	0,07	0,06	0,05
drought freshes		3,00				3,00						

Figure 5.2: Maintenance and drought IFR for IFR 7
Source: adapted from DWAF [1997a]

Due to concerns about the confidence in the results of the 1996 workshop a further workshop was held in 1998 to refine and improve the confidence in the results of the IFR at selected sites [DWAF, 1998].

The term IFR was in 1999 superseded by the Environmental Management Class which describes the river according to different classes ranging from class A (unmodified, natural) to class F (critically modified) [DWAF, 1999]. As a general rule, the higher the class, the more water will need to be allocated for ecosystem maintenance or conservation and, therefore, the higher EMC will be. Most of the rivers in the Sand catchment are largely natural (class B), the reach of the Sand River in the Sabi Sand Game Reserve is moderately modified (Class C) [DWAF, 2003b]. Placing a river into a certain Environmental Management Class is accomplished by expert judgment using a scoring system.

Table 5.1: Environmental Management Class for the Sand system

IFR Site	EMC
IFR 6	C/B
IFR 7 + 8	B

Source: DWAF [1999]

It should be noted that the early quantifications of IFRs were not acted upon because they were not backed by legislative requirements or implementation mechanisms [WorldBank, 2009]. The 1956 Water Act did not recognize environment as a water users. As a result the IFR were accepted for planning purposes by the Planning Division of DWAF, which had asked for them. The IFRs were not widely accepted within or outside the department [WorldBank, 2009]. As described above, DWAF changed its approach after the 1994 election. The department recognized the environment as a resource provider and stipulated that the water needs of the resource should be met first [DWAF, 2002a]. Through the NWA, the environment became a recognized water user. By means of the new water legislative framework, the environmental water requirements were backed by a legislative mechanism. The IFR formed the basis for the subsequent Reserve determinations [WorldBank, 2009].

5.3 The Reserve

According to the NWA each water resource must be classified, the resource quality objectives must be set and the Reserve determined [DWAF, 2003d]. This process had not yet been completed in the Sand catchment by the time of my research (2009). The comprehensive reserve determination is not set in the Sabie-Sand catchment. In the meantime, the IFRs and/or Reserve estimations are still used. Because of this delay in the Reserve determination, it is now more difficult to achieve the Reserve requirements than it would have been if the IFRs had been enforced. Because of the continuous increase in water demand it becomes more complicated to acquire water for the environment [WorldBank, 2009].

A comprehensive Reserve determination is currently underway and due for completion in November 2009. At present, a consultant[48] has been tasked by DWAF to design operational scenarios for the evaluation of the ecological goods and services and socio-economic consequences[49]. The consultant looks at the Present Ecological State and the Recommended Ecological State of the water resources so as to estimate the quantities of water required to maintain the water resources in this condition [DWAF, 2009a].

Eight Ecological Water Requirement (EWR) sites have been by the consultant in the Sabie-Sand catchment, of which three are in the Sand Catchment (see Figure 5.1). EWR 6 is located on Mutlumuvhi River and EWR 7 is located at the Tlulandziteka River, both sites are located upstream in the catchment nearby the irrigation schemes. EWR 8 site is located downstream along the Sand River in the Sabie Sand Wildtuin. The three EWR sites do not match with the previously used IFR sites. For example: IFR 7 site which was close to the only gauging station in the catchment will not be used in the new EWR methodology. By no longer using the IFR 7 site it becomes more complicated to adjust the modelled EWR flows according to the measured flows.

[48] The consultant has extensive experience in the calculation of South Africa’s environmental water allocations.
[49] Workshop: “Crocodile and Sabie-Sand comprehensive EWR assessment”, 17 March 2009, Pretoria.

The IFR was relatively easy to understand: a monthly fixed flow regime with several floods. IFRs were based on purely ecological needs. More recent frameworks, like the Reserve, include socio-economic considerations and are used to define the flow regime and quality of water required to achieve a healthy system [du Toit & Pollard, 2008]. The first Reserve estimations were expressed in the form of monthly Flow Duration Curves [Smits *et al.*, 2004]. Later on the Reserve determinations became more holistic[50] and subject to adjustment on the basis of daily rainfall data (which are not available in the Sand catchment) and including water quantity as well as water quality considerations. The Reserve will be defined for a point in the river known as the EWR site. The Reserve will be applicable for the river section upstream of the EWR site. For draft estimations of the Reserve see Table 5.2.

The environmental sector is a largely non-consumptive water user. Up to now, there is no comprehensive Reserve determination yet. Therefore, the preliminary results are used for EWR estimation (see Table 5.2). the EWR requirement for the Sand catchment is 43 Mm^3/a [DWAF, 2009a]. DWAF is currently working on the comprehensive Reserve determination and is updating the Reserve. This will result in improved confidence in the Reserve estimates [DWAF, 2008b].

The Ecological Reserve includes the international agreements [Pollard *et al.*, 2009b]. Since the environmental water requirement is a largely non consumptive water user, this water will be available for use in Mozambique [DWAF, 1994].

Table 5.2: Draft Reserve for the Sand

Sites	Former IFR site	Ecological Status	MAR (Mm^3/a)	EWR (PES) (Mm^3/a)	% MAR
EWR 6	IFR 6	C	45.0	13.7	30.4
EWR 7	-	C	28.9	9.7	33.6
EWR 8	IFR 8	B	133.6	39.3	29.4

Source: adapted from DWAF [2009a]

The consultant developed various scenarios based on the different Recommended Ecological States of the water resource. During a workshop in November 2009 these scenarios will be presented to the representatives of the stakeholders in the catchment. The developed operational scenarios will be used to discuss the implication of the classification. After discussing the implications the stakeholders will take a decision on the desired ecological state of the river. As described in section 2.4 these negotiations are by definition political.

This workshop will be one of the last steps before the Reserve will be set by the Minister. After the Reserve has been set and authorised by the Minister it is binding on any institution in water resource management and ICMA should start implementing.

However, due to the lack of awareness amongst the stakeholders about the Reserve and since the stakeholders were not involved in the preceding process it will become difficult for them to take an informed decision. Therefore, it is questionable whether the stakeholders will be fully aware of the far reaching consequences of their decision. Their decision will affect the water management practices of all stakeholders in the catchment.

According to the NWA [1998] the Reserve must be given effect to. The Sabie River Catchment Operating Rules for the management of the surface water resources are currently the best available methodology to give effect to the Reserve. For an extensive description of the Operating Rules see

[50] From a global perspective the NWA is widely regarded as one of the most progressive and holistic pieces of legislation regarding water resource management (Pollard *et al*,., 2009b).

section 8.3. In summary; the Operating Rules prescribes passive management of the irrigation abstraction weirs. The basic rule is that any abstraction (irrigation and domestic) must release a minimum fixed proportion of 35% of the flow downstream.

5.4 Conclusion

This chapter gave a description of the environment as water user in the Sand catchment. Since the 1990s there were several attempts to allocate water to the environment in the Sand catchment. Through the new water legislation the environment became a recognized and legal water user. However, more than one decade after the National Water Act came into effect there is still no comprehensive Reserve determination for the Sand catchment yet. Several key stakeholders expect the quantity aspect of the Reserve being in line with its precursor, the Instream Flow Requirements.

The Sabie River Catchment Operating Rules for the management of the surface water resources are currently the best available methodology to give effect to the Reserve in the Sand catchment. The Operating Rules prescribe a passive management of the irrigation abstraction weirs in the catchment. The next chapter describes how these rules are (in)visible in current practices.

6 Water distribution – actual situation

6.1 Introduction

The previous chapter (4) described the desired water management situation based on the new water legislation. This chapter illustrates the actual water management practices and shows how they differ from the desired state. This chapter treats the main water users in the catchment in a sectoral fashion; environment (section 6.2), irrigation (section 6.3), domestic (section 6.4), and forestry (section 6.5). The main water user in the catchment is the irrigation sector. Therefore, this water user will be described in more detail. This report does not describe the agricultural practices of the irrigators but focuses on their water practices e.g. water use, maintenance of the infrastructure, and ownership. The description of the water users is followed by a section (6.6) about water resource planning in the catchment. A concluding section (6.7) about the water management practices closes the chapter. This chapter does not describe the water requirements per sector, for a calculation of the water requirement and water abstractions see chapter 7.

According to its different water users the catchment can be divided in three zones (see Figure 6.1):
- Zone A: Mountains: Commercial forestry plantations;
- Zone B: Lowveld: Irrigation (4 abstraction weirs, 2 pumps) and domestic water use (9 pumps);
- Zone C: Conservation areas: Conservation areas.

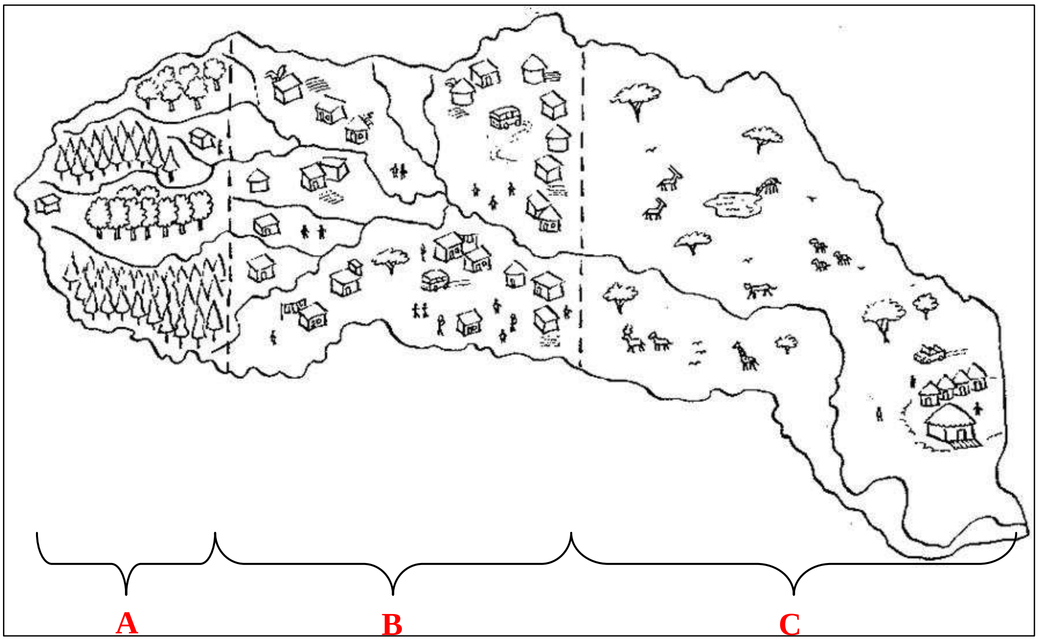


Figure 6.1: Map of the Sand catchment showing the different zones
Source: adapted from AWARD [2002].

In theory, the Sabie-Sand catchment is managed by the Sabie-Sand Catchment Management Committee. A delegation of this Committee represents the Sabie-Sand catchment in the ICMA. According to the proposal for the establishment of the ICMA, the Sabie-Sand Catchment Management Committee consists of representatives from all the stakeholders in the catchment [DWAF, 2001]. The ICMA should manage the water resources in the catchment according to the Catchment Management Strategy. Unfortunately there is no Catchment Management Strategy yet. The Catchment Management Strategy and the National Water Resource Strategy are the legally binding documents that operationalise the policies and standards created by the NWA. Since the Catchment Management Strategy is not written yet I could not identify specific policy objectives for the Sand catchment.

6.2 Environment

Since the environment is a voiceless water user, it must be represented by somebody. In the Sand catchment the environment is represented by the downstream (private) conservation sector; the Sabie Sand Wildtuin[51] and Kruger National Park. These two nature reserves act as the watchdogs for the water resources in the catchment. Therefore, it is not surprising that most of the interviewed stakeholders see the Reserve as something for Kruger. Most DoA officials argued that the Reserve is a waste of water, which is a scarce resource for the agricultural sector. Only one DoA extension officer underlined the importance of the Reserve for the sustainability of the ecosystem: "*no water is no life*".

The knowledge about the Reserve among the different water users is deplorable. There is no awareness about the Reserve amongst the irrigators and domestic water treatment plant operators. None of them has ever heard about the Reserve[52] with the exception of two irrigation management committee members who heard about the Reserve long ago during a workshop. Because of the lack of awareness of the Reserve by most interviewees it is not surprising that the Reserve is linked to the conservation sector. However, by assigning the Reserve as the remit of someone else, the responsibility for meeting it also resides elsewhere [Pollard *et al.*, 2008c].

Picture 6.1: Borehole in Kruger National Park
Source: www.thekruger.com

The few interviewed stakeholders with some knowledge about the Reserve argued mainly that it is "something for the animals in the park" (see Picture 6.1). The environmental sector is one of the large employers in the catchment, e.g. more than 1500 people work in the tourist industry within the Sabie Sand Wildtuin [Jackson & Swart, 2003]. The lack of flow in the Sand River could result in the decline of wildlife in the game reserves which will lead to a drop in the number of tourists. This will negatively impact the number of jobs in the conservation sector [Swart, 2008a].

6.3 Irrigation sector

6.3.1 Introduction

This section describes the irrigation practices in the catchment. The section is partially classified according to Uphoff's matrix of irrigation activities (see section 2.7). For a good understanding of the current irrigation practices an understanding of its history is important (see section 6.3.2). Next a general overview of the schemes (6.3.3) and its layout is presented (6.3.4). Followed by a description of the water use activities (6.3.5), the control structure activities (6.3.6), and the organizational activities (6.3.7). The irrigation activities are described according to the Uphoff matrix. Because of the several irrigation rehabilitation plans section 6.3.8 is dedicated to these plans. This section about the irrigation sector is closed with some remarks on the main challenges of the irrigation sector (6.3.9).

This report deals about water management practices. Therefore only actually existing irrigation schemes in the catchment are described, namely Dingleydale, New Forest and Champagne Citrus farm. Hence, the non functioning schemes (Zoeknog, Dumfries and Allendale) are not described because they do not abstract any water anymore. Because of its similarities, and the fact that they share parts of their infrastructure, Dingleydale and the adjacent New Forest will be partly described together. The

[51] On a workshop about the EWR assessment (Crocodile and Sabie-Sand comprehensive EWR assessment", 17 March 2009, Pretoria) the environmental sector was represented by an ecologist of the Sabie Sand Wildtuin. It is important to note that the irrigation and domestic sector were not represented during the workshop, the reason is unclear to me.
[52] From own observation and meeting with PhD student who is doing research about the WUA in New Forest.

irrigation practices of the pressurized irrigation scheme at Champagne, however, differs significantly from the others and will be described separately. It is important to note gain that employment creation was the main motive for the establishment for all these schemes.

6.3.2 History of the irrigation sector

The irrigation schemes in the Sand catchment were initiated by the Gazankulu and Lebowa governments. The schemes were managed trough their respective Agricultural Development Cooperation. Ownership remained with the Tribal Trust Land. The homeland governments were responsible for the development and maintenance of the irrigation infrastructure in the catchment. The government provided financial and market related support to the farmers [DWAF, 2007b]. This created dependence from the farmers towards the government and made the farmers highly vulnerable to the eventual withdrawal of support from the homeland government.

Following the abolishment of apartheid, management parastatal agencies were liquidated and government gradually withdrew from its past functions in smallholder irrigation schemes; extension, marketing and financial support [Perret, 2002a]. Since the liquidation of ARDC in 1996 government withdrew from any form of support to the farmers in the Sand catchment; the scheme has been left moribund, with few productive activities happening [Perret & Geyser, 2008]. The schemes became the responsibility of the Northern Province Department of Agriculture, Land and Environment (NPDALE). The management of the schemes was undertaken directly from the NPDALE local branches (for Dingleydale, New Forest, Dumfries and Allendale) or from the body formed after the merge of the homeland development corporation, and known as the Agriculture and Rural Development Corporation (ARDC). ARDC is a parastatal organisation linked to NPDALE which managed the irrigated schemes of Champagne, Zoeknog coffee and ARDC New-Forest tobacco scheme.

Dingleydale and New Forest

Both flood irrigation schemes were established in the early 1960’s. The schemes were set up as part of the government’s “betterment” policy. Local people were moved to areas where they were allocated housing plots and a piece of farming land [ARC-LNR, 1999]. During homeland control over the schemes government provided support through extension officers, they were responsible for water management tasks, tractor ploughing services and canal maintenance [Teba development, 2009]. After the change in political regime the situation changed drastically. State agencies were abolished and government support was almost entirely withdrawn from the schemes. The withdrawal of government support has led to the decline of the irrigation infrastructure.

Champagne

The community occupied the land as far back as 1914. They had customary ownership and use right on the land. They existed as a community under the leadership of Chief Ben Mashego. In the 1930’s mister Travers arrived on the land, he turned the community into labour tenants. Mr Travers began to develop a citrus plantation on the land. He forced the community to provide labour for free in return for a right to continue residing on the farm. Several community members refused to be used as labour tenants, this led to physical eviction and incarceration of those who refused to work.

In 1948 the South African Development Trust (SADT) acquired the farm from Mr Travers in terms of the Development Trust and Land Act 18 of 1936 in order to include it into the area set aside to include blacks in terms of the Native Land Act 27 of 1913. According to the Native Land Act the community was prohibited to own land. The SADT developed the citrus plantation on a portion of the farm Citrus Champagne 230 KU as part of a government irrigation scheme aimed at creating jobs in the homeland to discourage the movement of blacks from the homeland to urban areas which were predominantly occupied by whites. The families that used to live on the portion of the Champagne farm which was earmarked for SADT citrus scheme were forcefully removed around 1965 by DoA. The community was relocated to Kasteel where it is currently staying. Representatives of the removed community claimed their land at the Regional Land Claims Commission Limpopo in 1998. However, it took until 2004 before the farm was officially handed over to the community.

The financial situation of Champagne depends heavily on yearly subsidies from the government. For example; the gross income in 1997 was R 615.000, the expenses, however, were R 2.6 million. In the 1997 financial year the farm received a grant of R 2.4 million[53].

After the first democratic government took over, SADT collapsed and management of the farm became a shared responsibility between DoA and the farm workers. From 2003 onwards the farm was managed by South Africa Farm Management (SAFM) in cooperation with the Champagne community[54]. SAFM was a development corporation which should empower the farmers, but in fact the farmers became more like workers[55]. In October 2008 SAFM went bankrupt and left the operation of the farm in a complete state of destruction as no operation of what so ever is currently taking place.

After the withdrawal of SAFM, DoA promised to support the farm. In close cooperation between DoA and the Champagne farm manger a business plan was written as an interim operational plan (see annex H). In January 2009 the DoA Head Of Department promised a donation of R 3.000.000, however, no money was received until May 2009. Currently the farm is in a financial crisis and not able to pay its bills. For example salaries are paid irregular, Eskom switched of the power supply and Telkom switched of the telephone lines because they are not able to pay the bills.

6.3.3 Overview of the schemes

Dingleydale, New Forest and Champagne irrigation schemes are situated next to each other. The schemes are bordered by the Tlulandziteka River on the northern side, the Mutlumuvhi River on the Southern side and Thulamahashe town on the eastern side. See Table 6.1 for an overview of the main characteristics of the three irrigation schemes.

Table 6.1: Main characteristics of the irrigation schemes

Scheme	Dingleydale	New Forest	Champagne
Drainage area	X32C	X32F	X32C
Former homeland	Lebowa	Gazankulu	Lebowa
Area (ha)	1031	622	3341
Cultivated area (ha)	410 (60% fallow)	250 (60% fallow)	265
No. of farmers	785	531	60
Irrigation type	short furrow	short furrow	micro sprinkler
Water Source	Tlulandziteka river	Mutlumuvhi river	Tlulandziteka river and Klein Sand river
Water license status	registered	registered	not registered
License issued	22 Oct 2003	15 Oct 2003	no
Registered: total volume	5,079,376 m^3/year	3,584,960 m^3/year	no
DWAF invoice	423.281 m^3/month = 5,079,376 m^3/year	298,746 m^3/month = 3,584,960 m^3/year	no
Water use tariff (R)	0.73 c/m^3	0.73 c/m^3	no
Paid by	DoA (Thulamahashe)	DoA (Thulamahashe)	no
Pump capacity	-	-	unknown
Canal capacity	962 l/s = 30.34 Mm^3/year	283 l/s = 7.50 Mm^3/year	-

[53] Source: Champagne Citrus Project, Financial statement for the year ended 31 March 1997.
[54] From interview Champagne farm manger, 29 April 2009, Champagne Farm.
[55] From interview Community Property Association member, 24 March 2009, Champagne Farm.

Designed for user	Dingleydale	New Forest	Champagne + domestic
Current user	Dingleydale + Champagne	New Forest	Domestic

6.3.4 Layout of the schemes

This section describes the irrigation layout of the Dingleydale and New Forest irrigation schemes; abstraction weirs, the canal infrastructure and the storage and balancing reservoirs (see annex E).

Abstraction weirs

The irrigation abstractions along the rivers are mostly run of the river. The Dingleydale abstraction is supported by releases from a small supply dam; namely Kasteel dam, see below. There are six irrigation abstraction points in the catchment; four abstraction weirs and two abstraction pumps. Below and in Table 6.2 the different abstraction points and their current status are described in alphabetical order, for a more detailed description see annex B.

Table 6.2: Location of irrigation abstraction points

Name	River	Location
Champagne	Klein Sand River	Upstream
Dingleydale	Tlulandziteka	Downstream of Kasteel Dam
Edinburgh	Mwandlamuhari	Downstream of Champagne and+ Dingleydale weir and pump 1 and 2
New Forest	Mutlumuvhi	Upstream
Pump 1	Klein Sand River	Champagne farm, downstream of Champagne weir
Pump 2	Tlulandziteka	Champagne farm, downstream of Dingleydale weir

Source: author, 2009

Picture 6.2: Broken gate at Dingleydale
Source: author, 2009

<u>*Dingleydale weir*</u>: the position of the weir is 1.5 km downstream of Kasteel dam. The dam was designed to supply Dingleydale irrigation scheme only. Currently the water is used by Dingleydale and Champagne scheme. The water flows around the weir into a silting basin into the drop intake of the lowered irrigation. After the inlet two gates, near the canal overflow, allow for the water to go back into the river. Currently the sluice gate at the inlet is jammed and cannot be adjusted and thus not operated. Both sluice gates at the canal overflow are broken, all the water remain in the canal and no water is released back into the river (see Picture 6.2).

<u>*New Forest weir:*</u> the abstracted water is used by New Forest scheme. The irrigation abstraction point is a drop intake, the water is piped approximately 100 m to the canal (see Picture 6.3). The sluice gate at weir is broken and cannot be adjusted. Next to the irrigation abstraction point a sluice gate is installed to flush sediment and to release water back into the river. This gate, however, is jammed shut and does not release any water back into the river. In May 2009 a trench for a domestic water pipe was being excavated by a contractor. The client for this 4 km long pipeline is Bushbuckridge municipality who wants to bring domestic water to a nearby high school.

Picture 6.3: New Forest weir
Source: author, 2009

Champagne weir: the position of the weir is Southwest of Rooiboklaagte village. The abstracted water is pumped to Acornhoek dam for domestic use. A second water user of this abstraction weir was Champagne scheme; water was canalled to Champagne farm (see Picture 6.4). Due to conflicts along the canal (two farmers along the canal blocked the canal and diverted water to their plots), the canal was abandoned by the Champagne farmers and they installed their own abstraction pumps, see below. Since the irrigation canal is not in use anymore, the remaining water user is the domestic sector. Bushbuckbridge municipality blocked the irrigation canal entrance with a steel plate to prevent water going into the canal. All the water that eventually reaches the sandtrap is diverted back into the river. The domestic abstraction point is through a grid on top of the weir, therefore the dam need to overflow in order to feed the domestic abstraction point. This overflow used to limit the agricultural abstraction, but since the domestic sector is currently the only water users there is no conflict anymore between agriculture and domestic.

Picture 6.4: Champagne weir
Source: author, 2009

Picture 6.5: Edinburgh weir
Source: author, 2009

Edinburgh weir: the position of the weir is South of Songeni village. From the weir, the water is diverted through a canal to Edinburgh dam. The canal capacity is 1150 l/s [DWAF, 2003b]. The irrigation abstraction point is a drop intake. Next to the irrigation offtake, a sluice gate is installed to flush sediment and to release water back into the river. This gate, however, is broken and the outlet blocked thus does not release any water back into the river. A water treatment plant 50 m after the beginning of the canal abstracts domestic water from the irrigation canal. The abstracted irrigation water was used to fill Edinburgh dam and subsequently to irrigate at Allendale and Dumfries schemes. But since a couple of years ago both schemes are not in use anymore, therefore this irrigation canal is also not in use anymore.

Pump 1 and 2: both pumps are located at Champagne Citrus farm. Originally, Champagne farm received its water from a canal which originated at Champagne weir. But due to conflicts with two farmers along the canal the management of Champagne Citrus farm decided to install two abstraction points on their own property. There is no measuring device on both pumps, therefore their water use is unknown. The capacity of the 55 KWh pump installed at Tlulandziteka River is unknown (see Picture 6.7). The capacity of the 20KWh pump at Klein Sand River is approximately 50 m^3/h [56] (see Picture 6.7). Both abstraction pumps pump the water through a filter into the pressurized micro sprinkler irrigation scheme.

Picture 6.7: Abstraction pump at Tlulandziteka River
Source: author, 2009

Picture 6.7: Abstraction pump at Klein Sand River
Source: author, 2009

In conclusion: the four abstraction weirs are small weirs with an overflow. The abstraction weirs in the catchment are designed in such a way that under low flow conditions and bad maintenance all the flow in the catchment can be diverted into the irrigation systems. The concrete weirs raise the water level upstream of the intake, this ensures that almost all the river flow is abstracted, especially during time of low river flows. The reason being that the weir sill level is above the intake sill level. The status of the Dingleydale, New Forest and Edinburgh diversion weirs is dilapidated. All the sluice gates at these points are broken and jammed shut thus prevent water from returning to the river. The two abstraction pumps at Champagne are in a good condition, but currently not functioning since there is no electricity supplied anymore to the farm. Electricity is disconnected due to unpaid electricity bills. Therefore no irrigation is taking place and the pack house is not functioning as well[57]. Since the pack house is not functioning anymore the fruit crops cannot be washed and thus not sold to international clients.

Infrastructure –storage dams

There are five dams in the catchment. Besides these dams there are also nine small balancing dams in the irrigation schemes, their total capacity is very limited; 120,000m^3 [ARC-LNR, 1999]. In addition to these balancing dams there are many very small dams used for stock-watering purposes. Although not

[56] KSB pumps, curves-book, based on height of about 20m. Available at www.kbspumps.co.za
[57] After harvesting the citruses are cleaned, polished, and packed in a pack house before being send to the customers.

located in the Sand catchment, the Inyaka dam is also described because of its influence on the water situation of the Sand catchment. The Zoeknog dam which was built by the then Lebowa Government failed in 1993, during its first filling, and will not be rebuilt[58]. The Zoeknog dam is therefore not described in this report. Below and in Table 6.3 the different dams and their current status are described in alphabetical order. For a more detailed description of the dams see annex D.

Table 6.3: Main characteristics of storage dams

Dam	Catchment area (ha)	MAR (Mm^3/a)	Gross storage capacity (Mm^3)	Net storage capacity (Mm^3)	Designed for user	Current user	Juris-diction
Acornhoek	116	1.16	1.1	0.80	Domestic		DWAF
Casteel	73	0.73	1.6	1.35	Dingleydale scheme		DoA
Champagne			0.28		Champagne scheme		DoA
Edinburgh	28	3.34	3.3	2.42	Allendale + Dumfries scheme	Domestic	DWAF
Inyaka	209 km^2	100	123	120	Environment + Agriculture + Domestic		DWAF
Orinoco	107	1.07	1.9	1.62	Agriculture		DoA

Source: adapted from Pollard *et al*. 1998, DWAF 2003 RSA, n.d. (circa 1980) and AWARD 2008

Acornhoek dam: The small dam is located just south of Acornhoek village. Through a pump station next to the Champagne weir water is pumped to this dam. After treatment, the water is used for domestic use in the surrounding community and in Tintswalo hospital. DWAF is currently rehabilitating the dam under the "Dam safety rehabilitation program".

Picture 6.8: Kasteel dam
Source: author, 2009

Casteel dam: The dam was built in 1965 and raised during the late eighties (see Picture 6.8). The water source of the dam is natural runoff from a small catchment area. The stored water is used to augment the flow in the Tlulandziteka River and is used by the downstream Dingleydale irrigation scheme. The outlet valve at the outlet tower is blocked by a steel pipe[59]. According to several senior DoA officials it is very difficult and not cost effective to repair this valve. Therefore, a siphon (steel pipe with a diameter of about 300mm) is placed on top of the dam wall to release water into the downstream Tlulandziteka River. However, the siphon is blocked and does not function anymore. Since the siphon

[58] From interview DoA chief engineer, 6 March 2009, Nelspruit and DWAF, 2004a.
[59] From interview DoA maintenance coordinator, 23 March 2009, Thulamahashe.

is not functioning anymore, a small portion of the water is released by the blocked valve and partly over the dams' concrete spillway. Therefore, the Reserve is not released to flow past the dam. Another problem is the siltation of the dam by an upstream brick factory. The large siltation load reduces the storage capacity of the dam significantly. The future of the dam is unsecure due to dam safety problems. The first dam safety inspection was done by DWAF in January 2001 in which it was concluded that the dam may have to be abandoned due to possible slope stability insufficiency, excepts if a "useful purpose can be found" and provided that some remedial measures are taken[60]. However, except the placement of the siphon nothing happened. The situation got even worse due to the siltation of the upstream brick factory.

Champagne dam: The small dam is located on the Champagne farm and is only used to store water for the farm itself. The water source is the natural runoff of a small catchment and the Dingleydale canal. By use of a siphon the Dingleydale main canal passes under the Champagne dam. After passing the dam there is a division box from which water can be diverted to Dingleydale scheme or to fill the Champagne dam.

Edinburgh dam: This dam was built exclusively for agricultural purposes to provide irrigation water to the Allendale and Dumfries irrigation schemes. The dam discharges water into the main canal to these schemes. Since these schemes are not in use anymore, the only remaining water user along the former irrigation canal is Edinburgh A/B water treatment work, see below. The water source for this dam is natural runoff and two small streams, namely: Sephiriri and Mphyayana River.

Orinoco dam: this off stream storage dam receives its water from both Dingleydale and New Forest main canals. The surplus water of Dingleydale and New Forest-1 is stored in the Orinoco dam. The dam supplies water to New Forest–2. Currently no water from Dingleydale reaches the Orinoco dam because all the water is already abstracted or loosed before it reaches Orinoco dam.

Inyaka dam: The recently constructed large dam is located on the confluence of the Maritsane and Marite River in the Sabie catchment. The dam is designed to supply water for domestic, irrigation and environmental use in both the Sabie and the Sand catchment. The Dam is provided with multi-level intakes to the outlet works. For an extensive description of the dam and the accompanying transfer pipeline see section 8.2.

Infrastructure –irrigation systems

Both schemes are characterised by complex and extensive infrastructure. For example, the length of secondary canals at Dingleydale is 220 km, length of the main canal at New Forest is 21 km, plus an additional 16 inverted siphons (to cross valleys and gullies), Dingleydale main canal runs under the Champagne dam, 44 long crested weirs, and 18 balancing dams in both schemes [ARC-LNR, 1999]. Dingleydale and New Forest are served by two main concrete canals which both end in the Orinoco dam from where the second New Forest main canal supplies water to the rest of New Forest. There are four water measuring structures (Cipoletti measuring notches) in place along the m ain canals in the two irrigation schemes. However, these measuring structures are not used anymore.

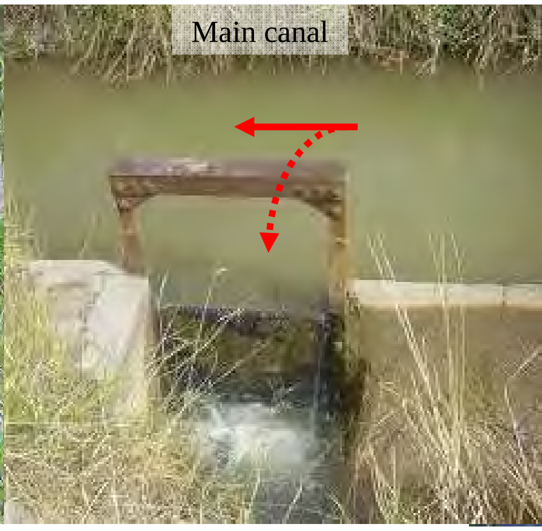
The main canals feed into off canal balancing dams which are located along the main canals (see Picture 6.11). During the night water is stored in these reservoirs for use during the following day. The water levels of the balancing dams are below main canal level therefore water can only flow from the main canal to the storage dams. These dams feed the secondary canals which lead to the farmers' fields. Besides the irrigation by use of the stored water, there are also several direct abstraction points from the main canal (see Picture 6.11).

[60] DWAF Directorate Civil Design, (Report No. X302/26/E701).

Several secondary canals receive its water from these direct abstraction points. Diagonal long crested weirs are situated just downstream most of the abstraction points along the main canal. The function of a fixed long crested weir is to control the water level upstream of the structure, thereby maintaining the upstream water level at a fixed level. A disadvantage of this structure is the accumulation of sediment. After construction the farmers made a hole in the weir to release water downstream.

The water source of Champagne Citrus farm used to be a concrete lined canal from the Champagne weir to the farm. As described before, due to conflicts along the canal, this canal was abandoned by the Champagne farmers. In 1999 two electrical pumps were installed to pump from the adjacent rivers direct into the pressurized sprinkler system. From the rivers water is pumped into the sprinkler system. All pumps are equipped with filters (they filter mainly sand). The irrigation type at the farm is micro sprinkler irrigation (see Picture 6.11).

Picture 6.11: Direct abstraction from main canal
Source: author, 2009



Picture 6.11 : Balancing reservoir abstraction
Source: author, 2009

Picture 6.11: Micro sprinkler
Source: author, 2009

6.3.5 Water use activities

Acquisition

Water acquisition is the abstraction of water from the surface resource by creating physical structures. As described in section 6.3.4 the irrigation sector abstracts water by means of two dams (Dingleydale and New Forest) and tow pumps (Champagne). The pumps at Champagne are operated by a labourer. The pumps are operated when water is required by the citrus trees[61]. Irrigation is determined by soil moister (by hands) and precipitation (rain gauge), usually it's once a week for a couple of hours. The abstraction weirs of Dingleydale and New Forest are operated by the water bailiffs (see section 6.3.6).

Allocation

This water use activity is about the allocation of water by assigning rights to users. The irrigation schemes in the catchment do not have a legal water right, their water use is only registered. Champagne, however, did not register their water use. DoA in Thulamahashe is paying water fees of the irrigation schemes[62]. Since the WUAs of the irrigation schemes are not registered they do not have a legal status. The WUAs must be registered first before they can apply for water license[63] (see section

[61] From interview Community Property Association member, 24 March 2009, Champagne Farm.
[62] From interviews irrigation management committee members and DoA officials.
[63] From interview senior ICMA official, 26 February 2009, Port Elizabeth.

8.4). The individual irrigators do not have a specific right to a certain amount of water, portion of delivery time, or whatever.

Distribution - water use

This section describes the distribution of water brought from the source among users at certain places, in certain amounts, and at certain times. It should be noted that none of the interviewed farmers has an idea about the irrigation requirement of their crops. Irrigation water is abstracted from the canals when needed by the crops. The amount of abstracted water is also unknown to almost all the interviewed farmers.

Water availability to the head end farmers is more reliable than to the tail end farmers. this is confirmed by a recent DWAF study in the irrigation scheme: The head end farmers enjoy more consistent and reliable water supplies whilst those at the bottom receive little or nothing [DWAF, 2007b].

One of the reasons for the irrigators abstracting more water than required by the crops (see chapter 7) is that a lot of water is wasted because of the dilapidated condition of the canal infrastructure. A variety of different losses are mentioned by different reports, organisations and stakeholders. In 1999 ARC estimated the losses to be 50% in total for the main canal and distribution and field losses [ARC-LNR, 1999]. Teba development, the NGO who wrote the refurbishment proposal (see below), estimated the losses to be between 65% and 75% in the main and secondary canals [Teba development, 2009]. It should be noted that this is a subjective figure and not based on a calculation or measurement. These losses mainly occur through cracks and breaks in the concrete lined canals (see Picture 6.13) caused by weathering and deliberate breaks to allow cattle to cross the canals (see Picture 6.12). In addition, most of the gates controlling the release of water from the main canals are also broken resulting in further water losses [Swart, 2008a]. The significant leakages lead to water logging at some of the plots adjacent to the leaking main canal sections.

Picture 6.13: Broken secondary canal at New Forest
Source: author, 2009

Picture 6.12: Broken main canal at Dingleydale, due to cattle crossing
Source: author, 2009

Irrigation abstraction should be restricted (theory), but this never happens (practice). In practice, the water bailiff opens the gate at the abstraction weirs even further to abstract as much water as possible. Since the irrigation schemes are not formally restricted to use less water during droughts, the irrigators are limited by the available river water, not by agreements with other users. The only restriction during droughts is the reduction of the number of farmers irrigating at the same time.

Drainage

This section describes the drainage of water where this is necessary to remove any excess supply. There is no drainage infrastructure in the schemes, natural drainage is provided by the topography of the terrain. Hardly any water is drained from the irrigated plots. The farmer stops abstracting water from the canal when all the crops are irrigated. Because of the considerable leakages in the irrigation canal a lot of water is lost. This leads to water logging on some of the plots adjacent to the leaking main canal. The leaked water drains to the subsurface groundwater and will eventually reach the downstream surface water as return flow[64].

6.3.6 Control structure activities

Because of the lack of available information on the design and construction of the irrigation schemes these two control structure activities are not described in detail. Since there is hardly any communication, decision making etc in the irrigation schemes (each irrigator manages his irrigation activities independent from other irrigators) the research is not focussed on the organizational activities

Design

Little is known about the design of the irrigation infrastructure. The irrigation infrastructure at Dingleydale and New Forest was designed by a consultant (EVN) in 1959. The schemes were originally laid out for flood irrigation. The design was for continuous flow in the secondary canals serving the plots. But the number of outlets on each canal served too many plots to make an equitable rotational sharing of water between farmers practicable [DOA, 1998]. Currently, however, the most commonly used irrigation type is short furrow irrigation

Construction

The irrigation infrastructure at Dingleydale and New Forest is build between 1961 and 1963. Unfortunately little is known about the construction of the irrigation infrastructure[65].

Operation - irrigation practices

In this paragraph the different irrigation practices are described. The paragraph starts with a description of the practices in the different schemes. Next, the most common irrigation type (short furrow irrigation) will be described in more detail.

Dingleydale: Irrigation water is abstracted by the Dingleydale weir at the Tlulandziteka River. Irrigation is from Monday till Friday, during the day. On Saturday and Sunday water is diverted to fill the Champagne dam, see below. During the night the water is diverted into the balancing dams. Every night a different dam is filled, the stored water is used to irrigate the fields for the next week. Water unused in Dingleydale scheme should flow into Orinoco dam. However the Dingleydale canal system is in such a decrepit state that the last 4 to 5 km remains dry even during the wet season [Swart, 2008a]. Several stakeholders mention different reasons for the water not reaching Orinoco dam. The main reasons are competition and water losses. Due to competition, between Dingleydale and Champagne, about the scarce water in the main canal no water reaches Orinoco dam[66]. An example of competition about water can be found at balancing dam 7. This dam is not directly connected to the main canal, but through another balancing reservoir, several times a year this dam is empty, the reason being that most of the water is used upstream of balancing dam DD-7[67].

[64] I was not able to find any data on return flows in the Sand catchment.
[65] I could not get hold of any (design) report or construction drawing. According to several government officials these reports are lost.
[66] All the water in the Dingleydale main canal is already abstracted before it eventually reaches Orinoco Dam. However, due to limited transport availability and bad roads I was not able to check the last section of the main canal, from balancing dam 9 onwards.
[67] DD-7: the 7th balancing dam in Dingleydale scheme

New Forest: Irrigation water is abstracted by the New Forest weir at the Mutlumuvhi River. Irrigation is from Monday till Thursday, during the day. During the night and from Friday to Sunday water is diverted to fill the storage reservoirs. Currently only 8 out of 10 storage reservoirs are functioning. Water unused in New Forest 1 flows into Orinoco dam, which is located halfway the New Forest main canal. From the dam water is released to New Forest 2. The scheme is divided in four wards, each ward being responsible for the distribution of water and the maintenance of a section of the irrigation scheme[68]. At the tail end of one of the secondary canals there is large commercial farm located. The crops at the "New Forest Vegetable Farm" are irrigated by a high tech drip irrigation system[69]. This farm is the only agricultural water user which determines irrigation scheduling by means of an evaporation pan. If the water does not reach balancing dam NF-2, next to the farm, the farm manager arranges his labourers to clean or maintain the upstream canal[70].

An irrigation schedule per secondary canal is drafted by the scheme management committee. Based on this schedule the different balancing reservoirs are filled. After filling the reservoir the stored water is used to irrigate its command area during the following week. For example balancing dam DD-1 is filled on Sunday during the day, the stored water is used to irrigate from Monday to Saturday[71]. One of the members of the dam committee opens the inlet of the dam once a week and opens the outlet of the dam every morning and closes it every afternoon.

From the main canal water is diverted (through the balancing dams) to the secondary canals. The concrete lined secondary canals each serve a group of farmers, the number in this groups vary according to the topography. Usually each secondary canal receives water once a week throughout the year. The first irrigation turn is from 7 to 12 o'clock, the second from 12 to 17 o'clock. Several farmers irrigate at the same time. The irrigation schedule is drawn in close cooperation between the dam committee and the farmer. It should be noted that I could not find any evidence for irrigation scheduling, there is no schedule available and the farmers irrigate when irrigation is required by the crops. According to several farmers there is an irrigation schedule indeed but they do not know the schedule, and if they know the schedule they do not follow it.

Along the secondary canals farmers are organized in dam committees, in which they divide the water amongst themselves. The farmers open and close the structures themselves. The number of farmers irrigating at the same time depends on the water availability. In dry periods it will take longer to irrigate a plot and the number of farmers irrigating at the same time will be restricted.

The most commonly used irrigation type is short furrow irrigation[72]. Water is diverted small canals (pre-constructed furrows) between the crop rows. There used to be sprinkler irrigation (30ha) at the plot owned by Agriculture and Rural Development Corporation (ARDC) to irrigate tobacco files. But the New Forest Tobacco Scheme tobacco scheme was not economically viable and is not operated anymore.

Several interviewees argued that furrow irrigation is very inefficient. Furrow irrigation is not the most efficient irrigation method indeed. But furrow irrigation is the best suitable irrigation type for these

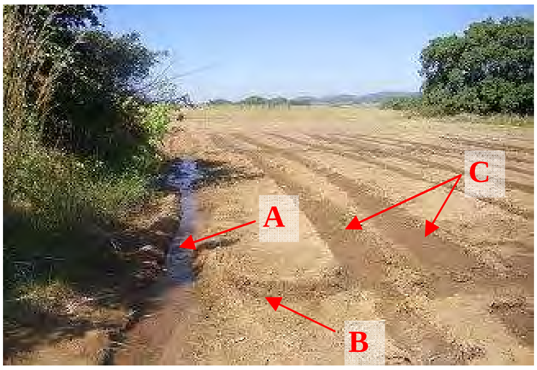
[68] From interview secretary of New Forest Irrigation Management Committee, 9 March 2009, New Forest.
[69] The high quality crops (pepper, tomato, beans and butternut) of this farm are sold in the large South African cities and to international clients.
[70] From interview farm manager, 13 May 2009, New Forest.
[71] From interview chairman of DD-1 committee, 8 April 2009, Dingleydale.
[72] Short furrow irrigation is a combination of basin and furrow irrigation and consist of short furrows with little or no longitudinal slopes, in which a certain amount of water is let in, in a relatively short time and the water is allowed to infiltrate the soil. Source: www.arc.agric.za accessed 4 August 2009.

schemes based on water availability, simple irrigation knowledge of the farmers, hardly any government support, and no financial means to upgrade the scheme to a more advanced irrigation type. This is confirmed by a 1999 report about the refurbishment of both schemes [ARC-LNR, 1999]. The engineers who drafted this report did several field tests to determine the field efficiency of short furrow irrigation in the two schemes. The report concludes:

- Supply furrow of 100m, efficiency between 59-74% depending on the soil type
- Supply furrow of 61m, efficiency between 66-77% depending on the soil type

Therefore, short furrow irrigation is probably the most suitable method of irrigation at the schemes at this stage. It doesn't require expensive equipment, and the farmers are experienced with this irrigation type. Despite the low efficiencies and other difficulties it is argued by several senior government officials and reports [i.e. ARC-LNR, 1999] that the irrigation practices on the two schemes is better than most furrow irrigation in the Northern Province.

Before the start of the irrigation season, the farmer prepares his plot by ploughing followed by disking the soil. Next, ridges are made to form a strip of three to six furrows, about 1m wide and 200mm deep. These long strips between 50 and 120m long are subdivided into sets of short furrow basins approximately 8 to 10m long, by construction cross furrows perpendicular at the furrows (see Picture 6.14). The top furrow is levelled as a supply furrow to convey water to each of the cross furrows. Once the plot is ready for irrigation, the water is released from the secondary canal. There are no structures in the secondary canal to divert the water to the fields. Therefore, obstacles (e.g. sandbag) are placed in the canal to divert the water to the adjacent fields (see Picture 6.15). After which the farmer diverts the water into the supply furrow and next to the short furrow. Some farmers start with the last furrow and works back to the supply furrow, other farmers irrigate the other way around. After irrigating the last short furrow, the first stet of furrows is closed and water is diverted into the next set of furrows.



Picture 6.14: Short furrow irrigation
Source: author, 2009
Note: A is the supply furrow
B is the cross furrow
C is the short furrow

The water in the main canal is controlled by water bailiffs, they regulate the water flow in the main canal, monitor that the appropriate farmers get their water at the right time, oversee the filling of the balancing dams and the cleaning of the canals. The water bailiffs have no authority to enforce any regulations and have been threatened by the farmers when doing so[73]. During homeland control over the irrigation schemes the water bailiffs were responsible for operation of the schemes[74]. Due to government withdrawal the number of water bailiffs decreased. For example, until several years ago there used to be 7 water bailiffs at New Forest, currently there are only 2 water bailiffs left. The reason for the water bailiffs leaving is retirement. The DoA is

Picture 6.15: Secondary canal with sandbag
Source: author, 2009

[73] From interview water bailiffs, 11 March 2009 Dingleydale and 9 March 2009, New Forest.
[74] From interview senior DoA official, 20 March 2009, Nelspruit.

responsible for the employment of new staff, but it is proven difficult to find new staff members[75]. The remaining water bailiffs hardly ever operate any gate or oversee any activity except the maintenance of the canals. One of the water bailiffs at New Forest still operates the gates to fill the storage reservoirs. At Dingleydale these gates are operated by the farmers. There is not much communication between the water bailiffs and the irrigation management committees about water distribution.

<u>Champagne:</u> Irrigation water is abstracted by means of pumps from three different sources; Champagne Dam, Tlulandziteka River, and Klein Sand River. The water from the Tlulandziteka River is pumped into a canal and flows to a small storage dam, from this dam water is pumped into the sprinkler system. The water source for Champagne dam is natural runoff and the Dingleydale main canal. The citrus trees at the farm are irrigated by a pressurized micro drip system. Every fruit tree is irrigated by one or two small sprinklers close to it. Irrigation scheduling is determined by soil moister (hands) and precipitation (rain gauge). Usually the irrigation scheduling is once a week for a couple of hours[76].

A water sharing agreement between the Dingleydale irrigation management committee and the representatives of Champagne farm both agreed to share the water. From Friday 16:00 till Sunday 8:00, irrigation water is diverted from the Dingleydale main canal into the Champagne dam. For the remainder of the week the water is used in the Dingleydale scheme. The gate at the division box is operated by the labourers of Champagne farm. It should be noted that the verbal agreement was made between the representatives of both schemes and that the Dingleydale farmers do not agree to the decision made by its representatives. Sometime the Dingleydale farmers deliberately adjust the division gate in the weekend and divert all the water to Dingleydale again. Because of the conflicts between the farmers of the two schemes, the Champagne farmers constructed a pipeline from the Tlulandziteka River to fill the Champagne dam. However, due to a lack of funding there is no pump purchased yet.

Maintenance

Following the confusion about ownership (see section 6.3.9) a variety of answers were obtained to the question who is responsible for maintenance. During government control of the schemes DoA used to maintain the irrigation infrastructure. However, minimal infrastructural maintenance has been conducted since the infrastructure was build in the 1960's. Minimal work has been conducted to maintain and repair the irrigation infrastructure. Construction work that has been undertaken has only been on a portion of the main canal.

As describe above, the water bailiff used to be responsible for amongst, others maintenance. The water bailiff should check the main canal daily. However, he does not have any transport required for this duty. Nowadays the water bailiff only operates the gate at the abstraction weir during maintenance of the canals and to flush the sediment (stored in the sandtrap) once a month.

Due to the withdrawal of government services in the irrigation schemes, maintenance became a shared responsibility between DoA and the farmers. It should be noted, however, that most of the farmers argue that the government should maintain the irrigation infrastructure because they own it. The farmers should clean the canal and DoA provides support through the water bailiffs and a maintenance unit based in Thulamahashe. Farmers are responsible for clearing overgrowth around the secondary canal. Clearing overgrowth usually happens after the rain season.

[75] From interview DoA team leader maintenance, 7 April 2009, Thulamahashe.
[76] From interview Champagne farm manger, 29 April 2009, Champagne Farm.

Once in a few years the government hires a contractor to maintain the main canals. The result of these activities, however, is disappointing. For example, in 2005 a contractor was repairing the Dingleydale and New Forest canals but due to the poor performance of the contractor there was hardly any progress. In the end only 6km out of 26km of the main canal was maintained[77]. The maintenance of both schemes was then postponed until April 2006 when a new contractor was supposed to be appointed but this never materialized [Swart, 2008a]. The disappointing result of the maintenance by the contractor makes the farmers lose their confidence in the government[78]; "*we are abandoned by the government we voted for*".

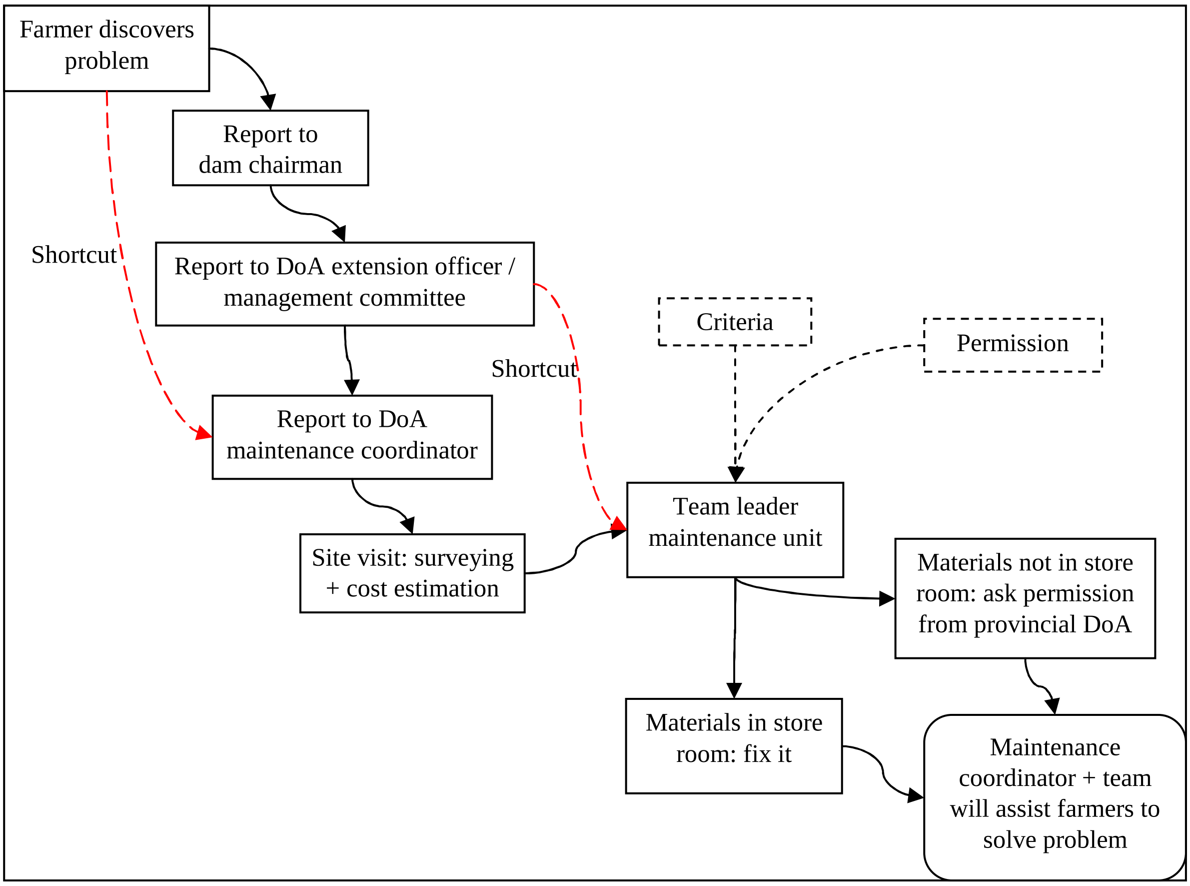


Figure 6.2: Compiled maintenance procedure
Source: author, 2009

Based on numerous interviews with farmers, extension officers, government officials and management committees a maintenance procedure is compiled (see Figure 6.2). This complied procedure is based on actual day to day practices. The official procedure is from farmer via dam chairman and management committee/ extension officer to the DoA maintenance coordinator. About once a month the maintenance team leader receives a maintenance request, by phone, from the farmers. However, several farmers contact the maintenance direct and do not follow the official procedure.

There is no contact between the management committees of the schemes and the team leader, the only contact is through the extension officers. The maintenance team leader approves maintenance based on priority, available materials and available budget. It should be noted that the team leader of the maintenance unit does not know his annual budget. Before a maintenance plan can be carried out it must be approved by the DoA director of sustainable resource management in Nelspruit[79]. The whole

[77] From interview chairman of Dingleydale irrigation management committee, 11 March 2009, Dingleydale.
[78] From interviews with several farmers.
[79] From interview DoA team leader maintenance, 25 March 2009, Thulamahashe.

process might take a couple of weeks. If the farmers cannot wait such a long time they will fix the small problems together[80]. On the other hand the farmers are not always in a hurry to report problems. For example, the broken inlet gate at New Forest abstraction weir was not reported for at least several weeks because the scheme chairman was not around[81]. The reason might be that the inlet gate is fixed in an open position which favours the farmer's abstraction.

As describe elsewhere in the report there are several constraints related to the maintenance of the irrigation schemes. One of the problems is the stealing of parts from the infrastructure (see Picture 6.16) and the demolishing of gates to release water downstream in order to catch fish. Another example is the stealing of trash racks of the inverted siphons, these trash racks are used as braai stands in the surrounding community. By removing the trash racks of the siphons the risk of blockages in the siphon considerably increases.

Picture 6.16: Missing steel plates at outlet tower Orinoco dam
Source: author, 2009

According to DWAF's Policy on financial assistance to resource poor irrigation farmers, the management bodies of WUAs or other approved legal entities with irrigation schemes are expected to mobilise their own resources to meet the O&M cost of their schemes. However, during the transitional period DWAF provides assistance to resource poor farmers, to assist them in becoming able to farm independently and cover the O&M costs within six years, in which period the O&M grant or subsidy will be phased out linearly [DWAF, 2004c]. If this policy is put in practice, it will have disastrous effects on the viability of the farmers in Dingleydale and New Forest schemes. This is confirmed by Perret and Geyser [2008] who did research about the financial situation of smallholder farmers in relation to the financial costs of irrigation services. They concluded that in Dingleydale and New Forest only successful intensified dry maize farmers maybe in a position to cover full financial costs of irrigation. But such farmers are only minority type in the schemes.

6.3.7 Organizational activities

Since there is hardly any communication, decision making, resource mobilization and conflict management in the irrigation schemes (each irrigator manages his irrigation activities independent from other irrigators) the research is not focussed on the organizational activities. The institutions mainly involved in day-to-day organizational activities are the irrigation management committees. The irrigation management committees, however, lack resources and leadership skills to become a strong institution. The organization of the schemes are characterised by a high level of ad hoc behaviour.

Decision making

The only decision making activity in the irrigation schemes is irrigation scheduling. An irrigation schedule per secondary canal is drafted by the scheme management committee. The irrigation schedule is drawn in close cooperation between the scheme committee and the dam committee. Along the secondary canals farmers are organized in dam committees, in which they divide the water amongst themselves. However, as described above, I found no evidence for irrigation scheduling in the field. According to Uphoff [1986: in Mollinga, 1997] planning is one major form of decision-making. I found no evidence for any planning making process except the above described irrigation scheduling.

[80] From interviews irrigation management committees.
[81] From interview secretary of New Forest irrigation management committee, 9 March 2009, New Forest.

Resource mobilization

The irrigators pay an irrigation fee to the irrigation management committee. The management committee uses this money to buy materials to maintain the infrastructure. There is a lot of confusion about the annual irrigation fee. Some farmers pay the annual irrigation fee of R100 per plot to the field office of DoA. However, several farmers mentioned that they do not pay an irrigation fee (anymore); *"we do not own the scheme, it is owned by the government so they should pay"*. Other farmers, however, pay an annual irrigation fee of R100 per plot to the irrigation management committee. In case of small maintenance or canal cleaning activities[82] the irrigation committees mobilizes the irrigators to collectively solve a common problem.

Communication

There is little communication among the irrigators and the committees. If there is any communication, it is mainly around the irrigation management committees and irregularly between DoA and the committees. The communication between the irrigation committees and DoA is about once a month by phone in New Forest, in Dingleydale the management committee meets a DoA representative weekly. According to Uphoff [1986: in Mollinga, 1997] a purpose of the communication activity is coordination. Due to a lack of resources and skills the committees are not performing this duty.

Conflict management

Most irrigators work independent of each other thereby causing conflicts with downstream water users. However, there are no formal structures to solve these conflicts. Dingleydale irrigators who do not follow the irrigation schedule are not punished, they will only be verbally disciplined at the next meeting. In New Forest, however, there are sanctions for those who do not follow the schedule, these farmers lose their irrigation turn to other farmers (New Forest). Small conflicts are dealt with in the dam committees, if they cannot solve the problem they consult the management committee.

6.3.8 Rehabilitation

As describe elsewhere in the report the condition of the irrigation infrastructure is dilapidated. The main reason for the dilapidated state of the infrastructure is the lack of maintenance. As mentioned by several authors [i.e. ARC-LNR, 1999: Perret & Geyser, 2008] the irrigation schemes in the Sand catchment are comparable with similar schemes in the country. ARC-LNR concluded in a 1999 report that there are in the order of 250 schemes in the country requiring rehabilitation, 167 have been identified in the Northern Province[83]. Limpopo DoA planned to spend R1.08 billion between 2006 and 2010 in rehabilitation of smallholder schemes [Denison & Manona, 2006: in Perret & Geyser, 2008]. This section describes, in a chronological order, the several plans to rehabilitate the irrigation infrastructure at Dingleydale and New Forest irrigation schemes.

ARC-LNR, 1999

As part of the Save the Sand programme ARC-LNR wrote a plan for the rehabilitation of the infrastructure of Dingleydale and New Forest scheme. The aim of this study was to make recommendations on how the irrigation scheme can be rehabilitated and managed so that it can contribute to the well-being of the community on a sustainable basis while conforming to the confines of anticipated water allocations [ARC-LNR, 1999]. The report suggested upgrading of the irrigation type to a drip irrigation system, which will save a lot of water. Another, less expensive, option was to rehabilitate the existing infrastructure; clearing of vegetation at least 1 metre on each side of the main canal, repair of storm drain, removal of sediment from the canals, reparation of outlet valves on major dams, and measuring structures, etc [ARC-LNR, 1999]. After finishing the report nobody took it forward and the report was shelved.

[82] The irrigation infrastructure is cleaned once a year (May)
[83] ARC 1999: Dingleydale action plan.

EVN Consultancy, 2006

According to the Inkomati Internal Strategic Perspective the Limpopo Province is implementing a programme to revitalise irrigation schemes. The master plan is for 117 schemes, among these are the Dingleydale and New Forest schemes [DWAF, 2004a]. Limpopo Province budgeted approximately R30 million for the refurbishment of the irrigation infrastructure. EVN Consultants was appointed to supervise the project [Swart, 2008a]. EVN did a survey, made several drawings and wrote a rehabilitation report. But before the project was completed Bushbuckridge was transferred from Limpopo to Mpumalanga Province. It is unclear what happened with the allocated R 30 million. EVN handed all their documentation over to Mpumalanga DoA. However, these reports are nowhere to be found in the Department. I spoke to several senior DoA officials who should know where to find the documentation but nobody knew where to find it. This is a bit strange especially because the DoA district head moved from Limpopo to Mpumalanga as well. He was responsible for the project under Limpopo and is still responsible under Mpumalanga Province. I phoned EVN to ask for a copy of the documents. One of the directors told me that they gave all the documents to Mpumalanga DoA and that they are not allowed to give me a copy because the ownership belongs to DoA.

New Forest Irrigation Management Committee, 2007

The New Forest irrigation management committee wrote a business plan for the rehabilitation of the scheme. They submitted their proposal was to Mpumalanga DoA. Until May 2009 the management committee did not receive any response on the proposal. However, the management committee also did not make any effort to follow up.

MABEDI, 2009

As described in section 3.8 the MABEDI project is implemented by several NGO’s. While working on several aspects of the project in the area, it became clear that the irrigation infrastructure must be rehabilitated in order to improve the livelihood of the small scale farmers. The farmers asked the MABEDI staff to write a proposal for the rehabilitation of the irrigation infrastructure. The agricultural part of the MABEDI project is coordinated by two NGO’s; Teba development and Lima. Teba development wrote a proposal for the refurbishment of the irrigation infrastructure. For a detailed description of the refurbishment proposal see annex F. The rehabilitation is based on a “farmer driven implementation approach”. The farmers will work on the rehabilitation of their own section of the canal(s). This helps to create ownership and through this the farmers will understand how to maintain the canals. Through the rehabilitation of their own canal sections they will become more aware that they are responsible for maintenance. And they will have the skills to maintain the infrastructure. In conclusion; the refurbishment of the canals will be done is such a way that the farmers and community will be skilled in the work allowing them to successfully maintain and manage the canals in the future and take full ownership and responsibility for their biggest asset and opportunity [Teba development, 2009].

Teba development wrote a realistic proposal, they do not promise an ideal scheme after the refurbishment. For example, they recognize that once the infrastructure is rehabilitated and the management committee is empowered, long term government support will still be required.

In April 2009 the proposal was discussed in the Mpumalanga Coordinating Committee on Agricultural Water (MCCAW). The ICMA asked Teba development to add the adjustments of the abstraction weirs in the proposal to make them compliant with the Operating Rules. After the MCCAW meeting one of the DoA directors wrote to the Head of Department a letter to ask permission to apply for funding at National DoA[84]. DoA did not have any funds allocated in their 2008 budget for rehabilitation[85].

[84] From interview senior DoA official, 15 April 2009, Nelspruit.
[85] From interview senior DoA official, 20 March 2009, Nelspruit.

However, this is in contradiction with DWAF [2007b] according to which both schemes had millions of Rand allocated to refurbishment of the infrastructure.

Discussion on rehabilitation

Almost all the interviewed stakeholders argued that the inefficient irrigation schemes must be rehabilitated to increase downstream river flow in the river. This section will examine the validity of this argument and the assumptions behind the reasoning. The question is: "*Will the river flow increase by rehabilitating the infrastructure*"?

It is argued that by fixing the canals, more water will reach Orinoco dam during the summer months so that adequate water is available for the irrigation schemes during periods of low flow, the winter months[86]. The assumption behind this reasoning is that because of the stored water, less water will be abstracted at the rivers. But since the irrigators abstract at maximum canal capacity it is improbable that less water will be abstracted during periods of low flow.

Another argument for rehabilitating the canals is that due to the poorly maintained canal system a lot of water is wasted causing water stress for the downstream water users. A senior ecologist in the catchment agreed with this argument: *"The canals need to be repaired so that the efficiency of the canals can be improved to make more water available to the agricultural schemes in order to allow the flow back into the rivers"*[87]. The assumption behind this reasoning is that by reducing the losses less water will be abstracted at the abstraction weirs. But, as mentioned above, the irrigators abstract at maximum canal capacity, therefore it is improbable that less water will be abstracted.

Thus, it is questionable whether the Reserve will be met after the canal infrastructure is rehabilitated. However the rehabilitation of the canal infrastructure can acts as bait for implementing the Operating Rules (OR). It will be easier to implement the OR by combining it with canal rehabilitation. This is confirmed by several interviewed key stakeholders who argue that the OR cannot be implemented before the repairs of the canal are completed. Implementing the OR before repairing the canals would only increase tensions in the community and may result in farmers attempting to manipulate the system by means of sand bags or damaging the diversion weirs and canals to get access to the water [Swart, 2008a].

Many more factors (e.g. stakeholder participation, adjusted abstraction weirs, controlled afforestation and monitoring) than simply infrastructural rehabilitation need to be in place before more water is available for the Ecological Reserve (see annex G). To make more water available a more holistic view of the catchment is required. For example, it is most likely that once the schemes are rehabilitated and the OR are in place, the downstream domestic water users will abstract the additional water[88]. This is confirmed by Lankford [2004: 5] who did research in the Ruaha River catchment in Tanzania where several indigenous small scale irrigation schemes were improved with among others improved offtakes. Based on his research in Tanzania he argues that *the improvement of traditional smallholder irrigation does not necessarily result in improved water performance, greater equity and reduced conflicts. The usual outcomes of such projects is a gain in water for the system being upgraded, especially if located upstream, accompanied by less ability to share water at the river basin scale.* Because of the lack of integrated planning (see section 6.6) this is expected to happen in the Sand catchment as well. Besides this it is not easy to foresee how water released from improved irrigation productivity will be shared between different goals of irrigation expansion or of meeting other sector's

[86] From minutes of meeting of Sand River irrigation schemes/ canals meeting between DWAF, DoA Limpopo and ARC, 14 June 2004.

[87] From interview ecologist SabieSand Game Reserve.

[88] The domestic pump operators abstract as much water as possible, depending on the water availability and pump capacity.

needs [Lankford, 2005]. Lankford's statement is valid by improved irrigation abstraction (implemented OR) as well. An irrigation rehabilitation project should not focus on fixing the infrastructure only. During the project one should also build on improved levels of manageability[89].

In conclusion, rehabilitation of the canal infrastructure is highly necessary but will not lead to more water in the River. This is in accordance with Lankford [2004], who argues that irrigation intakes may be a far more critical factor in reducing downstream water availability than the commonly held view that low irrigation efficiency is to blame.

6.3.9 Remarks on the irrigation sector

As presented above the extensive description of the irrigation sector is divided into three main categories according to the Uphoff matrix. However, for an understanding of the irrigation sector in the Sand catchment one needs to look at another very important factor as well; ownership.

Ownership

Above the maintenance activities at the irrigation systems are described. Closely related to maintenance is the notion of ownership. Because of the lack of ownership the irrigators do not maintain the infrastructure resulting in the current dilapidated irrigation infrastructure[90]. This is in accordance with Coward's [1983: in Coward, 1986] observation, who argued that ownership and responsibility for irrigation works invariably coincide. The irrigators in the Sand (except Champagne[91]) do not have a sense of ownership of the scheme. Explicit ownership of the scheme is fundamental to improve responsibility towards the scheme [Coward, 2006].

There is a lot of confusion about the ownership of the schemes. This is partly caused by the different definitions used to define ownership. For example, the ownership of the infrastructure belongs to the government, since the scheme is not handed over yet[92]. However, several farmers stated that they have the right to use the water from the scheme, hence, they are the owners of the scheme. This is confirmed by a number of government officials as well.

Mpumalanga DoA has plans to transfer the ownership of the irrigation infrastructure to the farming community. However, the farmers should be trained to manage the scheme first and the schemes will always be supported by the government[93]. Plans to transfer ownership are not new. The plans were already mentioned in the 1988's Agricultural policy in South Africa which describes the future situations of the irrigation schemes in the Northern Province; *"The schemes must be totally owned, managed and maintained by the participant farmers"* [DOA, 1998].

The land in the irrigation schemes is under the communal ownership of the tribal authority. Individual plots are utilised under Permission to Occupy (PtO) arrangement with the traditional authority. The land is controlled by the relevant chiefs, under whose tribal authority the land falls. Therefore, this land theoretically belongs to the chief who has ultimate authority over the allocation of that land. Households have been allocated pieces of land for farming, and are issued with a PtO certificate. A PtO gives exclusive individual lifetime usufructuary rights to the land but does not allow it to be sold, mortgaged, leased or subdivided [Perret, 2002b]. The PTO are handed down to family members of the household. The head of the family is usually a male and inheritance is traditionally through sons [ARC-LNR, 1999]. It should be noted that the PTO certificates remain the main visible claim to land,

[89] Personal communication B. Lankford.
[90] Another main reason for the dilapidated infrastructure is the government withdrawal from the schemes, the government used to maintain the infrastructure
[91] Champagne farm is owned by a Community Property Association.
[92] From interview senior DoA officials.
[93] From interview senior DoA official, 20 March 2009, Nelspruit.

even though, they have been obsolete since 1991 with the Abolition of Racially-based Land Measures Act [Perret, 2002b].

The ownership situation of Champagne is different from the situation at Dingleydale and New Forest. Champagne farm is owned by "Champagne Community Property Association" which is officially registered on March 24 2005 in terms of the Communal Property Association Act 1994. The Community Property Association (CPA) represents the claimant community; the people who used to live on the farm before they were forced to move.

Remarks

The irrigation schemes are a very important economic structure in the Bushbuckridge region. The schemes provide food to the community and requires employment (permanent + seasonal) [ARC-LNR, 1999: Perret & Geyser, 2008]. As described in chapter 3, the main purpose for building these systems was to provide employment for the local population [Pollard *et al.*, 1998]. The schemes were neither financially viable nor self-sustained since capital or operation costs were never covered by operation outputs and profit. Instead, under-pricing and government subsidization of water infrastructure and services, and management by parastatal agencies generated dependency and ignorance [Perret & Geyser, 2008: 2]. The irrigators were caught in a web of dependence in these heavily subsidized schemes. Government assistance was very often counterproductive and cultivated a sense of dependence and recurring request for aid [Irrigation Finance Commission, 1948]. Thus, today's government faces the challenges of rationalizing non-viable schemes, designed less for their named purpose (agriculture) than for the crises of an ever-burgeoning population [Pollard *et al.*, 2008b].

Before the first democratic elections the irrigation schemes were operated by (homeland) state agencies. After the change in political regime the situation changed drastically. This is in accordance with Mollinga & Bolding [2004] who argue that a change in the political regime of a country, like shifting from authoritarian forms of governance to democratic elected government, often entail changes in the configuration of state agencies and their relationship with the populace at large. State agencies were abolished and government support was almost entirely withdrawn from the schemes. The withdrawal of government support has led to the decline of the irrigation infrastructure. After the abolishment of the state agencies, the irrigation schemes were supposed to be managed by the local farmers, who do not know how to manage a large irrigation scheme. However, the old maintenance practices are not replaced by new practices.

A DoA review of small scale farmer irrigation projects found several common aspects, which are also applicable to the schemes in the Sand catchment; dilapidated infrastructure, ineffective water management, low production levels, little knowledge on crop production or irrigation, ineffective extension[94], lack of markets[95] and credit, and expensive and ineffective mechanisation [DOA, 1998]. Besides this enumeration several other characteristics of these schemes that are common to other small scale irrigation schemes can be mentioned [Merle *et al.*, 2000]:

- A diversity of practices and performance among irrigation farmers, generally little productive and subsistence-oriented;
- A simple conception of infrastructures (dam and canals, operating under gravity), deteriorating infrastructure, water allocation and water availability problems, especially in winter;
- A large majority of non-farming plot occupiers.

At present only about half of the farmers are operating at any level, on reduced areas [DWAF, 2007b]. Several reasons can be mentioned for the non cultivation of numerous plots. The main reasons are

[94] None of the interviewed farmers received any training from the extension officers in the last few years.
[95] Farmers lack access to markets to sell their crops and to buy inputs.

sickness, old age, no desire to farm, and no financial resources to maintain the farm [ARC-LNR, 1999]. During my field visits several farmers told me that the main reason for the plots being fallow is the high price of manure and fertilizers (and to a lesser extent water availability). Since the government withdraw its grants and other support most farmers cannot afford to buy these farm inputs. Another minor reason is that the soil needs to rest for several months[96].

Most of the interviewed farmers raised issues of immediate concern to them such as the lack of fertilizer, manure, or water. This is in accordance to Wester [2008], according to who poor people raise issues of immediate concern.

In an unpublished action plan written in the 1990's ARC-LNR concludes that virtually all the smallholder schemes must be regarded as failures. The main reasons are: top-down approaches, almost unmanageable water distribution systems, lack of irrigation expertise and ineffective service and input provisioning [ARC-LNR, unknown]. The same report argues that the rehabilitation of the infrastructure and the transfer of ownership will simply result in another cycle of failure, poverty and land degradation. Conditions for the success are competent management and production must be raised to acceptable standards.

In conclusion, the above mentioned problems are the result of decades of central management, lack of initiative or decision-making by the beneficiaries, lack of input, credit and produce markets, low land productivity, infrastructure degradation, massive male out-migration, unsuccessful financial management, and weakened land-related institutions [Backeberg & Groenewald, 1994: Perret & Geyser, 2008].

6.4 Domestic sector

The domestic water sector supplies the community with household water. The domestic situation in the catchment is characterised by inequities, the water availability in some of the villages is relatively good, in the rural areas, however, the situation is much worse. A research in the year 2000 estimated that about 44% of the population had supplies below government minimum levels of 25 l/p/d of potable water from a standpipe within 200 m of each household [Pollard & Walker, 2000].

The current problems in the domestic water supply sector partly originated from the apartheid policies. As a result of the apartheid policies the neighbouring Gazankulu and Lebowa homelands were governed as two separate states. Together with the ad-hoc planning of the homelands administration this resulted in poor record keeping, inappropriate systems and pipelines being diverted for kilometres to avoid crossing the territory of a different homeland government [Pollard *et al.*, 1998].

The influence on previous practices on today's infrastructure can be summarized by a statement of Butterworth *et al*. [2001: 4] who states that "*... historically, investment in rural water supplies has focused on extensive bulk water supply systems utilising surface water resources (relying upon large dams, treatment works and distribution networks). But in many cases, the planned reticulation systems have never been completed*".
Because of the insufficient capacity, insufficient coverage, and non-functioning of large parts of the water supply network, local people use other water sources for household consumption. People nearby the irrigation canals use these canals for domestic purposes e.g. washing, bathing, and drinking. During several field visits these practices were noticeable throughout the schemes. Alternatively, people use portable water from Bushbuckridge Municipality trucks that transport portable water to the villages. These trucks obtain their water from taps in communal systems in villages, from the irrigation canal

[96] According to several farmers the soil needs to rest for several months after being cultivated for a couple of years.

(see Picture 6.17) or from boreholes (see Picture 6.18). There are also several private vendors in the catchment who sell water [Pollard & Walker, 2000].

Picture 6.17: Water abstraction from irrigation canal
Source: author, 2009

Picture 6.18: Water abstraction from borehole
Source: author, 2009

Water services

The Water Service Act [1997] states that the local municipalities are responsible for drinking water. In the WSA these municipalities are called Water Services Authority (WSAU), they are defined as "any municipality including a district or rural council as defined in the Local Government Transition Act, 1993, responsible for ensuring access to water services" [WSA, 1997: chapter 1]. The duty of the WSAU to all the consumers/potential customers in its area of jurisdiction is to progressively ensure efficient, affordable and sustainable access to water services [Pejan *et al.*, 2007]. Every WSAU must have a water service development plan. This plan describes the existing water service, the future provision of water service, an implementation programme, a timeframe etc [Pollard *et al.*, 1998]. The WSAU is also responsible for the collection and treatment of sewerage, waste water and effluent. The WSUA in the Sand Catchment is the Ehlanzeni District Municipality. The Ehlanzeni District Municipality consists of the Bushbuckridge and Mbombela local municipalities, and the district management area of the Kruger National Park. Water service can only be obtained through a WSUA and it contracted Water Service Provider (WSP). The bulk water service provider for the Sand catchment is Bushbuckbridge Water. It is their duty to develop, operate and maintain the bulk water supply infrastructure [Pollard *et al.*, 1998].

In conclusion, the WSAU (Ehlanzeni District Municipality) is responsible for the water service in its district. The WSAU contracts a Water Service Provider (Bushbuckbridge Water) who is responsible for physical providing water supply and sanitation services.

Community water supply was the responsibility of the former Gazankulu and Lebowa homeland governments. After the abolishing of apartheid, DWAF became responsible for the water supply during the 1990's. DWAF would be responsible for water supply until competent local authorities exist to perform these functions [DWAF, 1994]. Since the establishment of Bushbuckridge Water in 1997, DWAF has shared responsibility for water provision in the Bushbuckridge area. Naturally, this has caused maintenance and planning difficulties [KJC, 2002]. Since the water service infrastructure is not owned by the Ehlanzeni District Municipality but by DWAF, water service delivery is a big challenge to the WSAU. The water service infrastructure in the former homelands is a bad shape, it functions inefficient or it is not present at al. The fact that there are several separate systems in place which are not linked, make it even more complicated.

Another challenge for Bushbuckridge Water is that the consumers are not used to pay for water services, which they used to receive for free. Since the Water Board's income is depending on the payment of the WSUA, which depends on the payment of the consumers to the WSUA there are severe financial problems at the Water Board. For example: due to the financial constraints it is difficult to operate the water treatment plants; expensive chemicals are required to purify domestic water because of the financial problems there is sometimes no money to buy chemicals and without chemicals the plant will be closed down. Two weeks before my visit of the Edinburgh A/B plant, this plant was temporary closed and there was no purified water for Thulamahashe. A few weeks later the municipality bought chemicals and the plant was reopened.

Water use

Since the water supply system in rural areas is seldom operational the main water source for the inhabitants of the villages was borehole water [AWARD, 2008b]. People have to walk long distances to collect domestic water from rivers or communal taps. Several villages are not connected to a bulk supply scheme at all, in addition most of the groundwater pumps do not have sufficient capacity [Smits *et al.*, 2004]. Only in the area around Acornhoek and Buffelshoek groundwater is fully exploited [Pollard *et al.*, 1998].

Abstraction infrastructure

This section describes the water abstraction component of the domestic sector. The focus of this research is on surface water, therefore the groundwater abstraction points are not taken into account. To focus even further this research deals with surface water abstraction and not with domestic water supply (pipes, communal taps etc) to the villages. For the main characteristics of all the domestic abstraction infrastructure in the catchment see Table 6.4, for a more extensive description of these abstraction points see annex C.

Picture 6.19: Missing transformer at groundwater pump
Source: author, 2009

The domestic infrastructure in the catchment is characterized by large and complex bulk supply networks. The chaotic layout of the infrastructure reflects the political and developmental history of the catchment [Pollard *et al.*, 2002]. Most of the water treatment plants are build in the 1990s by DWAF. Only one plant in the catchment is not build by DWAF Thulamahashe. This plant is build by Department of Works, the reason being that the former Gazankulu homeland managed water within the Department of Public Works in Thulamahashe.[Pollard *et al.*, 1998]

Most of these domestic schemes function erratically, if at all, due to poor maintenance and widespread unregistered connections. Domestic infrastructure within the Sand is generally poorly maintained, frequently broken and often parts are stolen [Moriarty *et al.*, 2004]. See Picture 6.19 for a picture of a missing transformer at a groundwater pump near Zoeknog. Another example is Zoeknog Water Treatment Works: due to a broken check valve it was not possible to take water quality samples for a couple of months in 2009.

It is argued by Smits *et al.* [2004], who did extensive water resource research in the Sand catchment, that the communities that could not meet their demands are limited by the available infrastructure, not by the available water resources. Therefore, the bottlenecks in domestic water supply are caused primarily by infrastructure. The management (operation and maintenance) of already existing infrastructure is the root of the current domestic water supply problems

Therefore, it is questionable whether the transfer from Inyaka dam will improve the situation in the rural communities. Before the purified Inyaka water can be pumped to the rural villages additional investment in conveyance infrastructure is required. Moreover infrastructure to convey water to the communities must be put in place.

The above mentioned problems are also valid for groundwater pumps. Most of the communities do have one or more boreholes installed. However, in practice many boreholes aren't equipped with pumps or those they have do not function [Smits et al., 2004].

In the rivers nearby the abstraction points small weirs are constructed to raise the water level. Water is pumped from these weirs into the water treatment plants, with the exception of Shatale, Edinburgh and Dingleydale. At Shatale water flows by gravity from a small dam in the mountains through a pipe to the treatment plant. The plant at Edinburgh A/B pumps water from the former Allendale irrigation canal (see Picture 6.20). The water treatment plant at Dingleydale is not comparable with the other plants and will therefore be describe separately below.

Near the Edinburg dam 2 water treatment works are build next to each other. Edinburg A is build by the then Gazankulu homeland administration to supply Tintswalo hospital in Acornhoek. Because of its limited capacity and the increasing demand in the surrounding villages a second larger plant was build; Edinburgh B. Both water treatment works are located along the former Allendale irrigation canal. Through this canal water was transferred from the Edinburgh dam to Allendale Citrus farm. Recently this citrus farm is closed. As a result the canal is now only used by the water treatment plant and a couple of small farmers upstream of the treatment plant. These farmers use siphons to water their plots.

Picture 6.20: Domestic abstraction from Allendale canal
Source: author, 2009

The Dingleydale water treatment work is located next to the Dingleydale canal. The purification plant abstracts its water from the irrigation canal (see Picture 6.21). The small and simple plant used to serve the communal taps in two villages, the nearby Dingleydale village and the further Stlari. Nevertheless, due to the very limited capacity the plant currently supplies Dingleydale village only. If the purified water is divided between the two villages, they each have only 2 hours of water per day. From Friday until Sunday, the water in the irrigation canal is used by the upstream Champagne Citrus farm. Therefore, the rest or the irrigation canal is empty and the plant cannot abstract water. To fill the irrigation canal up to the Dingleydale plant takes an additional two days, therefore the plant is only operated from Wednesday to Friday. The capacity of the small abstraction pump is 13 l/s. However, due to the dirtiness of the water and the simple treatment works the capacity of the plant is very limited. Therefore, the volume of treated water depends per day and varies between 43 and 100 m^3/day. The average of the two weeks before my visit in May was 72 m^3/day, which equals 0.01 Mm^3/a.

Picture 6.21: Dingleydale water treatment plant
Source: author, 2009

Table 6.4: Main characteristics of domestic abstraction points

	Zoeknog	Shatale	Dwarsloop	Sand River	Thulamahashe	Dingleydale	Champagne	Edinburgh A/B
Location	Zoeknog	uphill of Shatale and London	Dwarsloop Village	East of Edinburgh dam	West of Thulamahashe	within DD scheme	Champagne dam	Downstream Edinburgh dam
Position related to irrigation abstraction	Upstream of NF weir		outside reach of schemes	Downstream of DD weir and C pump	Downstream of NF weir	within DD scheme	Same site as C weir	Along Edinburgh canal
Water source	Mutlumuvhi river	Small dam at Narwhale river in the mountains	Tributary of Mutlumuvhi river	Mwandlamuhari river	Mutlumuvhi river	Dingleydale irrigation canal	Klein Sand River	Edinburgh canal
Construction year	1999	-	-	1994	1982	1998	2001	1992 (A) - (B)
Operator (since)	BBR Water (April 2009)	BBR Water (2003)	BBR Water	BBR Water (2001)	BBR Water (2002)	DWAF	BBR Water (2002)	BBR Water
Operation hours/days	24/7	24/7	12/7	24/7	24/7	12/3	24/7	24/7
Capacity (l/s)	32	20	5.3	12	106	13	70	17 (A) 33 (B)
Capacity (Mm^3/a)	1.01	0.62	0.17	0.38	3.33	0.01	2.21	0.53 (A) 1.05 (B)
Service area	Zoeknog + Mjambene	Shatale + London		Songeni + Mabomlo + Buffelshoek	Thulamahashe + Rolle	Dingleydale village	Acornhoek	A: Edinburgh + Cottendale B: Welverde + Lydlo
Connected to IBT	no	no	yes	no	yes	no	no	yes

Source: author, 2009

Legend: DD; Dingleydale
NF: New Forest
C: Champagne

Since all the domestic abstraction points in the catchment were visited it can be concluded that the operators have never experienced any water restriction. The operation of the plants is only restricted by the water availability in the river, not by any imposed restriction or agreement with other users, let alone the Operating Rules. None of the operators has ever heard about the Operating Rules. During times of low river flow the operators run a smaller number of pumps according to the water availability in order to abstract as much water as possible.

As described in section 8.2, the domestic water demand in the Sand catchment will be supplied through the Bosbokrand Transfer Pipeline (BTP). Until present (August 2009) only three water treatment works in the Sand catchment are connected to the BTP, namely; Edinburgh, Thulamahashe and Dwarsloop[97]. It will take another 5-6 years until all the current domestic river pumping stations are connected to the transfer pipeline. The BTP will be connected to the water supply networks currently supplied by the river pump stations. Once the water supply networks are connected to the BTP the pump stations will be decommissioned[98]. When required the pump station will be transformed to a booster station. It is important to note that there is no communication between Bushbuckridge Municipality and Bushbuckridge Water about this process. Since December 2008 Thulamahashe treatment works is connected to the BTP, but instead of adjusting the existing pump station to a booster plant, a new booster plant is constructed by Bushbuckridge municipality, next to the current station[99].

Since it still takes some time before all the domestic pumping stations are replaced by the BTP, DWAF decided in 2000 to maintain and upgrade the plants where required to meet the present demand until water would reach their service area from the Inyaka Regional Water Works through the BTP[100].

6.5 Commercial forestry

Due to its position upstream in the Sand catchment, forestry is in a strong position. It occupies the uppermost part of the catchment and its water consumption is thus before any other user in the catchment [Woodhouse, 1997]. Commercial forestry is often regarded as a threat for the water availability in a catchment. But on the other hand it has been claimed that forestry in South Africa generates more employment per unit of water, and at lower cost, than irrigation [Muller & Hollingsworth, 1991].

History

Afforestation started within the Sabie catchment in 1906. About the same time forestry plantations were also established in the Sand catchment. In 1972, the Department of Environmental Affairs introduced a permit system whereby new afforestation could only be carried out on application of the department. The permit system was established to prevent that more than 10% of the mean annual runoff (of the 1972 development conditions) would be consumed by plantations [Pollard *et al.*, 1998]. Homeland must also apply for permits. The plantations in the Sand catchment fell under the administration of the former homeland of Lebowa. The need to provide labour to the inhabitants of the Lebowa homeland combined with the desire to develop strategic reserves resulted in the planting of the plantations [Pollard *et al.*, 2008b]. Since the purpose of planting the trees was to provide labour rather than to make profit, it is not surprising that they were running at a loss. For example: during the 1997/98financial year the income from the plantations was R3.5 million and expenditure was R15 million [Pollard *et al.*, 1998]. The plantations are situated on three farms Onverwacht, Welgevonden and Hebron. These farms lay in the western portion of the catchment above the 1100 mm rainfall

[97] Own observation and personal communication Bushbuckridge Water production manager, 18 August 2009.
[98] Personal communication senior ICMA official 16 July 2009.
[99] See footnote 97.
[100] Supporting documentation of meeting of the Bushbuckridge area inter departmental water & sanitation planning forum to be held at the conference room, office of the premier, Thulamahashe on 13 September 2000.

isohyet. Additional there are small areas of exotic planted forests scattered throughout the catchment [Pollard *et al.*, 1998]. The planted trees were mainly pine (95%) and Eucalypt (5%) [Pike, 1999]. According to the NWA trees planted for commercial purposes prior to 1972 are considered as legal afforestation and are classified under existing lawful water use. The Lowveld plantation were established prior to 1972 [DWAF, 2009b]. The Lowveld Plantations are state forest land and managed by DWAF [DWAF, 2009b].

The Save the Sand report was very critical about local forest management [Pollard *et al.*, 1998]. The DWAF Director Commercial Forestry however indicated in a policy document that the area planted under commercial species can be classified as the best and highest productive areas for commercial forestry. In some instances, the annual increment is of the highest in the Mpumalanga Province and in the country [Reineke, 2002].

Streamflow reduction

Although forestry does not abstract water direct from the river, trees consume soil water or shallow groundwater and hence lead to stream flow reduction as less water is available for run-off. The NWA deals with streamflow reduction in section 36. The NWA *allows the Minister, after public consultation, to regulate land-based activities which reduce stream flow, by declaring such activities to be stream flow reduction activities. The Minister may..... declare any activity (including the cultivation of any particular crop or other vegetation) to be a stream flow reduction activity if that activity is likely to reduce the availability of water in a watercourse to the Reserve, to meet international obligations, or to other water users significantly"* [NWA, 1998: section 36]. Afforestation for commercial purposes is the only activity that is specifically mentioned as being a stream flow reduction activity in the NWA.

Several sources give a different streamflow reduction for afforestation. For example, Pollard and Walker [2000] argued that afforestation reduced the mean annual runoff in the catchment by 10 to 20%. Other sources, however, calculate the streamflow reduction based on the yield reduction. For example: DWAF states in its Inkomati Internal Strategic Perspective that the stream flow reduction is 3.1 Mm^3 per year [DWAF, 2004a]. A research about the Streamflow reduction in the Sand catchment by commercial afforestation showed that the impacts of afforestation were relatively insignificant near the only gauging station downstream in the catchment. The study proved that alien species might have a great impact on the streamflow on a local scale, but these impacts are 'dampened' or attenuated by the relatively small areas of commercial forestry (7 600ha of forestry compared to the catchment area of 107 190ha) and the contributions to the total streamflow of the downstream sub-catchments where commercial plantations are absent [Pike, 1999: 8].

Removal of plantations

Besides the stream flow reduction by forestry the poor management of the homeland authorities resulted in the afforestation of highly sensitive areas to serve the contracts of two sawmill operators. The afforestation of sensitive areas resulted in large amounts of sediments were introduced to the river due to poor management of roads and the clearing on steep slopes [Pollard *et al.*, 2008b].

The aim of the above mentioned Save the Sand Report was the rehabilitation of the ecological integrity of the catchment area in terms of biodiversity and water resources. The report recommended to clear at least (1250ha) 25% of the planted area [Pollard *et al.*, 1998]. These trees were planted on steep slopes, and in riparian and wetland areas. The government's restructuring programme for state forests, however, responded by exiting all the commercial plantations. The main reason for the forestry removal was the stream flow reduction, other considerations were the steep slopes of the area (resulting in high sedimentation losses), the high summer rainfall, and the ecology of the area [DWAF, 2009c]. Based on this Cabinet Memo 19 of 2001 questioned the environmental and commercial sustainability of 11 000 ha plantation forests in the Mpumalanga Lowveld, and approved of their removal [DWAF, 2009b]. The removal of the plantations was part of the catchment management programme called "Save the Sand". Both government and the Sabi Sand Wildtuin invested millions in the removal of the plantations [Swart, 2008a].

Picture 6.22: Former forestry plantations
Source: author, 2009

The Cabinet decided to incorporate the former plantation into the Blyde Nature Reserve, which should be managed by the Mpumalanga Park Board. This would result in the proclamation of a new national park, namely The Blyde River Canyon National Park [Swart, 2008a]. The intention of transferring the formal plantation to a National Park was for conservation purposes [DWAF, 2004a]. It was intended to develop conservation and ecotourism opportunities in collaboration with the surrounding communities [Swart, 2008a]. The two long-term timber supply contracts of York Lumber and Geldenhuys Sawmills had to be cancelled and the commercial forestry plantations had to be clear-felled within a 5-year period [Swart, 2008a]. Following government's decision to exit all the forestry in the catchment DWAF Forestry section made a falling plan for each year up to 2007 and the plantations were cleared through the Working for Water (WfW) programme (see Picture 6.22). The aim of the programme is to involve local communities in the destruction of vast areas of invasive alien species across the country, and in doing so improving the water supply for both rural and urban areas [Pike, 1999: 341]. The WfW program was started in 1996 in response to the recognition that alien invasive plants were using an estimated 7% of the country's mean annual runoff[101]. Invasive alien species are regarded as the single biggest threat to South Africa's biodiversity[102]. Since the beginning of the programme one million hectares of invasive alien plants are cleared. The program also aims to reseed cleared areas with indigenous species soon after clearance [Pike, 1999]. However, no rehabilitation has taken place in the Sand catchment. Several interviewed stakeholders mentioned that there has been no management in the cleared area. This has resulted in large tracts of land that are overgrown by unwanted species [DWAF, 2009b]. Mpumalanga Park Board was supposed to appoint a habitat rehabilitation manager in this area, however this never materialized [Swart, 2008a].

Besides the lack of rehabilitation of the cleared area is the loss of jobs in the forestry sector. About 375 DWAF employees were expected to be absorbed in the rehabilitation program and the proposed park structure. But the loss of an additional 780 direct jobs and 4260 in the supporting industries could not be accommodated [DWAF, 2009b]. The loss of employment and local economic potential further widened the poverty gap within the area [Reineke, 2002]. The local communities therefore requested DWAF to retain at least some of the plantations and sawmills, in conjunction with the establishment of the national park [DWAF, 2009b]. The skills required for tourism in the conservation sector does not match with the skills required in the forestry sector. Forestry is a labour intensive activity, which requires a large number of unskilled employees. It is difficult for these unskilled labourers to find new jobs elsewhere. Unfortunately, the area is already characterised by high unemployment rates, the unemployment rate in this area was 52% while the national average was 25-30% [DWAF, 2009c]. Therefore, additional jobs are desperately needed.

[101] National State of the Environment Report: www.environment.gov.za/soer/nsoer/Issues/water/response.htm
[102] Working for Water: www.dwaf.gov.za/wfw/default.asp

Because of the loss of jobs the neighbouring communities are lobbying for the timber plantations to be replanted [Swart, 2008a]. By clearing the forests through the Working for Water programme limited temporarily jobs were offered. After the WfW programme new jobs should be created in the newly established National Park. However, Mpumalanga Tourism and Parks Agency did not fulfil their mandate of establishing the National Park [Pollard *et al.*, 2009a: Swart, 2008b]. No new jobs opportunities became available. One of the reasons for the National Park not being established might be that the Premier of Mpumalanga did not sign the agreement for the management of the area due to problems relating to the budget allocation to the Lowveld plantations [DWAF, 2009c].

Plans to replant again

Based on the above described challenges DWAF reviewed the decision by the Cabinet to exit commercial forestry. The aim of the review study was to determine the feasibility of reinstating the forestry plantations in the upper catchment based on a request by land claimants of the local community to retain some of the plantations [DWAF, 2009c]. The review study is executed by a consultant: Ulusha Projects. It should be noted that DWAF could not find the report on which it based its decision to remove the forestry [Swart, 2008a]. This created difficulties in reviewing the original decision.

The original motivation to remove the Lowveld plantations was based mainly on environmental considerations of streamflow reduction weighed the heavier. The socio-economic and socio-environmental impacts of this decision were not considered at the time. The social impact studies conducted were focussed on the impact on mainly DWAF staff and the study therefore did not take a holistic view of all options available to achieve the objectives of conservation, job retention and job creation [DWAF, 2009b]. This is confirmed by the Acting Deputy Director of DWAF Forestry, according to him the original decision to exit from forestry was based on purely ecological and hydrological information without a thorough investigation into the social and economic impact [Swart, 2008a]. This contradicts the White Paper on Sustainable Forest Development according to which overall planning must be people driven, set within a national framework and built from the local level [DWAF, 1996].

Recently South Africa developed its millennium and growth objectives. One of the focuses of these objectives is the forestry sector. which is selected for accelerated growth under the Accelerated and Shared growth Initiative. Government realized that the sector cannot grow without securing and growing the plantation resource [DWAF, 2009b]. Additional, because of the escalation in timber prices arising from international and local timber shortages the demand for pine sawlogs is starting to exceed the sustainable cut, therefore the resource needs to expand urgently [DWAF, 2009b]. Therefore there is a need for renewable forestry resources to sustain economic growth and poverty relief expectations of the 21-century. The review study favours the Lowveld plantations because they are well positioned to contribute to this demand [DWAF, 2009b].

In conclusion "*the original decision to exit the plantations is no longer supported by the changing circumstances, e.g. economic and social priorities as well as market trends, within environmental and legal realities*" [DWAF, 2009b]. Based on this, the review study proposed that certain compartments (8,150 ha) of these former plantations should be re-planted over a three year period as per planting plan. It is argued that replanting the same area for the second time will be easier and cheaper than developing forest on virgin terrain. The reason being that there are already roads, store rooms and other facilities available.

To minimise the effect of the proposed forestry plantations on streamflow reduction it is suggested to plant longer rotation softwood. Softwood uses only a relatively small amount of water during the critical winter months with low river flows [DWAF, 2009b].

The "Exit Review Study" has been submitted to the Deputy Director General: Forestry. Currently final comments are being received, which will shape the submission through the ranks to the Cabinet. The previous removal of the plantations was approved by the Cabinet and only Cabinet can change this decision and approve replanting if this is the preferred option[103]. It is the deputy director general's expectation that the economic benefit that forestry and tourism can jointly give will positively influence the decision to replant the area. And even if the replanting will not be approved an alternative will be identified which will benefit the community. The exit review study recommends replanting some compartments of the former plantations and at the same time developing a National Park [DWAF, 2009b]. Therefore the coexistence of forestry and the needs of ecosystems are challenges that need to be addressed within the Bushbuckridge area [Reineke, 2002].

In conclusion: the Save the Sand Report [Pollard *et al.*, 1998] showed the impacts of afforestation as a stream flow reduction on low flows. Government then committed to remove the plantations and convert the land to conservation under the newly-established Blyde National Park. Although most of the forestry has been removed almost no progress is evident on the Park [Pollard et al., 2009a]. This, together with the community asking to replant the former plantations, has meant that DWAF explored the possibility of re-forestation. The exit review study recommends replanting some compartments of the former plantations and at the same time developing a National Park [DWAF, 2009b].

6.6 Planning

One of the main points from almost all the interviews was the lack of integrated planning. This is confirmed by Pollard *et al.* [2009a] who did extensive research in the catchment. According to her, the lack of overall integrated planning is regarded as a major problem by several stakeholders. Each water use sector is managed and operated independently. One example: during the 1992 drought the whole Klein Sand river flow was abstracted by Champagne Citrus Farm. As a result of the threat of a court action by the downstream game reserves water was released, but failed to reach further than Songeni were it was diverted to the off-stream Edinburgh dam [Weeks *et al.*, 1996]. Another example of the lack of integrated planning is the failure to incorporate the OR into other planning documents and the lack of knowledge about the OR and its implications for the different water users. This is confirmed by Pollard *et al*. [2009a].

Related to this is the lack of stakeholder involvement in the planning / decision process of water resources in the catchment. This becomes clear in the non participatory approach followed for writing the Catchment Management Strategies, see section 4.3.

The only functioning water management committee with jurisdiction in the Sand catchment is the Mpumalanga Coordinating Committee on Agricultural Water (MCCAW). Through this committee agricultural water matters are discussed between DWAF and DoA. However, this committee lacks decisiveness to reach common goals[104]. There is not only a lack of planning in between the different water use sectors, but even within the sectors. An example; there is no communication between the Champagne pumping station and its water receiver, the Acornhoek dam[105]. The pumping station operates independent from the dam(level). At the pumping house as much water as possible is abstracted.

As described in chapter 4 South Africa's water resources are managed in its "natural" unit the catchment by the Catchment Management Agency. This new institution is placed on top of a variety of

[103] Personal communication Deputy Director General: Forestry, 11 June 2009.
[104] From interview DoA director and ecologist.
[105] From interview pumping station operator, 13 may 2009, Klein Sand Water Treatment Work.

existing institutions with different jurisdictional boundaries [Swatuk, 2005]. According to Pejan *et al.* [2007] the mismatch between water management areas (catchment) and political boundaries (province, municipalities) raises many potential issues. An example is the participation of civil society, should they participate in water related issues through political structures, as outlined in the Municipal Systems Act or through CMA's as outlined by the NWA? Related to this is the mismatch in boundaries with water resource management being undertaken on a catchment basis and water services on a municipal basis (Pollard and du Toit 2005).

An often mentioned problem related to planning is the demarcation process of Bushbuckridge. Before South Africa's first democratic elections the homeland administrations were dismantled and integrated in the rest of the country. Bushbuckridge was allocated to Limpopo province. The local people, however, were in favour of joining Mpumalanga Province, which is much wealthier and most of the active farms on which people worked as well as most of the mines [Thornton, 2002]. Most interviewees mentioned that they wanted to move to Mpumalanga because Bushbuckridge is closer to major centres in Mpumalanga (Nelspruit) than Northern Province (Pietersburg). The local people showed their displeasure during several sometimes violent protests, for example: protestors burnt down the (Northern Province) government complex in 1997 [Ramutsindela & Simon, 1999]. After a long process Bushbuckridge was moved from Limpopo to Mpumalanga in March 2006. According to (mainly) government officials the uncertainty about the demarcation process delayed the planning process for the area.

The Sand catchment is a stressed catchment. Water scarcity appears in the dry winter months. My assumption was that social interaction would particularly be visible in situations of medium scarcity, and much less in situations of abundance or very severe scarcity, as discussed by Wade [1988: in Mollinga, 2003]. Thus water availability of natural resource relates to cooperation of the user of the resource. Wade [1988] argues that when the resource is plenty there will be no cooperation, there is plenty of water so there is no need for cooperation. But as the resource become scarce people will cooperate. However, cooperation reaches a point where it does not make sense because there is no resource at all (see Figure 6.3[106]).

For this research I define severe water scarcity as more water being consumed than renewably available. According to this definition the Sand catchment is not in absolute water scarcity: due to the very limited storage capacity in the catchment the water users are not able to abstract more water than the yearly renewable, there is simply no storage

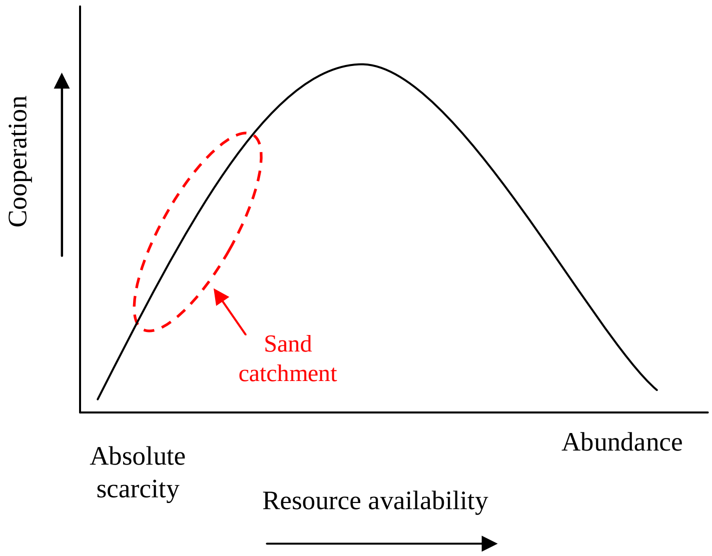


Figure 6.3: Graph relating value of cooperation to resource availability

Source: adapted from Uphoff *et al.* [1990]

[106] The figure is adapted from Uphoff *et al.* 1990. However, he seems to contradict his figure in the text. He states that in times of absolute water scarcity the dominant mode of irrigation management becomes mostly rationing the scarce supply. Fixed amounts of water are apportioned to all eligible parcels of land so as to spread the productive benefits of the water most widely and fairly. Because of the contradiction between the text and the figure the more suitable explanation of Wade, 1988 is used.

capacity available[107] to store more water.

In the Sand catchment, however, there is almost no cooperation between the different stakeholders, nor is there any participation in water allocation and management. The reasons for the lack of cooperation might be the lack of leadership, the struggles of the smallholder farmers to get organized, the lack of any coordination institution (except the irrigation management committees). In addition, most interviewed local stakeholders regard the ER as a waste of water, for which they are not prepared to reduce (or give up) their water use. Hence, they do not see any need for cooperation to improve this.

Monitoring

For planning purposes monitoring water uses and water availability is key. Therefore some remarks about monitoring water uses in the sand catchment are given.

There is only one river flow gauging station in the Sand catchment; X3H008 near Exeter. This gauging station is used to monitor the flow at the nearby IFR Site 7. The gauging station is constructed with a hydro flume and a sharp crested weir. The station is equipped with a data logger coupled to a GSM system. DWAF phones the stations every day (except on Sundays and public holidays) and updates the DWAF web site[108] with the hourly readings [DWAF, 2003b].

Picture 6.23: Exeter gauging station
Source: www.dwaf.gov.za

Because of the lack of monitoring several problems occur:
- Difficulties to establish water management rules (e.g. the Operating Rules);
- Difficulties modelling water availability and water use in the catchment;
- Risk of free riders since water use is not monitored.

As is the case in most smallholder irrigation schemes, the Sand catchment is inadequately equipped and designed to measure water flows and actual consumptions [Perret, 2002b]. It is important for the farmers at the schemes to register their actual water use. This will help them to enable future use to be properly managed[109].

There is no functioning irrigation monitoring structure in place. Along the main canals, near the abstraction weirs, discharge measuring structures are build, but no measurements are taken[110]. Hence there is no monitoring of the irrigation abstraction. Actual water use at main canal and secondary canal level are also unknown. At scheme level the irrigation management committee should monitor the water use in the scheme[111]. At secondary canal level the dam committees should monitor water use along the secondary canals[112]. During the several field visits I found no evidence for this. None of the interviewed farmers could mention when last did they saw somebody monitoring water use.

Almost all the interviewed stakeholders argued that the water use in the irrigation schemes is inefficient and that a lot of water is wasted. But due to the lack of monitoring it is difficult ground these statements based on actual water use figures. This is confirmed by Blankford [2005] who states that irrigation productivity and efficiency can be improved, but it is of concern that irrigation is

[107] It should be noted that this research does not focus on groundwater availability/abstraction
[108] Website: http://www.dwaf.gov.za/hydrology/cgi-bin/his/cgihis.exe/StationInfo?Station=X3H008
[109] From DWAF presentation; "Inyaka Operating Rules", 2003.
[110] From interviews water bailiffs, irrigation committees and government officials.
[111] From interviews irrigation management committees.
[112] From interviews dam committees.

frequently labelled as 'inefficient' especially since detailed measurement using appropriate whole system methodologies at the catchment level has been so very rare.

6.7 Conclusion

It becomes clear from the above that managing water in the stressed Sand catchment with its competing users is a complex process. The water management in the catchment, in every water use sector, is highly influenced by politics. As presented in chapter 2, the conceptual framework, water is a politically contested resource. Above the everyday politics of water in the Sand catchment is described. Water resource practices are shaped by local relations of power. Clear examples of this are the ("powerful") apartheid policies who shaped the landscape and practices of the catchment that we see today. A more recent example is the unequal access to domestic water in the catchment. The poor people have less social power resulting in inadequate access to the water resources. The apartheid policies have shaped the landscape and practices of the catchment that we see today. And despite the new, international commended, policy framework the water in the catchment is not managed according to new water legislation.

The irrigation sector, being the main water user, is characterised by poor operation and maintenance of its structures. It is proven to be difficult for the farmers to manage the schemes with their extensive infrastructure and large number of smallholder farmers. The current state of the irrigation schemes can be summarized by a statement from one of the interviewees; *"... the schemes are a management disaster"*.

According to DWAF and the ICMA surface water in the Sand catchment should be managed according to the prescribed Operating Rules. However, in practice the water is not managed according to these rules; the Operating Rules are invisible in current practices. The next chapter describes the results of the current water management practices on the water availability.

7 Water balance – water deficit

7.1 Introduction

This chapter gives an overview of the water balance in the Sand catchment. Following from the above described actual water management practices I will describe the resulting water availability. This section makes a start with assessing the water availability (section 7.2), after which the water requirements are presented (section 7.3). The following section describes the actual abstracted amount of water (section 7.4). The in section 7.5 presented water balance combines the water availability and the water requirement in the Sand catchment. This section will analyze the water resource situation in the Sand catchment and assess whether the catchment is in water deficit. As described in chapter 4 the Reserve is the only right to water and should be given effect to. In section 7.6 I will analyse the compliance of the actual river flow with the Reserve. The chapter is closed with a concluding section 7.7, showing the discrepancy between the water requirement and the actual water use.

The figures presented in this chapter do not include wastewater, evaporation, return flows, groundwater storage etc and therefore represent a simplification of the actual situation. While analyzing the several available reports it should be noted that every model which address the water balance of the Sand catchment shows considerable discrepancy between the different numbers, especially the water requirement per water use sector. The models use different assumptions and different levels of accuracy hence the difference in the outcomes.

While describing the different water users in the Sand catchment it should be noted that, there is no obligation on the Sand catchment to fulfil (part of) the international obligation to Mozambique. Water required for the international obligation comes from the Inkomati and the Crocodile catchments [DWAF, 2009a].

7.2 Water availability

Water availability can be expressed in several ways; in this report, only two ways are described namely mean annual runoff and yield. The National Water Resource Strategy defines the Mean Annual Runoff (MAR) as the total quantity of surface flow which is the average annual runoff originating from a certain geographic area [DWAF, 2004b]. However, in an arid country like South Africa it is not economical to plan based on the mean annual runoff. It is more sensible to plan according to the yield of a river. The National Water Resource Strategy defines yield as water that can reliably be withdrawn from a water source at a relatively constant rate [DWAF, 2004b]. Therefore, only a small portion of the mean annual runoff is available as yield. The Inkomati Internal Strategic Perspective refers to this amount as the utilisable yield [DWAF, 2004a]. Both previous definitions are not holistic and do not include the sustainable principle of the NWA. The Inkomati Water Allocation Plan, on the other hand, limits the yield to water that can be abstracted from the water resource on a sustainable basis, thereby including the sustainable principle of the NWA [DWAF, 2008b]. The three different definitions (yield, utilizable yield, and sustainable yield) are all used by DWAF. On first sight it seems that one can differentiate between the three yield types. However, after a closer look it becomes clear that the three terms are mixed up in the different reports. This research adopts the definition given by the Inkomati Water Allocation Plan according to which the yield is limited to water that can be abstracted from the water resource on a sustainable basis.

Because of the large seasonal fluctuations in stream flows in South Africa, the highest yield that can be abstracted at a constant rate from an unregulated river is equal to the lowest flow in the river [DWAF, 2004b]. By constructing dams, water can be stored during periods of high flow for release during periods of low flows. This increases the amount of water that can be abstracted on a constant basis and, consequently, increases the yield. As described in the previous chapter, water for the Ecological Reserve is water that must remain in the river and may not be abstracted. Therefore the ER reduces the utilisable yield [DWAF, 2004a].

Rainfall and subsequently stream flow differs from year to year. Therefore, the utilisable yield also varies from year to year. For example, the amount of water that can be abstracted for 98 out of 100 years on average is referred to as the yield at a 98 per cent assurance of supply. Thus, 2 years out of every 100 years this yield will not be available. Since it is not economical to plan on a yield, which is available 100% of the time, different levels of assurance and different levels of curtailments are used per water use sector. It is not economical to plan a 100% yield since this yield is very small and restricted by the lowest yield in the season.

In a forthcoming report on developing a methodology to classify water resources DWAF gives a first indication of target assurances. These assurances mentioned in the Inkomati Water Allocation Plan (see Table 7.1) are sourced from this report. There is no curtailment rule applied for international requirements, basic human needs or ecological requirements since these must be fully supplied at all times (see chapter 4).

Table 7.1: Assurance levels as proposed in the Classification System

User sector	Assurance	Maximum curtailment
Reserve		
- BHNR	100 %	0%
- ER	see below	see below
International	100%	0%
Strategic	99%	5%
Industrial	98%	20%
Irrigation[35]	70-95%	30-100%

It is difficult to determine the mean annual runoff for the Sand catchment. Several authors use different periods, different models and different runoff definitions e.g. virgin runoff and total runoff. The differences in annual virgin runoff, varies within a range of 121 Mm^3/a [Smits *et al.*, 2004] to 158 Mm^3/a [Weeks *et al.*, 1996]. The last figure was used for the IFR determination. It is not surprising that the total runoff under afforestation also differs, it varies from 134 Mm^3/a [Weeks *et al.*, 1996] to 145 Mm^3/a [Pollard & Walker, 2000]. This results in different stream flow reductions varying from 8 to 15%.

The research of Smits *et al.* [2004] shows clearly that there is a highly variable runoff in the catchment (see Figure 7.1). It becomes clear from this figure that there is a large variability in annual runoff over the years. The median total annual runoff in this period was 121 Mm^3 [Smits *et al.*, 2004]. It should be noted that Figure 7.1 is based on data collected in the 1970s which was a dry decade. A longer period might show a somewhat more optimistic situation.

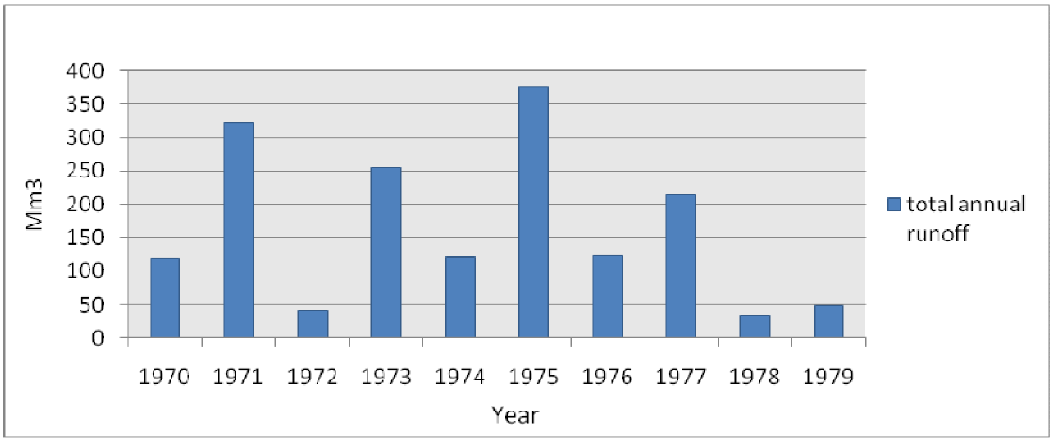


Figure 7.1: Total annual runoff
Source: adapted from Smits *et al.* [2004]

There is not only a highly variable annual runoff across the years but also within the years. See Figure 7.2 for the variability within a year, between the wet and the dry season as is to be expected in a river in a semi-arid region. Figure 7.2 shows daily runoff values for each month of the year at the catchment outlet under virgin conditions, at different levels of probability. It becomes clear from this figure that the variability in flows is especially high in summer from January to March and much less from July-October.

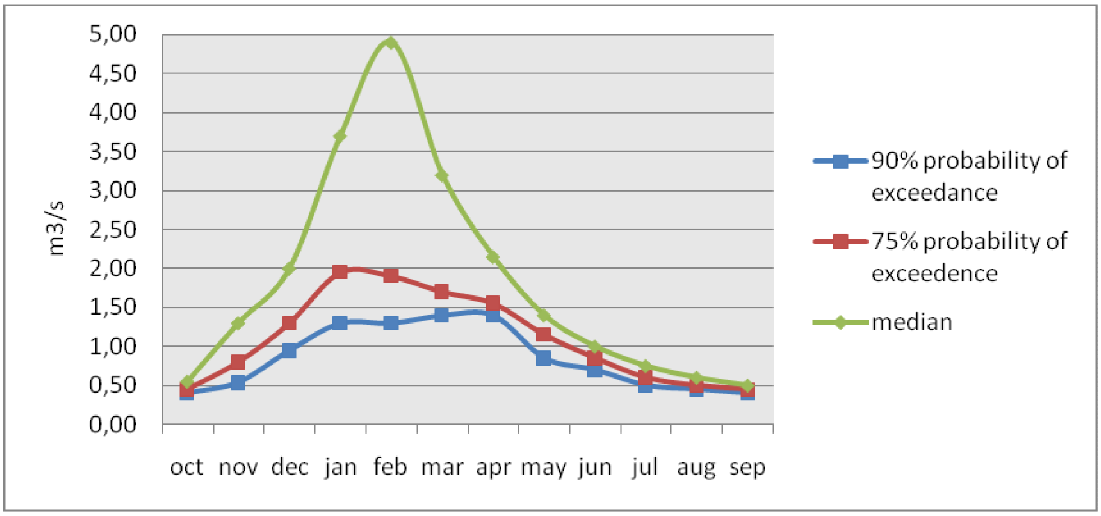


Figure 7.2: Catchment flow (m3/s) at different levels of exceedance
Source: Smits *et al.* [2004]

The available water in the Sand catchment is limited to the run of the river yield and the yield of the few small dams in the catchment [DWAF, 2004a]. Several dams, such as the Edinburgh, Champagne and Orinoco Dams increase the yield of the system. The total available yield (after supplying the ER) is 9 Mm^3/a [DWAF, 2004a]. However, a more recent study of the water resource system which included the removal of the forestry plantations estimates the yield (after supplying the ER) as 10.7 Mm^3/a [AWARD, 2008a].

The transfer of water from the Inyaka dam through the Bosbokrand Transfer Pipeline increases available water supply in the Sand catchment (see chapter 8). Currently about 25 million litres (9.1 Mm^3/annum) of treated water is transferred daily through the pipeline[113]. The discharge of the pipeline depends partly on the water level (= pressure) in the two storage reservoirs at Inyaka Regional Water Works.

7.3 Water requirement

Almost all the authors [i.e. DWAF, 2003b: Pollard *et al.*, 2009a] who quantified the water requirements in the catchment agreed that the calculation of consumptive water use per sector is a complex process. For example in calculating the irrigation requirement each author uses different input data for climate, efficiency, soil, drainage, and cultivated area etc. Therefore, it is not surprising that each report provides different water requirements. Below the water requirements of the different water use sectors are described in the same sequence as in the previous chapter.

<u>Environment</u>

The environmental sector is a largely non-consumptive water user. Up to now, there is no comprehensive Reserve determination yet. Therefore, the preliminary results are used for EWR estimation. The EWR requirement for the Sand catchment is 43 Mm^3/a [DWAF, 2009a]. DWAF is currently working on the comprehensive Reserve determination and is updating the Reserve. This will result in improved confidence in the Reserve estimates [DWAF, 2008b].

[113] From interview production coordinator Inyaka Regional Water Works, 29 April 2009, Inyaka Regional Water Works

Since the environmental water requirement is a largely non consumptive water user, the water will be available for use in Mozambique [DWAF, 1994].

Irrigation

Several sources mention different annual irrigation water requirements, it varies from 32.3 Mm^3/a [Butterworth *et al.*, 2001] until 11.6 Mm^3/a [DWAF, 2004a]. It is difficult to compare these figures because of the differences in irrigated area, type of crop, efficiencies etc. For example the calculated water requirement in the report of Butterworth *et al*. [2001] is based on the 1985 requirement including the coffee and tea plantations at Zoeknog. The ICMA report on the other hand calculated water requirement based on a much smaller irrigated area, and 10% canal losses [DWAF, 2004a].

The irrigated area also fluctuates from year to year in response to availability of water, farm inputs, access to markets etc. Besides these forces the irrigated area also changes due to the establishment of new schemes (e.g. Zoeknog) and the closing of existing schemes (e.g. Allendale). In the recent Inkomati Water Availability Assessment Study, an irrigation water requirement of 17 Mm^3/a is calculated [DWAF, 2009a]. This figure is based on the 2004 requirements and an irrigated area of 25 km^2. This figure is currently the most updated water requirement for the irrigation sector in the catchment.

The average evapotranspiration ET_o peaks in January and February at 5mm/day, in winter months it is about 2mm/day [ARC-LNR, 1999]. The average evapotranspiration is much higher in summer but due to sufficient rainfall there is enough water for irrigating summer crops. Hence, irrigation can be regarded as being supplementary and as an insurance against drought [ARC-LNR, 1999]. The situation in the dry winter months is different. In winter there is little rain and thus a small river flow. Throughout the year the irrigators strive to divert the river flow up to the maximum capacity of the canals, thereby neglecting the water requirement of downstream water users. In winter the irrigators use all the dry season baseflow often causing the Sand River to stop flowing completely [DWAF, 2009a].

Several authors mention that the cropping pattern and the cultivated area is adapted according to water availability [ARC-LNR, 1999]. However, during my fieldwork I found no evidence for this. According to the interviewed farmers the main factors influencing the irrigated area are the affordability and availability of manure and fertilizer and to a lesser extent water availability.

Domestic

Currently the domestic requirement is supplied by the (ground and surface) water resources in the catchment. In the future the domestic requirement will be supplied through the Bosbokrand Transfer Pipeline which supplies water from the Inyaka dam (see chapter 7). Thereby replacing the domestic abstraction in the catchment but the water supply infrastructure is not in place yet. Therefore it is assumed that users will continue to use groundwater to supplement their supplies [Smits *et al.*, 2004].

Domestic water use in the catchment is difficult to quantify, because of unmonitored abstraction points, uncertainty about the number of inhabitants, numerous unregistered groundwater abstraction points and the increase in available water from the Inyaka dam which is extended to previously unsupplied villages [AWARD, 2008a].

Due to uncertainty about the number of inhabitants in the catchment it is difficult to determine the actual and accurate domestic water requirement. A 2004 report calculates the domestic water requirement based on a population of 350,000 inhabitants (2004 population) and 25 l/p/d on 3.2 Mm^3/a [Smits *et al.*, 2004]. This simple sum is used in several reports [i.e. Moriarty *et al.*, 2004: Smits *et al.*, 2004], the total inhabitants are simply multiplied by 25 l/p/d. This calculated requirement does not take into account any losses or illegal connections. Because of the losses and illegal connections a lot more domestic water is required. Unfortunately, there is no information available on system losses in the catchment. But the system losses are likely to be high due to relatively poor maintenance and also owing to a large number of unauthorised connections [Moriarty *et al.*, 2004]. From my own observations I conclude that there are considerable losses in the catchment mainly due to broken pipes and leaking taps.

It is almost impossible to compare the different studies on domestic water requirement. Different studies use different population figures and quantities, sometimes even in the same year. For example two 2004 reports use different population figures: 294.000 [Moriarty *et al.*, 2004] against 350.000 [Smits *et al.*, 2004]. One of the most accurate domestic requirements is mentioned in the Inkomati Water Availability Assessment Study and is 11.3 Mm^3/a, based on 2004 requirements [DWAF, 2009a].

The nominal supply capacity of the installed domestic infrastructure is about 80 l/p/day[114]. This does not mean, however, that people have access to this amount of water. Due to management and infrastructure problems in the supply and provision of domestic water access to sufficient domestic water is limited.

Forestry

Since the forestry sector does not abstract water from the surface water resources it differs from the other water users. Forestry is regarded as a stream flow reduction activity, thus reducing the available yield as less water is available for runoff. Currently, there are no commercial plantations left in the catchment therefore there is no water used by the forestry sector. The water that the trees used to take became available further downstream in the catchment. Below I will describe some characteristics about water use of the former forestry sector and describe the effects of the proposed re-afforestation on the water availability in the catchment.

The streamflow reduction varies per report, because of different hydrological data, different planted area etc. The 1996 IFR study calculated a streamflow reduction in February of 20% of the total runoff. The same study shows that in September, however, the streamflow reduction from forestry is 75% or the total runoff [Weeks *et al.*, 1996]. This shows that the impact of the forestry in times of low river flow (dry winter) is significant larger than in times of high river flow. This reduction, in combination with the year round irrigation, might explain why the Sand River frequently stops flowing [Smits *et al.*, 2004]. Fortunately, the peak forest water consumption is from December until February when water availability is high.

Over time most of the catchment's plantations have been removed, thus older reports show a larger streamflow reduction than more recent reports. The Inkomati Internal Strategic Perspective calculates a yield reduction of 3 Mm^3/a [DWAF, 2004a]. The more recent Inkomati Water Allocation Plan calculates a yield reduction of 1 Mm^3/a [DWAF, 2008b]. This figure is based on only a small planted area of 43km^2 of pine and 13km^2 of eucalyptus left in the catchment [DWAF, 2006b].

As described in section 6.5 there are advanced plans to replant the former plantations again. Replanting will negatively affect the water resources in the catchment by reducing the available yield. According to DWAF's Review study the potential re-afforestation will have negligible effect on the natural stream flow [DWAF, 2009b]. As described above the streamflow reduction of forestry used to be 3 Mm^3/a [DWAF, 2004a]. Hence, by replanting the plantations the available yield will be reduced with 3 Mm^3/a.

The total annual required amount of water in the Sand catchment is 71 Mm^3 (see Table 7.2).

Table 7.2: Water requirement per sector

Domestic (Mm^3/a)	Irrigation (Mm^3/a)	Forestry (Mm^3/a)	Environment (Mm^3/a)	Total (Mm^3/a)
11	17	0	43	71

Source: author, 2009

[114] Personal communication International Water and Sanitation Centre researcher, 7 July 2009

7.4 Water abstraction

In practice the abstracted amount of water differs from the required and/or allocated amount. This section describes the actual amount of abstracted water as detailed as possible. All the (domestic + irrigation) abstraction points in the catchment were visited in order to get a clear picture of the actual water abstraction. Below the acquired information will be described, in the same sequence as before.

Due to a lack of detailed information on actual water use, the irrigation water requirements calculated in this study could not be verified. It is very important to calibrate the results of the several water availability studies with actual measured water use in order to increase the accuracy of this water balance.

Environment

Since the environmental sector is a largely non-consumptive water user this sector is not taken into account in this section.

Irrigation

Besides the uncertainty in irrigation water requirement there is also uncertainty about quantifying irrigation abstraction. This is due to the unmonitored irrigation abstraction. There are a few measuring devices in the irrigation schemes but they are not in use[115]. This is unfortunate since irrigation is the largest water user in this catchment, and therefore plays a major role in determining the water balance.

The current irrigation abstraction weirs are designed to divert water from the river up to the maximum capacity of the irrigation canals. Since the sluice gates at the inlet of the canals are not adjusted according to the crop water requirements, the water abstraction does not relate to the crop water requirements within the irrigation schemes. For practical reasons it can be assumed that the irrigators abstract all the available flow at the diversion weirs up to the maximum capacity of the canal[116]. The maximum abstraction capacity of the irrigation sector is calculated as being 36 Mm^3/a, see Table 7.3 [AWARD, 2008a]. This proves that the existing irrigation infrastructure is capable of (and often does) completely interrupt river flows during low flow periods in lower stretches of the river, as mentioned before by Moriarty *et al.* [2004]. This figure, which includes losses, is based on an 85 year simulation using monthly flow records. It should be noted that the Champagne abstraction canal is not in use anymore.

Table 7.3: Maximum water use by the irrigation sector

Irrigation abstraction site	Canal capacity (m^3/s)	Estimated diversion (Mm^3/a)
Champagne	0.127	3.5
Dingleydale	0.962	24.3
New Forest	0.283	8.2
Total		36.0

Source: adapted from Award [2008a]

However, in practice, the irrigators cannot divert this amount of water into their canals throughout the year. The irrigators are limited by the availability of water in the rivers. Hence, the river flow limits the maximum abstractable amount of water.

The irrigators at New Forest can abstract at maximum canal capacity for 85% of the year. Hence, for most of the year the irrigators can abstract at maximum canal capacity due to sufficient water availability in the river (see Figure 7.3). The situation for Dingleydale is completely different, the

[115] From interviews water bailiffs, irrigation committees and government officials
[116] From interviews water bailiffs and irrigation committees

irrigators can only abstract at maximum canal capacity for 16% of the year. Thus it is inaccurate to use the maximum canal capacity to calculate actual water use as done by AWARD [2008a]. The author therefore calculated an adjusted water use by comparing the river water availability with the maximum canal capacity. In case the river flow is above the canal capacity, the irrigators are limited by the canal capacity and the canal capacity is used. In case the river flow is below the canal capacity, the irrigators divert the entire flow into the canal and the river flow is used. This gives a modelled water abstraction for New Forest and Dingleydale of 7.3 Mm^3/a and 16.4 Mm^3/a respectively (see Table 7.4). The maximum abstraction of the irrigation sector is 23.7 Mm^3/a.

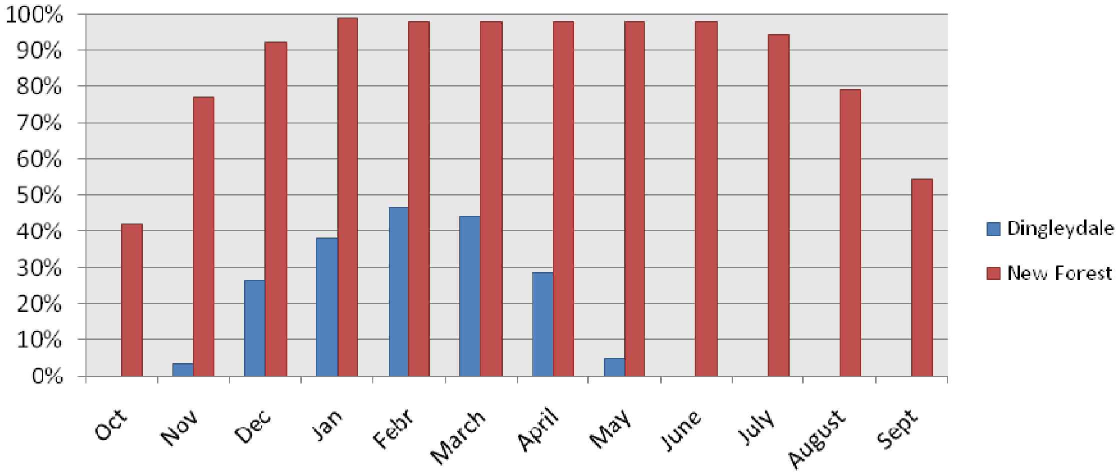


Figure 7.3: Canal capacities at irrigation abstraction sites
Source: author, 2009

As described in section 6.3 the registered volumes for New Forest and Dingleydale are 3.58 Mm^3/a and 5.08 Mm^3/a respectively. Thus it becomes clear that both schemes abstract more water that their registered volume. New Forest abstracts about twice the registered amount, Dingleydale abstracts about three times its registered amount. The registered amount is calculated by DWAF using the SUBWAT programme. The inputs for this Water Research Commission funded computer programme are the irrigated area and the cultivated crops[117].

The maximum abstraction is based on a simulation of monthly flow records of a period of 85 years from 1920 to the 2004 hydrological year. As shown in Table 7.4 the pump capacity of the two pumps at Champagne Citrus farm are not included since the capacity of the pumps is unknown and the pumps are not metered.

Table 7.4: Maximum water use by the irrigation sector, limited by water availability

Irrigation abstraction site	Canal capacity (m^3/s)	Pump capacity (m^3/s)	Estimated diversion (Mm^3/a)
Champagne	-	?	?
Dingleydale	0.962	-	16.4
New Forest	0.283	-	7.3
Total			23.7

Source: author, 2009

<u>Domestic</u>

According to Bushbuckridge Water their annual treatment capacity is 16.7 Mm^3 [Bushbuckridge Water, n.d.]. In order to crosscheck this figure all domestic surface water abstraction points were visited. The plant operators were interviewed to understand their practices. It should be noted that at some of the domestic abstraction points there is no functioning flow measurement equipment. Therefore the

[117] From personal communication senior DWAF official, 28 August 2009.

capacities of these abstraction points are based on experience and estimates of the pump operator. One example of a non working flow meter was found at Zoeknog Water Treatment Works, (see Picture 7.1). The flow meter is not working for almost two years. This is reported regularly to the municipality in Thulamahashe, but no action is taken place. Another example is the Champagne pumping station next to the Champagne dam. There is no flow measurement equipment in this recently constructed pump station. The operator reports only the running hours of the pumps. After consulting the consultant who designed the station the capacity of the pumps was found out.

Picture 7.1: Non functioning flow meter at Zoeknog water treatment plant
Source: author, 2009

The above described challenges related to water use registration of the public operated pumping stations is contract with the private operated pumps in the Sabie Sand Wildtuin. All the 110 pumps which abstract water from the Sand River are equipped with a flow meter[118]. The registered water use of the lodges is 39.000 m^3/a and thus negligible compared to the water use outside the game reserves.

After visiting all the abstraction points I calculated an annual abstraction capacity of 9.3 Mm^3 (see section 7.4). This figure differs significantly from the figure presented by Bushbuckridge water, see above. I found it difficult to come up with a convincing reason for this. One of the main reasons is the difference between the maximum abstraction capacity and the capacity in operation. Another reason is caused by the lack of maintenance which negatively influences the number of running pumps and subsequently the negative impact on the capacity.

Forestry
Currently there are no commercial plantations left in the catchment. Therefore, there is no water abstracted by the forestry sector.

Conclusion
The total annual amount of abstracted water in the Sand catchment is 33 Mm^3 (see Table 7.5).

Table 7.5: Water abstraction per sector

Domestic (Mm^3/a)	Irrigation (Mm^3/a)	Forestry (Mm^3/a)	Environment (Mm^3/a)	Total (Mm^3/a)
9.3	23.7	0	-	**33.0**

Source: author, 2009

7.5 Water deficit

The total water requirement in the Sand catchment is 71 Mm^3/a, however, the total available yield is 10.7 Mm^3/a [AWARD, 2008a]. It should be noted that the quoted yield, is the yield after supplying the ER, therefore the available yield is the yield plus the ER. Two additional water sources are groundwater and a water transfer from the Sabie catchment. The available groundwater is 2 Mm^3/a [DWAF, 2004a]. Currently 9,1 Mm^3/a treated water is transferred from the Sabie to the Sand catchment (see chapter 7). This gives a total available water quantity for water use of 65 Mm^3/a (see Table 7.6). The situation becomes even worse by partly replanting the former plantations. Since the water requirement in the Sand catchment is larger than the available water quantity, the Sand catchment is closed. There is no more allocable water in the Sand Catchment [DWAF, 2006c]. According to the International Water Management Institute a basin is closed when all the accessible water resources in a river basin are already in use or have been allocated to users [Seckler, 1996]. In simple words, a basin is closed if the river does not reach the sea or lake. Besides the clear water deficit in the overall water supply and

[118] From interview Sabie Sand Wildtuin ecologist, 9 April 2009, Kasteel.

demand situation, seasonal and regional variations in rainfall pattern often complicate the catchments water balance [Smits *et al.*, 2004].

Table 7.6: Water availability and requirement Sand catchment

Water availability (Mm3/a)		Water requirement (Mm3/a)		
			Current situation	with re-afforestation
Local yield	(11+43=) 54	Domestic	11	11
Groundwater	2	Irrigation	17	17
Transfer in	9	Ecological Reserve	43	43
		Forestry	0	3
Total	**65**	Total	**71**	**74**
Balance			**-6**	**-9**

Source: author, 2009

Several modelling studies showed the water deficit in the catchment. One of the most clear reports about the water deficits written by Smits *et al*. [2004] states that in the 1980s there was only sufficient water available to meet domestic needs and not those of irrigation. A second conclusion was that meeting irrigation demand implies breaking the ER most of the time. It should be noted that the ER was not determined by then and IFRs were used. By removing the forestry plantations the situation improved but the amount of water unused by the forestry will still be less than irrigation demands. The model scenarios of Smits *et al*. [2004] showed that even in the majority of the wet months the ER requirement was not met.

Within the next few years all the domestic use within the Sand catchment will be supplied from the Inyaka Dam, which will free up water for other users in the catchment [DWAF, 2009a]. Most of the interviewed stakeholders see the Inyaka dam as the solution to solve all their water problems. This is confirmed by Pollard *et al*. [2009a] who confirms that it appears that the Inyaka dam acts as a “buffer” (at least partially) against any perceived need to address the issue of water resources constraints.

Previous studies [DWAF, 1994: DWAF, 2003a] indicated that there was scope for additional irrigation development in the Sabie and the Sand catchment following completion of the Inyaka Dam (see section 8.2). The more recent Inkomati Water Availability Assessment Study [DWAF, 2009a], however, shows that the estimated mean annual runoff into the Inyaka dam is 20% less than in the previous studies. Consequently the Inyaka Dam can only meet its obligation to transfer 25Mm^3/a to the Sand catchment at a high level of assurance. Besides this transfer, there is no remaining yield for irrigation development in the Sabie or Sand catchments.

7.6 Compliance

In order to assess whether or not the Reserve is being met (= ’compliance with the Reserve’) one can compare the flow duration curves of the Reserve and the recorded flow. Since there is no comprehensive Reserve determination for the Sand catchment yet, the assessment of Reserve compliance is not possible. To overcome this one can compare the daily flow record with the IFR[119]. By this approach, one gets an indication of the trends in meeting the commitment to environmental flows.

The method used in this research is adopted from Pollard *et al.* [2009a]. She compared the daily flow data against normal and drought IFR requirements. All data was analysed against the normal IFR requirements, in the next stage all data was analysed against the drought IFR requirements. However, this is somewhat unfair as not all months were dry or wet throughout the analysed period. Therefore, I

[119] It should be noted that the major floods of February 2000(after the IFR workshop) dramatically changed the hydraulic characteristics of the rivers in the Sabie-Sand catchment.

divided the months between normal and dry months and compared this data with the corresponding IFRs.

The first step was to categorize a month as being "normal" or "dry". The criterion for a month being dry is when the river flow is smaller than 70% of the normal flow. For EWR8 a flow duration curve is drawn, this duration curve is regarded as the normal flow (see Figure 7.4). EWR8 is the nearest EWR site to gauging station.

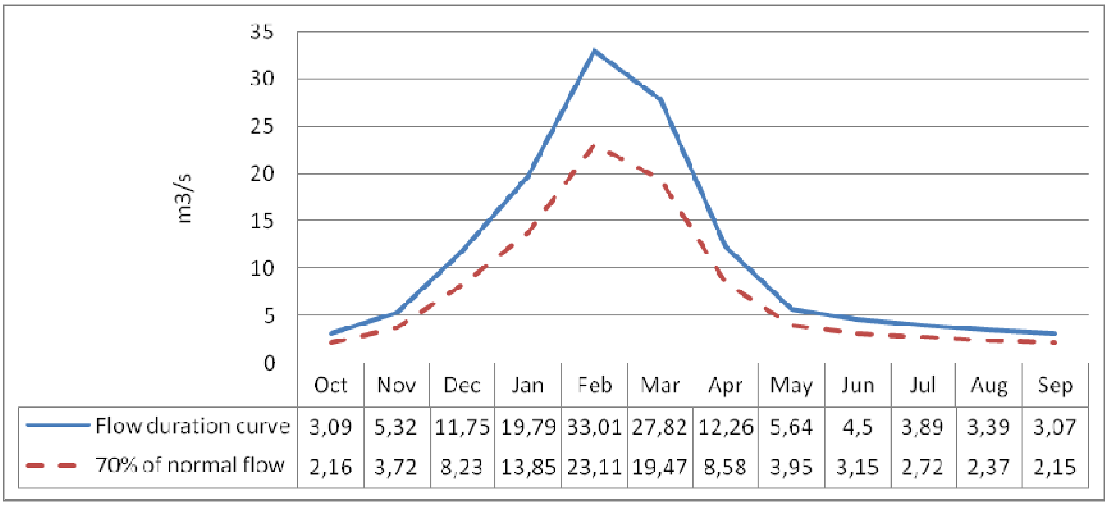


Figure 7.4: EWR 8 Flow duration curve

Source: adapted from "Sand EWR8 data sheet from DWAF"

The daily flows from the only gauging station (X3H008 Exeter) in the Sand catchment were analysed. Records from this station are available since 1976. There are some gaps in the recorded flow e.g. no data is available for 1975. In order to get a clear picture, the months with missing data are not taken into account. Average monthly flows were generated from the daily flows (see annex K). The generated monthly flow data is compared to the IFR requirement at IFR 7, which is located very near to the gauge. During an IFR workshop in 1996 it was already decided that IFR7 would be the indicator because of it high confidence, compared to the other IFR sites [DWAF, 1999].

Two periods were analysed:
- 1994 – 1999: period following the drought, new government, and pre-NWA period
- 2000 – 2008: period following policy change (NWA) and implementation of OR

Table 7.7: Incidents of non-compliance

Period	1994 - 1999	2000 – 2008
Months of non-compliance	10 %	7 %

Source: author, 2009

The incidents of non-compliance show the percentage of months that the IFR requirements are not met. From the presented pattern of non-compliance, in Table 7.7, it seems that non compliance with the IFR got a bit better after the introduction of the new water policy. However, this might be caused by the unevenly distributed flood or drought events. It should be noted that the non-compliance from 1968 until present is 11 %.

Problems of water shortage

As described in several sections of this report a number of problems appear in times of low flow. For example; while irrigators still divert water the downstream domestic abstraction points the downstream river stops flowing and the downstream domestic abstraction pumps are unable to draw water for domestic use. Besides the water competition between the domestic and irrigation sectors there is another competing user, the ecological sector.

The lack of flow leads to environmental degradation through, among others, the destruction of ecosystems. The Sand River is historically a perennial river and consequently the indigenous aquatic fauna are dependent on flowing water for part or all of their life-cycle [Swart, 2008b]. The lack of flow or even a reduction in flow could seriously impact on the ecosystem's biodiversity. This becomes clear in a research of O'Keeffe [1996: in Swart, 2008b] who states that during the 1992 drought the diversity of communities of invertebrates were drastically reduced with the reduction of river flow. These small life forms support a variety of larger life forms (birds, mammals and reptiles) that live in or around the river system [Swart, 2008a]. Thus, for a perennial system such as the Sand River a continual flow is the most important factor in maintaining the ecological integrity of a river [Swart, 2008b].

The lack of flow in the Sand River could result in the decline of wildlife in the game reserves which will lead to a drop in the number of tourists. This will negatively impact the number of jobs in the conservation sector [Swart, 2008a].

7.7 Conclusion

This chapter described the results of the actual water management practices on the water balance in the Sand catchment. This chapter shows clearly that the Sand catchment is in water deficit. Despite the new water legislation and the introduction of the Operating Rules there is still not enough water for the ecosystem.

There is no comprehensive Reserve determination for the Sand catchment yet. This creates some uncertainty about the catchment's water balance. It also becomes clear from this chapter that there is a discrepancy between the water requirement and the actual water use. The determination of the latter is complicated because of the lack of flow measuring equipment and staff to register the actual water abstraction.

Several plans are drafted to overcome this water deficit and to address the Reserve. These plans are described in the following chapter.

8 Strategies to resolve water deficit

8.1 Introduction

As described in the previous chapter, the Sand catchment is in water deficit. Thus, despite the NWA there is still not enough water for the ecosystem. Several plans are drafted to overcome this water deficit. This chapter describes the strategies that have been put in place to solve the water deficit and to address the Reserve. I will analyse which plans could potentially lead to an increase in water availability for the Reserve. Below the major plans and their background and implementation will be described. The two main technical solutions for bringing the Sand catchment back into balance and meeting the Reserve are the Inyaka Dam and the Bosbokrand Transfer Pipeline (section 8.2) and the Operating Rules (section 8.3). These technical solutions can be seen as typical solutions of the supply driven approach of the old minority government. Besides these infrastructural components another solution to bring the Sand catchment back into balance is water licensing (section 8.4). A different strategy to solve the catchments' water deficit is by consuming less primary water and reusing grey water. However, during my field visits I found no supporters of this approach. Another solution could be to build more dams to store additional water, several sites have been suggested e.g. New Forest and Dingleydale [DWAF, 2004a: ICMA, 2008]. However, the new government changed its water policy from a supply driven approach to a more sustainable demand driven approach. Therefore it is not expected that these dams will be built in the near future.

8.2 Bosbokrand Transfer Pipeline

About 15 years ago DWAF developed criteria for the riverine environment in the Sand catchment. The criteria that has been adopted is that the flow must not cease at the confluence with the Sabie River during the low flow season [DWAF, 1994]. However, from time to time the Sand River stopped flowing at the confluence with the Sabie River. Several environmental groups expressed their concern that the water use in the Sabie catchment has reached the level where the natural riverine environment could be irreparable damaged. Besides the environmental problems several irrigation projects are not in production mainly due to a shortage of water. This water shortage is partly caused by the unregulated flow of the rivers in the Sabie catchment. DWAF was aware of the water shortages in the Sabie catchment, therefore they carried out several studies during the period 1985 to 1991 to investigate the development possibilities of the Sabie catchment. This process did not include representation at community level [DWAF, 1994]. Their conclusions were presented in the Inyaka White Paper [1994] which states that unless water supplies are augmented the basic requirement of the population in the largely underdeveloped region will not be met.

The White Paper [1994] concludes that the proposed Inyaka dam was the most economical first-phase development of the water resources of the Sabie catchment. In order to supply the water requirement in the Sand catchment it was proposed to construct the Bosbokrand Transfer Pipeline from the Sabie to the Sand catchment. Part of the long term water resource development plan for the Sabie catchment is the construction of three more dams at Dingleydale, New Forest and Madres [DWAF, 1994]. However, according to a senior DWAF official there are presently no detailed plans for the construction of these dams. The first phase of the development plan consists of a storage dam on the Marite River, a pumping station at the dam and a

Picture 8.1: Inyaka dam
Source: author, 2009

rising main pipeline which delivers water into a balancing reservoir from where two gravity mains will deliver the water to the Sand catchment. The construction costs of the Inyaka dam and the Bosbokrand Transfer Pipeline was estimated to be R221 million and R36 million respectively [DWAF, 1994]. Part of the first phase but not described in the White Paper [1994] are the treatment plant and several pipelines that have to be provided by DWAF. Additional costs of these works are R336 million at 1994 prices.

Due to the construction of the Inyaka dam (see Picture 8.1) there is potential for irrigation expansion in the Sabie catchment, the potential was mainly limited by water availability. However, the failure of the Zoeknog Dam reduced the projected quantity of water available for irrigation. The major difference in the table between the 1993 and 2010 situation is the increase in water requirement due the expected population growth. It should be noted that Environmental water requirement is not included in the White Paper. The flow required for conservation of the natural riverine environment is concisely described, but no figures for water requirements are given.

Purpose of the dam and the transfer pipeline

The purpose of the dam is described in the Inyaka white paper and DWAF's Water Sector Policy Database [2005c]:

- Provide a secure source of water for the domestic, municipal and industrial users in the Bushbuckridge area in the sub catchments of the Sabie and Sand Rivers, west of the Sabie Sand Game reserve complex;
- Stabilise water supply for irrigation development and provide for its small increase;
- Augment the low flows and provide ecological water requirements in the Sabie and Sand Rivers.

Because of this additional water the low flows will be maintained at acceptable levels to prevent irreparable damage to the natural riverine environments. The Incomati Internal Strategic Perspective prescribes that water that will come available through the BTP must be used to supply or compensate for domestic use in the Sand catchment and to supply some of the Ecological Reserve [DWAF, 2004a].

On the basis of yield analysis and the above mentioned purposes a water allocation plan is formulated (see Table 8.1). The table shows the benefits that can be derived in the Sand catchment from the Inyaka dam. The high assurance supplies will be available for 98% of the time on average. The low assurance water supplies for irrigation will be available for 80% of the time on average. The capacity of the transfer pipeline is based on the transfer of 25 million m^3/a.

Table 8.1: Water allocation from the Inyaka dam

Inyaka dam: High assurance supplies	
Water for primary use in the Sand catchment	*18.1* million m^3/a
Water for primary use in the Sabie catchment	14.0 million m^3/a
Water for augmenting low flow of the Sand River in the Sabie Sand Game Reserve	*4.1* million m^3/a
Water for augmenting low flow of the Sabie River in the Kruger National Park	5.0 million m^3/a
Inyaka dam: Low assurance supplies	
Irrigation of 280ha in Sand catchment	*2.9* million m^3/a
Irrigation of 1480ha in Sabie catchment	13.7 million m^3/a
Total	57.8 million m^3/a
Total (IBT: Sand)	*25.1* million m^3/a

Source: adapted from DWAF [1994]

The Inyaka White Paper [DWAF, 1994] and the Operating Rules [DWAF, 2003b] both indicated that there is sufficient water for additional irrigation development in the Sabie and the Sand catchment following completion of the Inyaka Dam. As described in chapter 4 a recent study [DWAF, 2009a], however, shows that the estimated mean annual runoff into the dam is considerable less than in the previous studies. Therefore, there is no scope for additional irrigation development in the catchment.

The current discharge through the Bosbokrand Transfer Pipeline is 25 million l/day[120], this equals 9,1 million m^3/annum. The current capacity of the Inyaka water treatment works is 40 million l/day. Currently a contractor is extending the treatment works to four 25Ml/day modules. The Inyaka water treatment plant is managed by Bushbuckridge Water Board, the Inyaka dam, however, is managed under the newly established National Water Resource Infrastructure Branch of DWAF.

Change of plans

The four duty pumps and an additional standby pump will have a peak pumping rate of 1,43 m^3/s. At present only three pumps are installed in future two more pumps will be installed in the pumphouse. From the intake tower to the pumping station at the toe of the Inyaka dam raw water is pumped through a rising main into a balancing reservoir which supplies a water treatment works; the Inyaka Regional Water Works. According to the Inyaka White Paper raw water for domestic use will be treated at the treatment works and raw water to augment the flow in the Sand catchment will not be treated but will be pumped into a tributary of the Mutlumuvhi River which is a tributary of the Sand River [DWAF, 1994]. However, it is impossible to pump treated and untreated water through the same pipeline and because it is not economical to construct separate pipelines for raw water and for treated domestic water, all the water is treated at the Inyaka Water Treatment Works (WTW) [121]. Thus even though the White Paper states that one of the purposes of the transfer pipeline is to augment the low flow in the Sand River, it is impossible to bypass the treatment work with raw water. Therefore all the water is treated. However, treated water cannot be discharged into the river[122]. Hence, no water is released into the Mutlumuvhi River. The pipeline and the outlet (see Picture 8.2) are constructed, but there is no water flowing out of the outlet. One of the key stakeholders called the outlet *"a white elephant"*.

Picture 8.2: BTP outlet at Mutlumuvhi River
Source: author, 2009

Besides the non release for augmenting the low flow in the Sand catchment another problem is the changed purpose of the BTP. The municipalities along the BTP hijacked the transfer pipeline by attaching new bulk infrastructure to the pipeline[123]. Some stakeholders describe this as "hijacking" the BTP, but it can also be regarded as a solution to provide clean domestic water to the community who is currently lacking sufficient clean water. By hijacking the BTP one of the purposes of the BTP in the Sand catchment changed from "*augmenting low flow*" to "*replacement*". It is unclear who is responsible for the "change of plans" but it is obvious that DWAF did not sufficiently control the

[120] From interview production coordinator Inyaka Regional Water Works, 29 April 2009, Inyaka Regional Water Works.
[121] From interview senior DWAF official, 25 May 2009, Pretoria.
[122] Purified water contains chloride which is harmful for the ecosystem in the river. From interview Sabie Sand Wildtuin ecologist, 9 April 2009, Kasteel.
[123] From interviews senior DWAF official, ecologist and S. Pollard.

process. Several stakeholders mentioned their concern about the measureless expansion of the supply infrastructure by the municipalities. The lack of planning and coordination is summarized by Pollard *et al.* [2009a] who states that the lack of integration is evident in all the unauthorised expansions to infrastructure by the municipalities and, in particular, around the inter-basin transfer from Injaka.

The new purpose of the BTP is to provide all domestic water in the Sand catchment. In future water treatment works in the Sand catchment will be supplied by purified water from the Inyaka dam. This releases the pressure in the stressed Sand catchment and will increase the water available for environmental flow[124]. In future the Bosbokrand Transfer Pipeline will supply all domestic requirement in the Sand catchment with purified water up to a maximum of 25 million m^3/a, the 2010 domestic water requirement will be 24.6 million m^3/a [DWAF, 2003b]. The pipeline will be connected to the Bushbuckridge bulk distribution system of treated water and, in time, will provide treated water to the whole Bushbuckridge area north of the Inyaka dam and to Marite in the south of the dam [DWAF, 2005c]. Currently the Inyaka Regional Water Works is under construction. After the upgrading of the water treatment plant, the BTP can pump at its full capacity of 25 million m^3/a. In the interim period when several water treatment plants in the Sand catchment still abstract surface water, the BTP should transfer additional water to the Sand catchment to compensate for domestic use (see section 8.3). The total domestic water requirement *should* be transferred to the Sand catchment: direct to the consumers (if supply network is in place) and to the Mutlumuvhi River to compensate flow release (if the supply network is not in place yet)[125]. The compensated release equals the domestic use which is not supplied directly. However the infrastructure to distribute the domestic water to the consumer must still be installed as part of the second phase of the project[126]. The delay in the supply of the domestic use directly from the Inyaka dam is causing conflicts in the Sand catchment.

As mentioned in Table 8.1 the water which is transferred by the BTP to the Sand catchment was planned to be used for domestic, irrigation and the augmentation of the ecological requirement. The authors of the Inyaka White Paper [1994] anticipated a significant beneficial effect for the natural environment in the lower reaches of the Sand River by constructing the Inyaka dam. But until present no water is released into the Mutlumuvhi River to compensate for domestic use. However, the water transferred through the BTP removes part of the domestic requirements from the Sand catchment.

It should be noted that during the planning and design process of the Inyaka dam IFR were not determined yet. However, efforts were made to accommodate early estimates of IFRs in the dam design [DWAF, 1997a]. During a workshop in 1996 the IFRs were determined (see chapter 5), the results were used in the finalisation of the dam design and for the establishment of the Operating Rules (see next section). But since the dam is situated in a tributary of the Sabie River and is designed with only reasonably small outlets, it will be impossible to manage medium to large floods from the dam [DWAF, 1999].

8.3 Operating Rules

The water users in the Sand catchment depend mostly on the unregulated flow of the Sand River and its tributaries. There are only a few suitable storage dams built in the Sand catchment namely: Casteel, Orinoco, Acornhoek and Edinburgh (for location see figure 8.1, for description see section 6.3). The storage capacity of these dams is limited; therefore the water users in the catchment depend mostly on the unregulated flow of the Sand River and its tributaries.

[124] From interviews with several government officials.
[125] From interview senior DWAF official and consultant responsible for OR.
[126] Minutes of the Water Resource Meeting for the Sand catchment, 30th June 2003.

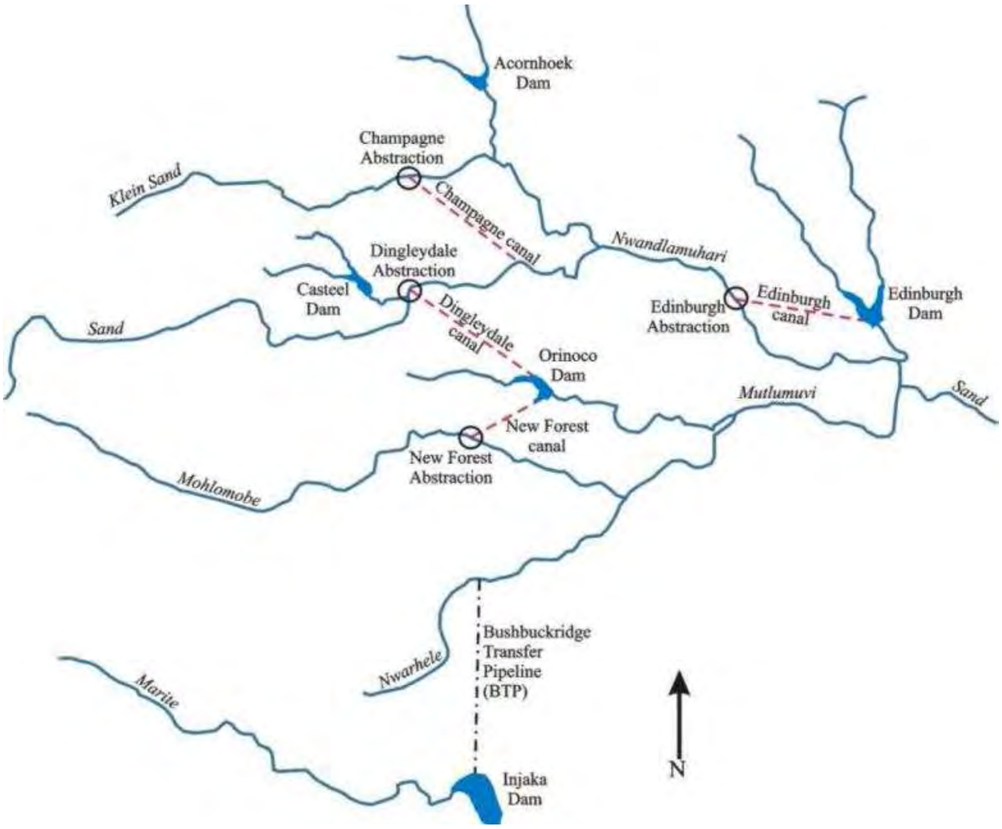


Figure 8.1: The Sand River catchment showing the location of the four dams and the abstraction sites
Source: Jackson and Swart [2003]

As part of the Inyaka dam development a set of Operating Rules (OR) has been established by DWAF for water resource management in the Sabie-Sand catchment. The applicable OR for the Sand catchment are the Sabie River Catchment Operating Rules. These operating procedures were developed by a consultant (Charles Sellick & Associates) and commissioned by DWAF.

The management objective of the OR is to ensure that the river flow and quality requirements of the ecological Reserve and of the consumers are met with the least possible curtailment and that the Inyaka Dam will not be emptied, even under severe drought conditions while maximising the use of the stored water [DWAF, 2003b: 108]. The OR describe in detail how the Sand Catchment should be managed from a water resources point of view once the Inyaka Dam and Transfer Pipeline are in full operation (25 million m^3/a) [DWAF, 2003b]. Several key stakeholders agree that the OR are a properly researched report and are based on sound hydrological principles. Part of the OR are the decision support models. The decision support models are aimed at providing tools to assist the ICMA to manage the water resources of the Sabie catchment. The decision support models are used to instruct the operators at the Inyaka Dam and to inform the water users [DWAF, 2003b].

The basis for making releases from Inyaka Dam for the ER was to utilise flow measured from a representative undeveloped catchment to trigger releases. For this purpose a new gauge was constructed at Emmet on the Sabie River just downstream of the confluence with the Mac-Mac River. The system has, however, never been operated mainly due to the lack of sufficiently skilled staff [DWAF, 2009a: 8].

As described above there are no suitable storage dams in the Sand catchment to manage the river flow directly. Due to a lack of storage by which one can actively manipulate the river, simple passive OR are developed in the Sand catchment. Most of the irrigation requirements are therefore supplied from run-of-river and not from storage. Because there are only a few small storage dams the water resources must be controlled by means of its abstraction points. In future all domestic use in the catchment will be supplied by the BTP, the only remaining abstraction points are the irrigation abstraction points. A passive management system ensures that the irrigation scheme offtakes release a certain percentage of the flow. The basic OR is that any abstraction (irrigation and domestic) must release a minimum fixed proportion of 35% of the flow downstream [DWAF, 2003b]. The irrigation management will be a passive management under the following rules:

- A reasonable compromise level of assurance for irrigation water and that required for the ecological Reserve was established that requires a minimum release of 35% of the flow in the river downstream at any abstraction point in the Sand River;
- All licenses will stipulate this requirement;
- Allocations must be made on the proportional flow release method in the Sand catchment.

The OR are not only applicable for irrigation but also for domestic use. The OR states that the BTP must transfer water into the Sand catchment to meet all the domestic requirements in the catchment. This will relieve a lot of pressure on the Sand catchment and water will be freed for the Environmental Requirement. However, as described in section 8.2 this is not the case yet.

Development of Operating Rules

By developing the OR the Instream Flow Requirements were used to estimates environmental water allocation. As part of the development of the OR the IFRs were critically reviewed in a multi-disciplinary follow-up workshop held in 1999 that comprised ecologists, hydrologists and water resources managers.

In order to supply the estimated Ecological Reserve the consultant accepted that only the water from the Sand catchment was to be used and that irrigation and afforestation would be the only water users since domestic use will be supplied through the BTP. According to the consultant even with no irrigation water use and only afforestation in the catchment the target ecological Reserve would not be available at IFR site 7 throughout the year [DWAF, 2003b]. According to the OR the Ecological Reserve is 33,8 million m^3/a on average, but falls as low as 6,9 million m^3 in the driest year. If there is no irrigation abstraction and the natural flow remains in the river the IFR will be not be met in one month a year on average [DWAF, 2003b]. Hence it is not possible to meet the Ecological Reserve always. For a discussion on the assurance of the Reserve see section 4.3.

The above mentioned figures indicate that the IFR could be too high as a natural or virgin catchment will always meet the ecological requirement[127]. It was therefore necessary to determine a reasonable level of irrigation water abstraction that would in effect be a compromise between the water requirements of the irrigators and the water required for the Ecological Reserve. Different percentages of release (flow past the weir) were modelled. The outcome was that 35% of the natural flow needs to remain in the river. Several well known researchers proved that if 35% of the natural flow remains in the river, even in a dry year, you are doing quite well. If one reduces the stream flow by 65% the stream flow reduction (as well as "*water height*" and "*water dept*") is less than 15%. But if you reduce the stream flow by more than 70% all of a sudden all values drop significantly. This is the so called "velocity concept"[128].

In conclusion, the outcome was a trade off between irrigation and the Ecological Reserve. The ratios were developed as a balance between agricultural requirements and the Environmental Flow Requirement (EFR) formerly known as Instream Flow Requirement (IFR). This compromise will be managed through passive management in the form of proportional flow releases at all abstraction sites.

[127] From intern DWAF email about drought in Sand catchment, 12 September 2003.
[128] From interview consultant responsible for OR, 11 June 2009.

By means of the recommended passive canal diversion rule irrigators can divert only a constant fixed predetermined proportion at the diversion point. Irrigators divert a fixed proportion of the incoming flow into their canal and release the remaining flow towards the downstream users (see table 8.2). The fixed proportion comes into effect when the river flow drops to the level indicated by the river flow threshold and the canal capacity based on the percentage of offtake at this threshold. The weirs must be adjustable until this threshold flow, than the passive split will come into effect[129].

The proportion of water that is supposed to be released varies between the weirs depending on their position within the catchment. The minimum release was adopted for one abstraction point; Edinburgh (downstream of Champagne abstraction point). The proportion of the incoming flow that had to be released had to be adjusted from 35% to 65% to allow for the effect of the upstream abstractions. Based on above mentioned reasoning the OR stipulate management requirements on the irrigation abstractions as presented in Table 8.2.

Table 8.2: Flow release rules

Irrigation abstraction site	Canal capacity (m^3/s)	% flow release downstream	Adjusted % flow release downstream	Threshold river flow (m^3/s)
Champagne	0.127	35 %	-	0.20
Dingleydale	0.962	35 %	35 %	1.48
New Forest	0.283	50 %	35 %	0.57
Edinburgh	1.150	65 %	57 %	3.28

Source: adapted from DWAF [2003b]

If the Dingleydale and Champagne abstraction sites do not comply with the OR than the BHNR will not be met at downstream Edinburgh [DWAF, 2003b]. In addition, even if Dingleydale and Champagne weirs are releasing the correct amount of water, the water will not reach the Sand River if the Edinburgh weir does not comply with the OR. Thus, the management of water released back into the river at Edinburgh is vital.

After modelling several scenarios to meet the Reserve in the Sand catchment it is concluded that implementing the Operating Rules is the best scenario to improve the quantity of the water downstream in the catchment. However, the Reserve is still not met in July and August (see Annex J).

Interim period

The OR describe how the Sand catchment should be managed from a water resources point of view once the Inyaka Dam and BTP are in full operation. Currently only three, out of eight, water treatment plants are connected to the BTP (see section 6.4) In the interim period adjusted rules are applicable. These rules compensate for domestic water use upstream of the irrigation abstraction weirs and/or abstractions from the canal. Based on their location in relation to the irrigation abstraction points and their abstraction capacity amended proportions can be calculated. All domestic abstraction points in the catchment were visited to determine their location and to inquire their abstraction capacity. For the author's calculation of the amended proportions see annex I. It should be noted that domestic abstraction points downstream of the irrigation abstraction points are not taken into account. This is remarkable because the capacity of the abstraction pumps at some of the downstream water treatment works is large enough to empty the river especially during times of low flow.

[129] See previous footnote.

Stakeholder involvement

It seems like there was only very limited stakeholder participation during the development of the ORs[130]. There was only a small committee formed with water resource stakeholders who made inputs into the process. It is most likely that other stakeholders like the municipalities and the Water Board were not involved in the process. But since the development of the OR is mainly a technical process it is understandable that stakeholders are not involved in all the steps of the writing process.

However, as part of the IWRM approach stakeholders must be informed and consulted during the decision process. This level of participation coincides with the second group of stakeholders participation in Arnstein's [1969] ladder of participation, see above. Therefore the outcomes of the technical process should be presented to the stakeholders and their opinions should be taken into account. It should be noted that there were a couple of meetings with several stakeholders to present the results[131].

Plans to operationalise Operating Rules

In 2003 the draft OR were finalized and presented to DWAF. After that several meetings were held and numerous plans were dawn to implement the OR. Below a small selection of the main events are described in chronological order:

- November 2003: Based on an EVN consultancy site visit critical adjustments of the irrigation abstraction points were given. EVN recommends an awareness champagne amongst the communities before any work can be done[132].
- December 2003: A Sand River Forum (established by the Save the Sand NGO) meeting was held to discuss the water shortage and come up with possible solutions for implementation. All applicable stakeholders in the Sand catchment were present at this meeting. Following the outcome of this meeting a business plan was drawn for the implementation of the OR. The business plan was delivered to DoA Head of Office in January 2004 [Swart, 2008a]. The aim of the first phase of the business plan was to implement a temporary emergency solution to provide an equitable distribution of the available water as quickly as possible. The Sabi Sand Wildtuin was willing to provide the funding for this phase. The implementation was planned to be done by the Save the Sand NGO with the support and approval of DWAF and DoA. The first phase of the business plan consisted of an initial facilitation phase with all the relevant stakeholders, a survey of abstraction sites and canals, design of the amendments and construction and further facilitation. Redesign and a permanent modification of the weirs were considered in phase 2 [Jackson & Swart, 2003].
- Jan 2004: Discussions between DoA and DWAF about implementation of the business plan. DoA does agree that the OR need to be implemented. But the DoA Head of Office does not accept the proportional flow releases. The reason is his concern about the repercussions of the farmers and the chiefs in the area [133]. DoA was also concerned about the assurance levels for the present development and that the month with shortfalls will generally follow each other which result in a shortfall for several months in a row[134].
- June 2004: Meeting of Sand River irrigation schemes/ canals meeting between DWAF, DoA Limpopo and ARC. It was agreed that the Sabie River OR are the applicable rules for the operation

[130] From interview consultant responsible for OR and several senior DoA, DWAF and ICMA officials.
[131] However, none of the interviewed official knew who was present at these meetings, where they were held etc. Due to the high staff turnover at the concerned organisations, and since the OR were never implemented, it is not surprising that the current staff has no idea of the rules.
[132] From EVN site visit, 4 November 2003.
[133] From email from senior DWAF official to Deputy Director General: policy and regulation, 23 January 2004.
[134] From minutes of meeting of Sand River irrigation schemes/ canals technical committee, 11 march 2005.

of the Sand catchment and must be implemented. And it was agreed that the proposed minimum flow release was reasonable. The use of Inyaka water still needed to be finally negotiated[135].

- August 2004: The OR were supposed to be gazetted by DWAF, but this was delayed[136]. DoA was unhappy with the proportion of the OR and called for another meeting[137].
- October 2004: DoA still did not agree to the ratio of the OR. The ratio for New Forest was changed from 50% to 35%, The original ratio was based on calculations that included the failed Zoeknog dam[138]. Discussion on the way forward: efforts should be focussed on the repair of Kasteel dam and the rehabilitation of the New Forest and Dingleydale irrigation infrastructure followed by the implementation of the OR at the these two abstraction points[139]. Dingleydale and New Forest are the only abstraction pints where there is no domestic water takeoff, therefore these sites were chosen to modify first. The efficiency of the canals needed to be improved to make more water available for the agricultural schemes in order to allow the flow back into the rivers. Limpopo DoA agreed to repair the Dingleydale and New Forest infrastructure. It was argued that by fixing the canals more water will reach Orinoco dam during the summer months so that adequate water is available for the irrigation schemes during periods of low flow, the winter months. However, as discussed in section 6.3 it is doubtful that by rehabilitating the irrigation infrastructure the river flow will be increase.
- November 2004: DoA district head complained about not being involved in the development of the OR from the beginning[140]. This can be regarded as an internal DoA communication problem because the DoA Head of Office was involved from the beginning.
- December 2004: A meeting was held with DoA, EVN, representatives of the irrigation management committees and the contractor to inform the farmers about the planned repair of the canals. After the refurbishment of the canals the irrigation abstraction points would be amended to make them compliant to the OR. Sabie Sand Wildtuin promised to financially contribute to the amendment of the weirs.
- January 2005: The contractor is busy repairing the Dingleydale and New Forest canals there is hardly any progress[141] (see section 6.3).
- March 2005: A meeting of the Sand river irrigation scheme technical committee was held to finalise the OR. The passive rule was accepted by all as the most proper rule for implementation. It was agreed that an initial rule should be implemented immediately with monitoring to allow for any adjustments to the rule that may be required.
- May 2005: Meeting scheduled to finalise OR. Postponed by DoA because they were waiting for the outcome of a monthly irrigation requirement calculation which was necessary for the adjustments of the OR. The meeting to finalise the OR never took place, a number of excuses were given for not holding the meeting. The most recent was that the key personnel dealing with this issue had left the Department, another was that there was simply too little water in the rivers and all the water diverted into the canal systems was being utilised for domestic use [Swart, 2008a].
- March 2006: After a long and sometimes violent process Bushbuckridge municipality is transferred from Limpopo to Mpumalanga Province. Logically Limpopo DoA only has funds until the transfer of the area. Since the transfer in March 2006 almost nothing happened. DoA pulled back their support. It is not clear whether the allocated funds were also transferred from Limpopo to Mpumalanga. After the transfer to Mpumalanga the province inherited a difficult situation. EVN consultants handed over all documents regarding the adjustments on the abstraction points and the refurbishment of the irrigation infrastructure to the DoA Polokwane in September 2006. DoA Polokwane handed it over to

[135] From minutes of meeting of Sand River irrigation schemes/ canals meeting between DWAF, DoA Limpopo and ARC, 14 June 2004.
[136] From notes ecologist.
[137] From notes ecologist and interview hydrologist, 21 May 2009, Acornhoek.
[138] From minutes meeting regarding implementation of the Sabie River Catchment OR, 25 October 2004.
[139] From minutes meeting regarding implementation of the Sabie River Catchment OR, 25 October 2004.
[140] From email senior DWAF official to DWAF National Strategic Planning, January 2005.
[141] From interview chairman of Dingleydale irrigation management committee, 11 March 2009, Dingleydale.

DoA Mpumalanga in March 2007[142]. But the EVN documents are nowhere to be found at Mpumalanga DoA.

The list can easily be continued for the following years, but it is clear from the above that a lot of meetings were held and several plans were made, but nothing happens in practices. Because of the lack of plans at Mpumalanga DoA and the lack of cooperation the Sabie Sand Wildtuin lost its patience and they are preparing a court case, see below.

It becomes clear from the several meetings concerning the implementation of the OR that the objective was to implement the OR without compromising the agricultural schemes and domestic water users[143]. However, it is impossible to implement the OR without compromising at least one of the current users. The minimum release of 35% (at all the abstraction points; domestic and irrigation) of the flow downstream must be at the expense of an upstream user(s).

Constrains

Despite all the above described meetings the OR are still not implemented in the Sabie-Sand catchment. Several reasons for the non implementation are mentioned by the different stakeholders. Below the main constrains for the implementation of the OR are described in alphabetical order per subject. This means that the one on top is not necessarily the most important constrain.

Domestic use: An often used argument is "*Water for domestic use is abstracted from the irrigation canals, the available water for domestic use cannot be decreased and therefore the OR cannot be implemented*". However, there is only one domestic abstraction point from the irrigation canal: Dingleydale Water Treatment Work. The capacity of this small treatment plant is only 72 m^3/day (see section 6.4). This small amount (0.01 Mm^3/a) is negligible compared to the available water in the Dingleydale canal (16.4 Mm^3/a). In recent years the abstracted waster at Edinburgh weir was only used for domestic use and not for irrigation anymore. Therefore it was impossible to implement the OR at this weir. But since there is only one small water treatment plant remaining which abstracts water from the canal, this argument is not valid anymore and the OR can be implemented. The other water treatment plants which used to receive water from the Edinburgh weir are not linked to this abstraction point anymore. It is important to note that due to the limited capacity of the several water treatment works and the low coverage of drinking taps people still continue to use irrigation water for domestic use.

Government: The implementation of the passive split at the irrigation abstraction points is a combined responsibility of DWAF and DoA[144]. Several senior government officials are aware of the OR but they do not take any action. Further pressure at a higher level may be required[145]. There is a lack of cooperation from the responsible government departments. The departments should work together to solve the problems and to implement the OR. DWAF should adjust the weirs and DoA should operate their irrigation system in cooperation with the farmers. Cooperation with the farmers is necessary otherwise the farmers will just use sandbags to divert the water to the irrigation canal. Besides the lack of government cooperation there is also un-clarity about enforcement between government departments. It is unknown who is responsible for the enforcement of the OR at the abstraction points. One of the DoA directors who is responsible for sustainable resource management in Mpumalanga province told me *"Nobody asked me to enforce the OR"*.

Infrastructure: The current irrigation abstraction points do not allow the release of a proportional flow. The weirs are designed in such a way that under low flow conditions all the flow in the catchment can be diverted into the irrigation canal. In some cases the entire river is diverted at the offtakes, especially during low river flows. This causes stress on the other water uses in the catchment, especially the ecological reserve requirements downstream and domestic use. For example during the

[142] From notes ecologist.
[143] From email from senior DWAF official to Deputy Director General: policy and regulation, 23 January 2004.
[144] From interview senior DWAF and DoA official.
[145] From intern DWAF email about drought in Sand catchment, 12 September 2003.

drought of 2003/2004, the irrigators at the New Forest scheme diverted all the water into their scheme. As a result the downstream river stopped flowing, the abstraction pump in the Mutlumuvhi River was unable to draw water for domestic use (i.e. the BHNR was not met) and most of the river was completely dry (i.e. the ER is not met). The weirs need to be redesigned and reconstructed by doing so one need to make sure that it is not too easy to change the proportions at the weirs and that the management of the weirs must be quite simple in order to be reasonably assured of success in practice [DWAF, 2003b].

Due to the bad shape of the irrigation infrastructure a lot of water is wasted (see Picture 8.3). Hence, a smaller portion of the abstracted water reaches the fields. If the OR are implemented even less water reaches the farm plots. The sluices gates at the irrigation abstraction points have not been maintained for a long time. Due to the bad state of these gates it is difficult to adjust the position of these gates. Almost all the stakeholders agreed that the infrastructure must be rehabilitated before the OR can be implemented (see section 8.3). It is argued by several key stakeholders that if the OR are implemented before the repairs of the canal are completed it would frustrate the improvement of the low flow in the Sand River.

Picture 8.3: Broken section of Dingleydale main canal
Source: Author, 2009

Knowledge about OR: There is a lack of knowledge about the OR, especially under government officials, farmers and the operators of the domestic abstraction points. Only a small number of senior government officials are familiar with the rules. Most of the interviewed district DoA officials have never heard of the OR. Hence if the DoA district head has never heard about the OR, how can he instruct his staff to implement the rules? It is not surprising that none of the farmers have not heard about the OR, however it is worrisome that almost all the members of the irrigation management committees and the water bailiffs have never heard about the rules. The water bailiffs operate the sluice gates at the weir in consultation with the irrigation management committees. The water division at the irrigation abstraction points is partly based on the position of the sluice gates, especially during times of the low flow. Since the water bailiff is unaware of the OR he will divert as much water as possible into the irrigation canals even if the river dries up downstream of the offtake. The same situation applies to the domestic abstraction points. None of the operators has ever heard of the OR and consequently they don't operate the pumps according to it.

Monitoring: There is no staff and infrastructure to monitor the water use, water levels etc. Without proper monitoring structures the OR cannot be managed. Monitoring is also required to check whether the different water users comply to the OR. Currently there is only one gauging station near the end of the catchment. To make the situation in the future even worse there are strong rumours that the budget of the DWAF unit responsible for monitoring will be cut by about 30% in the next financial year.

Out of date: Before the OR can be implemented they need to be updated since they were developed several years ago. The OR are based on old data and need to be reviewed according to the current status. Besides this the technology is improved as well, different and more accurate software and equipment is available. Once implemented the OR are not a static set of rules, they need to be updated once in a while[146].

[146] From interview senior DWAF official, 25 May 2009, Pretoria.

Staff: It is very difficult to implement the rules in a setting with a lack of staff and resources[147]. The decision support models must be operated by skilled staff and reliable monitoring data is required. However, it is well known that DWAF is understaffed. There is a lack of professional staff, however, DWAF is overstaffed at junior level[148]. Almost all the key stakeholders mentioned the lack of staff at DWAF as one of the main problems. Besides the lack of staff there is a high staff turnover and key personal leaves the department. Numerous examples were given by the interviewed stakeholders. One characteristic example: the DWAF employee who was involved in the development of the OR was transferred to the ICMA, after he left DWAF nobody took over[149]. Because of the lack of staff at DWAF consultants are a regular feature of the department's resources and a lot of work is done by consultants. But their commitment is only until the last payment is done and they are not liable for their own recommendations and advice. It is necessary for DWAF as the regulator to oversee the overall picture.

Water sharing: A consequence of the passive split is the division of the river stream between irrigators and downstream users. The irrigators are used to abstract at maximum canal capacity whenever possible. It will be difficult to change this practice, especially during times of drought. Several senior DoA officials and almost all the interviewed farmer state that during times of drought there is not enough water to share. During times of drought the farmers need all the water for their crops.

As one of the main advocates for the implementation of the OR, the Sabi Sand Wildtuin is still willing to financially contribute to the required amendments to the weirs to allow the passive split. The payment of the downstream Sabie Sand Wildtuin to the upstream irrigators to get downstream water can be seen within the broader concept of "*Payment for Ecosystem Services"*. An interesting question is what will happen if the game reserve pays but if they do not receive more water downstream because of, for example, increased domestic abstraction? Several years ago the Sabie Sand paid for the removal of forestry plantation, but they did not receive more water downstream[150]. Therefore Payment for Ecosystem Services only is not *the* solution. It must be combined with good management and commitment.

Court case

The Sabi Sand Wildtuin acts as the environmental watchdog for the river environment of the Sand catchment. However, the game reserve is not an environmental group but a business and the environment is the subject of their business and they want water in the river to keep their business running. Despite the fact that they are not an environmental group, they act as the representative of the downstream environment in the catchment. The Sabi Sand Wildtuin is very concerned about the low water levels during times of drought ([Swart, 2008a]). According to the game reserve the responsible governments departments do not show commitment to solve these problems. Because of the lack of commitment from the departments the game reserve is losing its patience and is preparing a court case to take legal action against DWAF and DoA. The court case will focus on 2 main problems:

Picture 8.4: Dried up Sand River
Source: Swart [2008a]

[147] See previous footnote.
[148] Implementation of the National Water Act (1998): briefing, Parliamentary Water Affairs And Forestry Portfolio Committee, February 11 2004. Source: www.pmg.org.za
[149] From interview senior DWAF official, 15 April 2009, Nelspruit.
[150] From personal communication S. Pollard, 14 April 2009.

- Plans to re-afforest the DWAF plantations again. By taking legal action against DWAF Forestry they try to prevent them from having the commercial forests replanted and to ensure that the original exit plan is executed [Swart, 2008a].
- No implementation of OR at the irrigation abstraction points. By threatening DoA the Sabie Sand Wildtuin will pressurize the department to comply with the OR at each of the irrigation abstraction points. They want DoA to ensure that the canal systems are refurbished to minimize water wastage and that they implement the OR by at least allowing the release of the Reserve (ER and BHNR).

As the custodian of South African's national water resource DWAF should enforce the NWA. According to the Inkomati Internal Strategic Perspective the directorate National Water Resource Planning and Regional office are responsible for implementation of the OR [DWAF, 2004a].

In its supporting document of the legal action the Sabie Sand Wildtuin uses several arguments why the OR should be implemented. Many arguments are related to the sustainability principle of the NWA (see section 7.6). Another argument is that the lack of flow in the Sand River could result in the decline of wildlife in the game reserves which will lead to a drop in the number of tourists. This will negatively impact the number of jobs in the conservation sector [Swart, 2008a]. This argument is related to the "productivity principle" of the NWA.

But DWAF is reluctant to implement measures to ensure that DoA complies with the NWA to release flow downstream [Swart, 2008a]. Therefore the legal team of the Sabie Sand Wildtuin intended to take legal action against DWAF so that they could put pressure on DoA to implement the OR at the diversion weirs. However, if it turned out that the DoA were still not releasing water past the weirs into the river then DWAF would have no course of legal action against them [Swart, 2008a]. Because government departments are prohibited from taking legal action against each other, as stated in the Constitution under the cooperative government principle [Klarenberg, 2004]. Thus, the final course of action is to take legal action against the DoA [Swart, 2008a]. If it becomes a court case, it will be the first of its kind in the country[151]. DWAF wrote a letter to DoA about the proposed legal action of Sabie Sand Wildtuin. DoA should reply within a month. In April I met a senior DoA official who was busy writing a letter to the DoA Head of Office to ask permission to apply for funding for the refurbishment of the canals at National DoA.

Way forward

Threatened by the legal action of the Sabie-Sand Wildtuin DWAF is searching for solutions to solve the problems. Fortunately, the MABEDI initiative has drafted a plan to refurbish the irrigation infrastructure. After consultation with the ICMA, MABEDI added the upgrading and metering of the abstraction weirs in their proposal. MABEDI presented their plans at the Mpumalanga Coordinating Committee on Agricultural Water and is currently looking for funding. Last April I met the DoA director who is represents the department in water related matters. By then he was busy writing a letter to the Head of Department to ask permission to apply for funding at National DoA[152].

8.4 Water licensing

Besides the above presented infrastructural solutions to bring the Sand catchment back into balance a non technical solution is water licensing. Water licensing is one of the main instruments of the CMA to redress inequities [Brown, 2006]. The water licensing process in the Sand catchment is still in an early stage. Not all the water users in the catchment are registered let alone being licensed. To date there are some 55 registered users in the Sand catchment[153]. Therefore I will just briefly describe the water licensing process.

[151] From interview Sabie Sand Wildtuin ecologist and ICMA manager.
[152] From interview DoA director Technology Research and Development, 15 April 2009, Nelspruit.
[153] WARMS QA Data Report, Water use type: DW760 (taking water from a water resource), 25 May 2009.

According to the Internal Strategic Perspective of the ICMA the irrigators in the Sand catchment do not allow water for the Reserve to pass their abstraction points. Failing this, compulsory licensing needs to be implemented [DWAF, 2004b].

According to the NWA [1998] there is no ownership in water and all water use is subject to a licensing system. Water use is defined in Section 21 of the NWA. These include, amongst other uses, taking water from a water resource, storage of water, diverting water, discharging waste into a watercourse, disposing of waste in a manner that may detrimentally impact on a water resource and recreational use [DWAF, 2003d]. The following water uses are excepted form water licensing:

- Water use that is set out under Schedule 1 of the NWA;

  Schedule 1 of the NWA [1998] outlines the permissible use of water:

  A person may, subject to this Act—

  (a) take water for reasonable domestic use in that person's household, directly from any water resource to which that person hits lawful access;

  (b) take water for use on land owned or occupied by that person, for -

  (i) reasonable domestic use:

  (ii) small gardening not for commercial purposes; and

  (iii) the watering of animals (excluding feedlots) which graze on that land within the grazing capacity of that land,

  From any water resource which is situated on or forms a boundary of that land.

  If the use is not excessive in relation to the capacity of the water resource and the needs of other users;

  In summary, Schedule 1 uses include water above the BHNR that is used for small scale productive uses within households [Pollard *et al.*, 1998]. Productive use includes subsistence activities like vegetables and fruit tree growing, beer making and brick making but does not allow water to be used for commercial purposes. According to the National Water Resource Strategy the NWA's provision in respect of Schedule 1 primarily intended to reduce the administrative effort of authorising every use in the country individually. Nevertheless, any water use that exceeds a Schedule 1 use, or that exceeds the limits imposed under general authorisations, must be authorised by a licence [DWAF, 2004b]. Schedule 1 use will have a minimal or insignificant effect on water resources.

- General authorisations issued under Section 39 of the NWA;

  A general authorisation allows limited, but conditional, water use without a license [DWAF, 2004b]. The limitations depend on the nature of the use and the capacity of the resource. A general authorization is valid for 3 to 5 years. A general authorisation must be made widely available for comments and will be published in the Government Gazette. An example of a general authorisation is the storage of a limited amount of water in a dam or abstracting a limited amount from certain rivers [DWAF, 2008a].

- Existing lawful use recognised under the NWA until such time as the person is required to apply for a license.

  As a transitional measure the NWA permits water use that was lawfully exercised under any law preceding the introduction of the NWA, on 1 October 1998, to carry on using the water under existing conditions until they get a license. Until that time the water use is called existing lawful water use [DWAF, 2004b].

A license, however, does not guarantee water availability or quality to the licensed user [NWA, 1998]. Under the NWA water became a public good therefore it cannot be claimed as a right under the right to property[du Toit *et al.*, 2009a]. Du Toit *et al.* [2009a] argues that a water right can be regarded as a privilege rather than a strict right Licenses will be assessed on the basis of the three principles of the

NWA (sustainability, efficiency, equity) and will be the duty of the CMA[154], or, if the CMA does not yet exist, the Minster. A water license can only be for a maximum period of 40 years and is subject to a review period of not more than five years [DWAF, 2003d]. As stated in the National Water Resource Strategy the Reserve has priority over all water uses and the requirements of the Reserve must be allowed for before any use is licensed. Authorisation of a water licence is therefore conditional on a Reserve determination being carried out, and the requirements of the Reserve being taken into account when determining the water available for allocation [DWAF, 2004b].

The Sand catchment is one of the four sub-catchments of the Inkomati WMA which is water stressed. Because of the water stress water allocation reform is necessary [ICMA, 2007]. The new government recently emphasized that it will accelerate the Water Allocation Reform programme[155]. The aim of Water Allocation Reform (WAR) is to share water more fairly, but also to grow the economy and to ensure that water use benefits all South Africans [DWAF, 2006a]. Section 43 of the NWA [1998] requires that the responsible authority may issue a notice for users to apply for licences in a stressed catchment. An essential preliminary step in the licensing process is the registration of current water use.

Registration

Water users were asked to register their water use at the appropriate Regional Office. The DWAF Regional Office for the Sand catchment is situated in Nelspruit. DWAF gave the registered water users a registration certificate [DWAF, 2006a]. Registration of water use in the Sand catchment closed on 30th June 2001[156]. The authorisation of all water users is a considerable task and will take some time to complete especially because of the lack of capacity with regard to registration at the Regional Offices[157]. The water licensing process in the Sand catchment is currently in this stage. Most of the water users in the catchment are registered.

Irrigation: The DoA applied for a water license on behalf of the farmers of the Dingleydale and New Forest irrigation schemes (see Picture 8.5). Ultimately the licence will be transferred to the scheme [Pollard *et al.*, 2009a]. However, as described above and in more detail in section 6.3 the management committees of Dingleydale and New Forest irrigation schemes are not registered as a WUA, they do not have a legal status. The WUAs must be registered first before they can apply for water license[158]. The water use of the farmers at Champagne Citrus farm is not even registered yet[159].

Picture 8.5: Water use registration certificate Dingleydale
Source: author, 2009

Domestic: None of the 9 large domestic abstraction points in the catchment are registered. Only the domestic abstraction points at the private game lodges are registered. The lodges have registered their water use because they make profit[160]. Bushbuckridge Water Board also need to register their water use because they are a large water users, however they are still not registered as a

[154] Minutes of the Water Resource Meeting for the Sand catchment, 30th June 2003.
[155] Speech by Ms. B. Sonjica, Minister of Water and Environmental Affairs. Budget Vote of 2009/10, 24 June 2009 Source: www.dwaf.gov.za
[156] Minutes of the Water Resource Meeting for the Sand catchment, 30th June 2003.
[157] From interview with senior DWAF official, 15 April 2009, Nelspruit.
[158] From interview senior ICMA official, 26 February 2009, Port Elizabeth.
[159] From interview Champagne Citrus farm manager, 29 April 2009, Champagne Farm.
[160] From email DWAF Regional Office official, 2 June 2009.

water user. It should be noted that the ICMA water use manager is unaware of the non registration of the Water Board[161]. At present DWAF Regional Office is in the process of registering the Water Board as registered user. After registration the Water Board needs to pay the water charges based on the water used from when they started using water. The National Water Resources Strategy is clear about the registration of domestic water use; *although a water services institution requires a licence for the total quantity of water it takes from a resource to supply its consumers, the responsible authority may not refuse to authorise the quantity required to meet basic human needs* [DWAF, 2004b: 66].

Forestry: Trees planted for commercial purposes prior to 1972 are considered as legal afforestation and are classified under existing lawful water use. The Lowveld plantations were planted prior to 1972 and are therefore existing lawful water users [DWAF, 2009b].

Verification of water use

The next step after registration of water use is the verification of existing water user. The responsible authority will verify (= confirm) the quantity and lawfulness of the existing water use. The verification process will be prioritised in areas where existing use exceeds the capacity of the resource [DWAF, 2004b]. Once a registered water use if verified and is found lawful a water use license will be issued. Only if water use licences are issued water scheduling can be planned based on the licensed amount of water. Water scheduling is regarded as the operation plans of the abstraction points. The following step is the monitoring of the water scheduling and water use, therefore flow measuring devices are necessary (see figure 8.2). Currently not all the water users in the catchment are registered, let alone being licensed, metered or even monitored. Therefore monitoring of the licensed amount cannot take place.

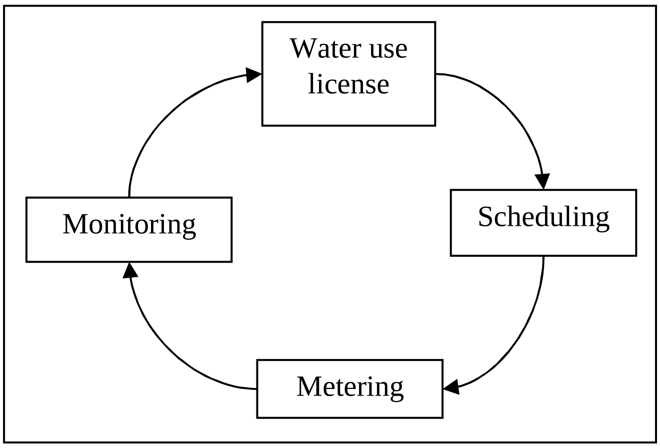


Figure 8.2: Monitoring of water use license
Source: author's observation and discussion, 2009

Framework for Water Allocation

If it becomes clear from the verification process that there is more water use registered than the water availability the next step is compulsory licensing. Before the compulsory licensing process can be undertaken in terms of the NWA, a framework for water allocation in the WMA must be developed. The Framework for Allocation must give practical ideas how to allocate water between the environment, existing lawful users and new water users [DWAF, 2006a]. The Framework will give a thorough understanding of current water use and the currently available water resources[DWAF, 2009a]. The water allocation process must support Government's poverty eradication and economic development strategic objectives [DWAF, 2005b].

The *Framework for Water Allocation to guide the Compulsory Licensing in the Inkomati WMA* was developed in 2007 by Water For Africa and Pegasys Management Consultancies for the ICMA and DWAF [ICMA, 2007]. Part of this process was the consultation and empowerment of local stakeholders. This framework is part of a larger project including validation and verification of existing lawful use, water availability assessment etc. The outcomes of these studies will be used in the preparation of a framework for water allocation and stakeholder empowerment to participate in the compulsory licensing [ICMA, 2007]. While allocating water in an over allocated catchment a principle of "not below the present ecological state" will be followed [DWAF, 2005b].

[161] From personal communication senior DWAF official, 16 June 2009.

Compulsory licensing

Where there is not enough water for all users in the catchment the CMA can call for compulsory licensing: all existing and potential users (except for the Reserve and Schedule 1) will have to apply for licenses [Pollard *et al.*, 1998]. Another reason for compulsory licensing is when the Reserve cannot be met without cutting the water allocated to certain companies or individuals. In the case of over allocation the government, through the CMA, has a constitutional obligation to cut the allocations in order to guarantee the right to water as it has been articulated within the NWA [du Toit *et al.*, 2009a]. However, curtailing water use to meet the needs of equity has complex political, legal, and economic consequences [Seetal & Quibell, 2005].

The compulsory licensing process is a labour intensive program. Therefore, the government will initially limit the compulsory licensing process to the priority catchments identified in the National Water Resource Strategy [DWAF, 2005b].

In conclusion, compulsory licensing allows the state to reallocate the water resource in accordance with the water supply objectives and priorities given in the NWA and the National Water Resource Strategy [DWAF, 2009a: 1]. According to the National Water Resource Strategy [DWAF, 2004b] the process for compulsory licensing is described as follows:
- Existing use and its lawfulness is verified;
- The responsible authority issues a notice to all (current and prospective) water users calling for licence applications;
- Users and prospective users prepare and submit licence applications;
- The responsible authority evaluates all licence applications;
- The responsible authority develops possible solutions to balance water requirements with water availability;
- The responsible authority invites public comment on a proposed allocation schedule;
- After considering all comments and objections a preliminary allocation schedule will be published.

The final stage of the Water Allocation Reform process is the final allocation schedule [DWAF, 2006a]. After the final allocation schedule is published in the *Government Gazette* the licenses must be issued to water users.

8.5 Conclusion

There is not enough water available in the Sand catchment to supply the current water users and the Reserve. Therefore it was decided to increase the catchment area by transferring water from the Sabie catchment into the Sand catchment. Initially it was planned by the White paper [1994] to augment low flows in the Sand catchment by the BTP. It should be noted that by then the environment was not a recognized water user. But since all water is used to fulfil the domestic requirement no water is transferred to the river to augment low flows. It is unclear when one of the purposes of the BTP changed from "*augmenting low flow*" to "*replacement*". The change of plans creates confusion about the purpose of the transfer pipeline. Several key stakeholders mentioned that the change of plan must be a political decision. This shows the influence from politicians on water resource management.

As planned all water treatment works in the Sand catchment will decommissioned after being connected to the BTP. Some pump stations will be transformed to booster stations to pump the water from the BTP to the surrounding committees[162]. But it is doubtful if this will really happen[163] and that the BTP will replace the domestic abstraction and thereby freeing up some surface water to relieve the situation in the catchment. For example, at the moment only two water treatment works are connected

[162] From interviews with several Water Treatment Works operators, 29 April, 12, 13, 21 May 2009, Sand catchment.
[163] Most interviewed pump operators expect that the pump stations will not be decommissioned after being connected to the BTP. The pump stations will remain as back up pumping stations.

to the IBT, but they are still abstracting surface water. So they do not relieve the stressed water resource situation.

According to the NWA [1998] the Reserve must be given effect to. The Sabie River Catchment Operating Rules for the management of the surface water resources is currently the best available methodology to give effect to the Reserve and therefore these rules must be implemented. But it is proven to be difficult to implement the OR. The OR can be regarded as a water allocation mechanism. The rules allocate water between the irrigation sector and the downstream users. Because of the impact of water allocation on the water users stakeholder involvement is important in this process. However, there was no stakeholder involvement during the writing process of the OR, the people concerned did not have any decision-making power about the outcomes of the OR.

Several conditions must be met before the OR can be implemented: cooperation from the farmers is key to the success of the implementation, without their approval it is senseless to adapt the weirs. It is also necessary to monitor water use to check if the abstraction points comply tot the OR. One cannot monitor without water measurement equipment to monitor the irrigation water use and the domestic abstractions. Therefore this equipment must be installed as soon as possible. Another condition before implementing the weirs is the refurbishment of the irrigation infrastructure. Most of the stakeholders argued that the OR cannot be implemented without rehabilitation the irrigation infrastructure.

Since the Sand catchment is a stressed catchment, compulsory licensing is another option to bring the Sand River back into balance. The Inkomati Internal Strategic Perspective even states that compulsory licensing need to be implemented in the catchment. However due to the administration burden of licensing and the resulting backlog at DWAF Regional Office not all the water users in the catchment are registered, let alone being licensed. Once implemented the compulsory licensing process will have a significant impact on the existing and potential new users [ICMA, 2007]. Therefore stakeholder participation is key to the implementation of water licensing and there must be ongoing communication and consultation with the water users and water stakeholders.

In conclusion, three strategies have been put in place to solve the water deficit and to address the Reserve. The Inter Basin Transfer and the Operating Rules can be regarded as the engineering solutions to solve the water deficit. The third strategy, water licensing is a non technical approach. Through the Inter Basin Transfer the water availability in the catchment will increase, however, this does not necessarily lead to an increase in water availability for the Reserve. By implementing the OR and compulsory licensing the distribution of the currently available water will be changed. It becomes clear that the implementation of these strategies is a time consuming and complex process, partly because of current and past political and social influences.

9 Conclusions and recommendations

9.1 Conclusions

This section answers the research questions, and is closed with some final remarks about water management in South Africa. The conclusions of this thesis are made within the context of complex and interwoven social, political, environmental, and economical issues that are prevalent in the Sand catchment.

Water allocation

One of the novel elements of the new water framework is the Reserve. The conditions of the Reserve must be met before any other authorisation to water use can be made. In the Sand catchment, however, the Ecological Reserve is the last (downstream) water user in the catchment. Water is abstracted by several upstream water users regardless of the Reserve, only the remaining water (if any) is left for the Reserve. The Sabie River Catchment Operating Rules for the management of the surface water resources are currently the best available methodology to give effect to the Reserve. The Operating Rules prescribes passive management of the irrigation abstraction weirs. The basic rule is that any abstraction (irrigation and domestic) must release a minimum fixed proportion of 35% of the flow downstream.

Water distribution

After analyzing the practices of the several water users in the catchment it can be concluded that the legacy of apartheid remains an important part of people's everyday lives. The current water management, in every water use sector, still reflects the abolished apartheid policies. Despite the new water policy framework, the water in the catchment is not managed in accordance to it. There is a gap between actual water distribution (reality) and the desired distribution according to the new water legislation (planning). The main reason for this gap is that the new policy model is not combined with an effective implementation strategy and monitoring plans.

Water control is about the regulations and control of human behaviour, particularly with regard to the forms of cooperation necessary to make irrigation systems functioning [Mollinga, 2003b]. The irrigators in the Sand catchment, however, hardly cooperate[164]; they act independently of one another. The lack of cooperation amongst the irrigators is one of the reasons for the non functioning irrigation systems. Another reason is the lack of ownership on the part of the irrigators. Because of the lack of ownership the irrigators do not maintain the infrastructure resulting in the current dilapidated irrigation infrastructure[165]. This is in accordance with Coward's [1983: in Coward, 1986] observation, who argued that ownership and responsibility for irrigation works invariably coincide. The irrigators in the Sand catchment (except Champagne[166]) do not have a sense of ownership of the irrigation scheme. Explicit ownership of the scheme is fundamental to improve responsibility towards the scheme [Coward, 2006]. However, the government does not have any plans to officially hand over the schemes to the irrigators. Thus explicit ownership by the irrigators is not likely to happen in the near future.

The water control technology in the catchment is socially constructed. The irrigation infrastructure and water control structures are developed by the white officials of the previous apartheid government. Implementation of the Reserve (and its related Operating Rules) is impossible with the

[164] In some circumstances they do cooperate e.g. in canal cleaning (once a year).
[165] Another main reason for the dilapidated infrastructure is the government withdrawal from the schemes, the government used to maintain the infrastructure.
[166] Champagne farm is owned by a Community Property Association.

current water control infrastructure. It is simply impossible to implement the passive split, prescribed by the Operating Rules, with the current infrastructure (abstraction weirs).

Meeting the Ecological Reserve

A comprehensive Reserve determination is currently underway and due for completion in November 2009. Once the Reserve is signed by the Minister, it is binding on any institution in water resource management and it needs to be monitored. Proper control measures will need to be implemented to ensure that the Ecological Reserve is met [DWAF, 2004b: p. 53]. However, the Reserve is not set yet, therefore there is no benchmark to monitor the actual river flow against. At the moment, only the Instream Flow Requirements can be used to monitor compliance. The non-compliance from 1968 until present is 11%. This percentage shows the percentage of months that the IFR requirements are not met.

Obstacles

Implementing and meeting the Reserve has proven to be difficult. The new water policy faces a difficult transition period. It should be noted that the new water legislation does not envisage an instant implementation with regard to the Environmental Reserve. But the Reserve will be met by a progressive improvement[167]. Therefore, it is not realistic to change, all of a sudden, from the current stressed situation to a situation where the Reserve is implemented and complied with.

The Sand catchment is in water deficit, especially during times of low river flow. Several strategies have been put in place to address the water deficit and to meet the Reserve; 1) Inter Basin Transfer, 2) Operating Rules, and 3) water licensing. Despite the completion of the Inyaka Dam, the Sand catchment remains water stressed. Though the transferred water will relieve the pressure in the stressed catchment and will thus increase the environmental flow. The water licensing process in the Sand catchment is still at an early stage. Only a small number of water users are registered, let alone being licensed. Six years after signing the Operating Rules, they are still not functioning[168]. One of the main reasons is the lack of knowledge about the Operating Rules amongst decision makers and that the current irrigation abstraction points do not allow the release of a proportional flow. It is expected that the threat of a legal case by the Sabi Sand Wildtuin will elicit some cooperation from the government[169]. Fortunately for the accused government the solution is near; Teba development wrote a proposal for the refurbishment of the irrigation infrastructure[170]. The government wants to rehabilitate the infrastructure, but they lack the staff to implement the project themselves. By funding this refurbishment project a NGO will rehabilitate the infrastructure and empower the irrigation management committees.

Despite the catchment being in water deficit there are advanced plans to partially replant the former commercial forestry plantations. According to DWAF's[171] review study, re-afforestation with long

[167] This is in accordance with Section 27(2) of the Constitution according to which the State must take reasonable legislative and other measures, within its available resources, to achieve the progressive realization of each of these rights. Source: National Water Act Amendment Bill: discussion & voting, Water Affairs And Forestry Portfolio Committee, October 26 1999. Source: www.pmg.org.za

[168] After modeling several scenarios to meet the Reserve in the Sand catchment it is concluded that implementing the Operating Rules is the best scenario to improve the quantity of the water downstream in the catchment. However, the Reserve is still not met in July and August (see Annex J).

[169] It is interesting to note that one of the arguments employed by the Sabie Sand Wildtuin is about the numbers of jobs created in the conservation sector. This argument is related to the "productivity principle" of the NWA.

[170] The refurbishment proposal includes the adaptations of the irrigation abstraction weirs to make them compliant with the Operating Rules

[171] As almost every DWAF report, this report is written by a consultant as well. Because of the lack of sufficient capable staff at DWAF, consultants are hired for almost every job. Hence, DWAF became dependent on these consultants for almost every knowledge intensive decision. This raises the question to what DWAF can take informed decisions based on these reports written by consultants.

rotation pines would not have a significant effect on water requirements [DWAF, 2009b]. But even a small increase in water requirement will make the water resource situation in the already closed Sand catchment even more stressed.

Almost all the interviewed stakeholders argued that the inefficient irrigation schemes must be rehabilitated to increase downstream river flow in the river. This research shows that this is not a valid reasoning. Many more factors (e.g. stakeholder participation, adjusted abstraction weirs, controlled afforestation, and monitoring) than simply infrastructural rehabilitation need to be in place before more water is available for the Ecological Reserve.

Based on the new water policy framework numerous plans, reports and policies have been or are being drafted; e.g. Water Service Development Plan, Catchment Management Strategy, Water Conservation and Demand Management plan etc. However, despite all these plans it has proven to be difficult to implement the new water legislation. In conclusion, despite the new (highly acclaimed) water legislation, the reality on the ground remains typically one of business as usual, as we enter into the second decade of South Africa's democracy.

Perception of water users

The focus of this research is on the Ecological Reserve. There is hardly any awareness about the Ecological Reserve and it is poorly understood by most of the interviewed local stakeholders: e.g. *"it is for the park"* or *"it is water for Kruger.* There is a better understanding about the Reserve among senior government officials. However, the local people (e.g. irrigators and pump operators) are the actual water users, therefore, it is important that they have a good understanding of the Reserve. Because the local people are not aware of the Ecological Reserve (the Reserve is not included in any operating manual) they do not control their (abstraction) infrastructure according to these rules.

Stakeholders do not participate in the decision making process surrounding the implementation of the Ecological Reserve. In relation to this, one can wonder what will happen if the water users mobilised in the ICMA would really get a say over water management in the catchment. It is questionable that they will change the water allocation in favour of the environment. Because of the lack of awareness of the Reserve by most interviewed water users, it is expected that they will push the environment even further down the ladder of priority[172]?

Inefficient irrigation discourse

A common discourse among South Africa's water decision makers and researchers is that the country is in water deficit and since the irrigation sector (the biggest water user) is inefficient it should be improved or land taken out of production:

- As described by several researchers and government reports, South Africa is a water scarce country: e.g. 1) 15 out of 19 WMAs are in deficit whilst a surplus exist in the country as a whole [DWAF, 2004b: A1], 2) only 8.6% of rainfall converts to usable runoff, the lowest proportion in the world [Hamann & O'Riordan, 2000], and 3) the country is expected to be among the most water scarce countries in the world by 2025[173] [de Lange, 2001]. This was recently confirmed by the current minister of Water and Environmental Affairs in her speech at the parliamentary Budget Vote of 2009/10, 24 June 2009[174].

[172] It is important to note that he environmental sector is one of the largest employers in the catchment. The lack of flow in the Sand River could result in a drop in the number of tourists. This will negatively impact the number of jobs in the sector.
[173] IWMI water scarcity map, presented on 2nd World Water Forum in the Hague, 2000.
[174] Speech by Ms. B. Sonjica, Minister of Water and Environmental Affairs. Budget Vote of 2009/10, 24 June 2009 Source: www.dwaf.gov.za

- Almost all the reports and almost all the interviewed stakeholders blame the irrigation sector for this water deficit since it is the major water resource consumer. It is argued that the irrigators use the water in an inefficient and unsustainable manner. Agriculture is valued as a “low value” water user, as confirmed by Wester [2008].
- As a response to the water crisis DWAF should act by implementing more efficient and sustainable irrigation techniques. This is confirmed by de Toit *et al*. [2009a: 14] who states that the CMAs and regional DWAF have the legal obligation to respond to crisis situations by taking the measures necessary to meet the Reserve. In terms of irrigation, this involves requiring the use of efficient and sustainable irrigation techniques in all new licenses and altering existing licenses (particularly those of users largely contributing to the crisis situation) to require a shift to efficient forms of irrigation.

Way forward

The domestic sector in the Sand catchment will be supplied through the Bosbokrand Transfer Pipeline. This transfer pipeline is an example of the old supply driven approach to water management[175]. The remaining water user will be the irrigation sector (and forestry). Meeting the Ecological Reserve in the Sand catchment is only possible by limiting water abstraction of other water users. The water abstraction of the irrigation sector can be limited by; 1) reducing the water allocation, 2) more efficient water use in the scheme. By reducing water allocation, strict monitoring is required, however, there is no staff available to monitor irrigation abstraction and it is relatively easy to tamper with the monitoring structures. A more efficient water use in the scheme requires a costly upgrade of the schemes’ infrastructure. Therefore, both options are not realistic for the near future.

Concluding remarks

The focus of the catchments’ water management is on domestic water use. This becomes clear in the effort shown to meet the BHNR (by connecting the domestic networks to the Bosbokrand Transfer Pipeline). The focus of Bushbuckridge Municipality is on delivering drinking water, as promised by the ANC government. The Ecological Reserve should be augmented with water provided by the same transfer pipeline, however, so far this did not happen. This proves that the Ecological Reserve is overruled by the political reality to satisfy the basic needs of the population (the voters). The satisfaction of the basic human needs relates to the “social equity principle” of the National Water Act. This shows that the fundamental principles underpinning the NWA are in conflict with each other. It becomes clear that in the Sand catchment the “social equity” and “economic productivity”[176] principles of the National Water Act are more important for the implementing agencies than the “environmental sustainability principle”.

This section concludes with the title of one of South Africa’s most famous books: *“Long walk to Freedom”*, an autobiographical work written by Nelson Mandela. To meet the Reserve there is still a long way to go, it is a long walk indeed and it might involve curbing the freedom of some water users. Hence, in order to put DWAFS’s slogan “*some, for all, for ever*” into practice some tough political choices have to be made. These political choices will be the outcome of a political negotiation process among the water users.

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[175] The persistence of supply driven thinking is still visible amongst the responsible policy actors e.g. Bushbuckridge Municipality and DWAF. DWAF recently created a new infrastructural branch responsible for the infrastructural management of the water resources.

[176] Although not extensively researched in this thesis (only briefly described in chapter 2), the productivity of the industrial sector (e.g. power generation in Gauteng province) is of national economical importance. Therefore, water is transferred from several other catchments to fulfil the industrial water demand. Another example of the productivity discourse is the Sabie Sand Wildtuin’s argument about job creation.

9.2 Recommendations

Based on the research, as presented before, this report closes with some recommendations to several key stakeholders in the Sand catchment.

Department of Water Affairs and Forestry

The irrigation abstraction weirs are owned by DWAF. Therefore, they should alter the weir to comply with the Operating Rules. The weir crest geometry (height and/or length) must be adjusted to ensure a passive division of water between agriculture and other users. Modification of the abstraction weirs to comply with the rules is the best option to alleviate the stressed situation in the downstream part of the catchment. Besides the adaption of the abstraction weirs, a campaign to raise community awareness is a prerequisite before any work can be done.

One of the responsibilities of DWAF is monitoring of water flow and water use. An adequate monitoring system is required in order to properly determine whether there is a violation of the ER in a particular time and space. In addition, in order to get a better understanding of the water resources in the catchment monitoring is also required. Water resource data is used for, among others, water availability studies, which are carried out before issuing licenses. However, until present there is only one gauging station in the Sand catchment. I recommend DWAF to construct more gauging weirs to monitor river flow. It is recommended to provide at least one new river flow gauging station in the upper catchment to improve the estimates of the water resources. DWAF should also originate a structure to monitor water use at several strategic points. The lack of staff to monitor water use is one of the reasons for the lack of monitoring. A solution could be to involve the water bailiffs in monitoring. However, the water bailiffs are employed by DoA.

Inkomati Catchment Management Agency

Stakeholder involvement is one of the main aspects of the new water policy framework. Therefore, it is recommended that the ICMA emphasize local stakeholder involvement in all its activities (e.g. the writing process of the Catchment Management Strategies!). The ICMA should emphasize the need for a functioning Catchment Management Forum. They should support the Forum as well.

The knowledge about the Reserve amongst the different water users is deplorable. It is vitally important that the water users become aware of the importance of the Reserve to sustain their future and that of their children. Sustaining the environment is not only necessary for their health but it also impacts on the employment in the region. The ICMA should commence an awareness campaign to raise awareness among the different water uses, this campaign should be combined with the campaign required for the implementation of the Operating Rules.

Catchment Management Forum

It is likely that the water resource situation will not improve if there are no appropriate platforms for integrated planning. Therefore, I recommend to breathe new life into the Catchment Management Forum and to turn it into a functioning forum. At this forum stakeholders should come together and discuss water resources management issues in the catchment. By involving the stakeholders in the decision-making process it will help them to understand the bigger picture so they can make more informed decisions.

Department of Agriculture

The withdrawal of government support has led to the decline of the irrigation infrastructure. It is proven that the resource poor farmers cannot manage the schemes without government assistance. Therefore, DOA should assist the farmers and show its commitment towards the irrigators (e.g. by granting the refurbishment proposal). The department is also recommended to empower the extension officers in the irrigation schemes[177].

Irrigation Management committees

The management committees should do its utmost best to serve the farmer with the limited resources available. The committees should inform the water bailiffs about the Operating Rules and should tell them to stick to these rules. I recommend that after rehabilitating the canals, some parts of the main canal will be fenced by the farmers to prevent cattle crossing[178]. The management committees (assisted by NGO's or consultants) should develop a structure plan or roadmap for the schemes.

Bushbuckridge Water

I recommend that the abstraction points of the water board adhere to the Operating Rules. The water board should inform the pump operators about the rules. The water board should also include the operating rules in the operation procedures of the abstraction pumps.

Researchers

Numerous articles and reports are written by several water researchers about the situation in the Sand catchment. The focus of these researchers is mainly on policies and hydrology. To get a better understanding of the actual practices it is recommended to focus on the situation on the ground[179]. For example, one should visit the domestic pumping stations and interview the operators, instead of quoting the documentation from the water board only.

Further research is required on the performances of the current irrigation schemes. This should clarify if irrigation is the best suitable landuse in the water stressed Sand catchment. Possibly other farming options, or other types of landuse, are more appropriate in the Sand catchment.

Further research is also required on how to define the principles of the National Water Act, namely equity, sustainability and efficiency. How will these principles be defined or negotiated by the stakeholders? By negotiating these principles new questions will arise, e.g.; how can one compare the bench marks (e.g. economic profitability) of each principle and are productivity and sustainability comparable?

[177] By empowering the extension officers they can train the farmers how to increase their productivity.
[178] Cattle crossing causes breakages of the concrete canals.
[179] This reasoning is not only valid in the Sand catchment but can be applied throughout the country.

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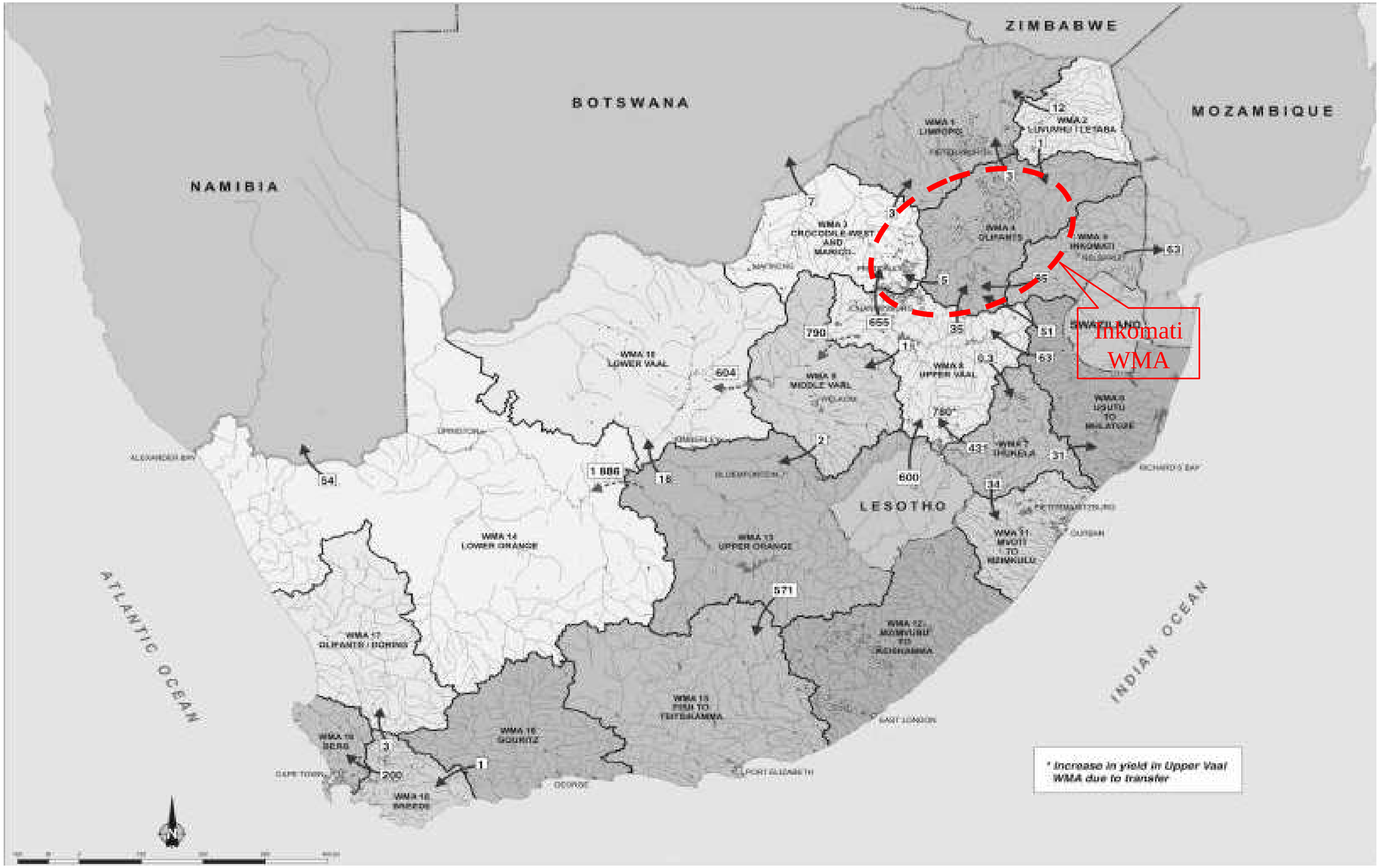
Appendices

Appendix A: Water management areas in South Africa

Location of water management areas and inter-water management area transfers. Source: DWAF [2004b]



Appendix B: Description of irrigation abstraction points

Dingleydale weir

River:	Tlulandziteka River	
Location:	1,5 km downstream of Kasteel dam	S 24º41’37.8 E 31º02’26.1
Water use:	Irrigation canal to Dingleydale/ Champagne scheme	
Description:	Small weir with overflow. The water flows around the weir into a silting basin A sluice gate is mounted on the head wall, this gate is only closed for maintenance in the canal	
Current state:	The sluice gate at the head wall is broken and can’t be adjusted. Currently the gate is fixed in an open position: water goes into the canal The sluice gate to release water from the canal into the river is broken, no water is released back into the river	

New Forest weir

River:	Mutlumuvhi river			
Location:	Upstream of NF scheme	S 24º44’30.8 E 31º04’17.2	Sandtrap:	S 24º44’37.0 E 31º04’22.1
Water use:	Irrigation canal to New Forest scheme			
Description:	Weir with overflow. Irrigation abstraction point is a drop intake, the water is piped approximately 100m to the canal.			
Current state:	Sluice gate at weir is broken and cannot be adjusted. Gate was only closed for maintenance in the canal Pipe to pump for chicken farm not in use anymore New pipe is excavated by a contractor for BBR municipality to bring water to six JoJo-tanks near two schools. Location JoJo tanks: S 24º43’73.8 E 31º03’26.5			

Champagne weir

River:	Klein Sand River	S 24º39’07.6 E 31º03’24.8
Location:	Close to Rooiboklaagte village	
Water use:	Irrigation canal to Champagne scheme Domestic water pumped to Acornhoek dam: Tintswalo hospital+ domestic	
Description:	The domestic abstraction point is through a grid on top of the weir, therefore the dam need to overflow in order to feed the domestic abstraction point. This limits the agricultural abstraction.	
Current state:	Irrigation canal not in use anymore. Municipality blocked the canal entrance with a steel plate to prevent water going into the canal. All the water that eventually reaches the sandtrap is diverted back into the river	

Edinburgh weir

River:	Mwandlamuhari river (downstream of Klein Sand river)
Location:	South of Songeni village
Water use:	Domestic use for Songeni community: “Sand River purification plant” Irrigation canal to Edinburgh dam: Allemande scheme
Description:	Weir with overflow. Water abstraction point is a drop intake. A water purification plant close to the weir pumps water from irrigation canal
Current state:	Canal to Edinburgh not in use anymore. The purification plant pumps water from the canal, 50m after start of canal.

Appendix C: Description of domestic abstraction points

Zoeknog Water Treatment Works

Location:	Zoeknog (upstream of NF weir) Pump station: S 24º54’33.8 E 31º00’25.7 Treatment works: S 24º45’26.1 E 31º00’35.9
Water source:	Mutlumuvhi River
Construction year:	approx. 1999 by DWAF
Operator:	BBR municipality since 1 April 2009, plant operated 24/7
Capacity:	32 l/s : 2765 m^3/day: 1.00 Mm^3/a
Service area:	Zoeknog + Mjambene
Pumping method:	Water is pumped from the Mutlumuvhi River at the weir into a pipeline to the water treatment plant Water is pumped throughout the year, no restrictions in times of water scarcity
Challenges:	Flow meter is not working for almost 2years, not possible to take samples for a couple of months. Outlet valve of Hydrocare tank is broken since 1,5 week, so they can’t add this chemical. Problems are reported to the municipality in Thulamahashe. The pump at the weir is blocked by sediment a temporary pump is installed.
IBT:	Not connected (the pipeline to the plant is not yet constructed)

Shatale Water Treatment Works

Location:	uphill of Shatale and London Treatment works: S 24º48’17.1 E 31º01’21.5
Water source:	Small dam in the mountains (not visited)
Construction year:	-
Operator:	BBR Water since 2003, plant operated 24/7
Capacity:	1700 m^3/day: 0.62 Mm^3/a
Service area:	Shatale (850 m^3/day) and London (850 m^3/day)
Purification method:	Chemicals- Fluctuating canals- settling basin- sediment tank- filter- reservoir
Pumping method:	Water flows by gravity from the dam through a pipe to the treatment plant
IBT	Not connected, pipeline stops just nest to the plant, outside the fence. Plans to connect IBT to a new build reservoir next to the existing plant.

Dwarsloop Water Treatment Works

Location:	Dwarsloop Pump station: S 24º45’54.2 E 31º07’31.6 Treatment works: S 24º47’19.3 E 31º04’51.6
Water source:	name unknown
Construction year	-
Operator:	BBR Water
Capacity:	460m^3/day in two shifts 7.00-12.00-17.00hour: 0.17 Mm^3/a
IBT:	not yet connected, will be connected in august 2009

Sand River purification plant

Location:	East of the Edinburgh dam			
	Pump station:	S 24º41'47.4 E 31º10'11.8	Treatment works:	S 24º41'11.5 E 31º10'11.1

Water source: Mwandlamuhari river (downstream of Klein Sand river) downstream Champagne + Dingleydale dam + Champagne pump
Construction year: approx. 1994
Operator: BBR Water since 2001, plant operated 24/7
Capacity: 350m^3 in one shift: 8 hours: 1050 m^3/day: 0.38 Mm^3/a
Service area: Songeni + Mabomlo + Buffelshoek
Purification method: Soda + Chlorine + Chemietech + Soda ash
Pumping method: Water is diverted from the Mwandlamuhari River at the weir into a canal in the direction of Edinburgh dam, water is pumped from the canal and piped (about 100m) to the purification plant
IBT: no

Thulamahashe purification plant

Location:	Next to the Thulamahashe-New Forest road			
	Pump station:	S 24º43'45.7 E 31º10'22.8	Treatment works:	S 24º43'19.5 E 31º10'33.6

Water source: Mutlumuvhi River (downstream of New Forest weir)
Construction year: 1982 by Department of Works, water supply section
Operator: BBR Water since 2002, before operated by Department of Works, water supply section, plant operated 24/7
Capacity: 380m^3/hour: 9120 m^3/day: 3.33 Mm^3/a
Service area: Thulamahashe + Rolle
Pumping method: Water pumped from the Mutlumuvhi River and piped (about 2km) to the purification plant, from the plant the treated water is pumped to a large reservoir. The IBT is also connected to this reservoir, water is already pumped through the IBT into the reservoir.
IBT: Reservoir next to treatment plant is connected to IBT since December 2008

Dingleydale purification plant

Location: Next to the Dingleydale – Songeni road, along DD main canal
Pump station = treatment plant: S 24º42'07.3 E 31º13'28.4
Water source: Dingleydale irrigation canal
Construction year: build in 1998 by DWAF
Operator: DWAF
Capacity: pump: 13 l/s, volume of treated water depends per day, depending on dirtiness of the water, varying between 43 and 100 m^3/day (if water is dirty a lot water must be drained and backwashed). For the last 13 pumping days the average was: 72 m^3/day: 0.01 Mm^3/a
Service area: Dingleydale village (+ Stlari)
Purification method: Hydroca + HtH + Chlorine + Soda ash
Pumping method: Water is pumped from the irrigation canal into settling tank. Fri-Sunday irrigation water is diverted to Champagne: DD canal is empty, it takes two day for water to reach Water is only pumped on Wednesday-Friday. Water is pumped from the canal for three hours into settling tank -> water treated and pumped for two hours. 3 hours collecting, 2hours pumping (two times a day)

Present:	No water is pumped to Stlari anymore due to the limited capacity of the plant. If the water is divided between the two villages they both have only 2hours of water
IBT:	not connected

<u>Champagne pumping station</u>

Location:	North of the Champagne dam	Abstraction weir:	S 24º54’33.8 E 31º00’25.7
Water source:	Klein Sand River, same abstraction weir as old Champagne canal		
Construction year:	build in 2001, operation started in 2002 Build by DWAF and BBRWaterBoard		
Operator:	BBR Water, plant operated 24/7		
Capacity:	no flow meter, report only running hours of the pumps 4 pumps (1 standby): 30Kw 20l/s 2 pumps (1 standby): 18,5Kw 10l/s Max capacity: 70 l/s: 2.21 Mm^3/a		
Service area:	Acornhoek dam		
Purification method:	- (only pumping)		
Pumping method:	Water needs to overflow into the inlet, from the inlet water is gravitated through a 300mm steel pipe to the basement of the pumphouse, 6 pumps pump the water from the basement (h: 15m) into the pipeline to Acornhoek dam, pumps work 24/7, during times of low river flow a smaller number of pumps is operated, as much water as possible is abstracted.		
Present:	No water is pumped to Acornhoek dam, due to rehabilitation of the dam There is no communication between Acornhoek dam and the pumphouse. The pumphouse operates independent from the dam, as much water as possible is pumped.		
IBT:	not connected		

<u>Edinburg A/B water treatment works</u>

Location:	downstream of Edinburgh dam
Water source:	Edinburgh canal, from Edinburgh dam Edinburg A: 10m south of canal } just opposite each other Edinburg B: 50m north of canal }
Construction year:	1992 (Edinburgh A) - (Edinburgh B) Build by DWAF
Operator:	BBR Water, plant operated 24/7
Capacity:	A: $60m^3$/hour: 0.53 Mm^3/a } 1.58 Mm^3/a B: $120m^3$/hour: 1.05 Mm^3/a }
Service area:	A: Edinburgh + Cottendale B: Welverde + Lydlo
Pumping method:	Water is pumped from the Edinburgh canal into the two treatment works.
History:	Edinburgh A was build to supply Tsintswalo hospital The next user along the canal was Allendale Citrus farm, but since they are closed, the treatment plant is the only water user along the canal, except a couple of small farmers upstream of the plant who use siphons to water their plots (very small volume).
Present:	Sometimes there is not enough water in the canal in winter
IBT:	Connected to IBT, IBT water must be tested first before the transferred water can be used. This plant will become a booster/ standby plant.

Appendix D: Description of storage dams

<u>Kasteel dam</u>

Source:	natural runoff
Location:	Upstream of DD next to R40 road
Water user:	Irrigation: Dingleydale scheme
History:	The dam was built in 1965 and raised during the late eighties
Current state:	Valve at outlet tower is blocked by a steel pipe. It is not cost effective to repair this valve. Therefore a siphon (steel pipe with a diameter of about 300mm) is placed on top of the dam to release water into the downstream Tlulandziteka River. However, the siphon is blocked and doesn't function anymore. Currently water is released partly through the broken valve and over the spillway. Problem: siltation of the dam caused by the upstream brick factory: reduction in storage.
Dam safety:	A "first" dam safety inspection was done by PJA Slabbert for the DWAF Directorate Civil Design in January 2001 (Report No. X302/26/E701) in which it was concluded that the dam may have to be abandoned due to possible slope stability insufficiency, excepts if a "useful purpose can be found" and provided that some remedial measures are taken

<u>Orinoco dam</u>

Source:	Natural runoff + irrigation canals from DD and NF
Water user:	Irrigation: New Forest
Description:	The water that is not used in the Dingeydale scheme is diverted to the Orinoco Dam and used in the New Forest scheme
Current state:	Currently no water from DD canal reaches the Orinoco dam: *because of water shortage?* Community members (fishermen) opened the valve at the outlet tower to release water to catch fish downstream of the dam

<u>Acornhoek dam</u>

Source:	Water pumped from Champagne dam
Water user:	domestic + Tintswalo hospital
Current state:	DWAF is rehabilitating the dam under a "Dam safety rehabilitation program: Group 1 Dams Phase 1: Acornhoek dam" A road is constructed on the dam wall.

<u>Edinburgh dam</u> *(not visited)*

Source:	natural runoff only
Water user:	domestic
Description:	Edinburg Dam discharges water into a canal, from which two water treatment works abstract water (AWARD, 2008)
Current state:	unknown

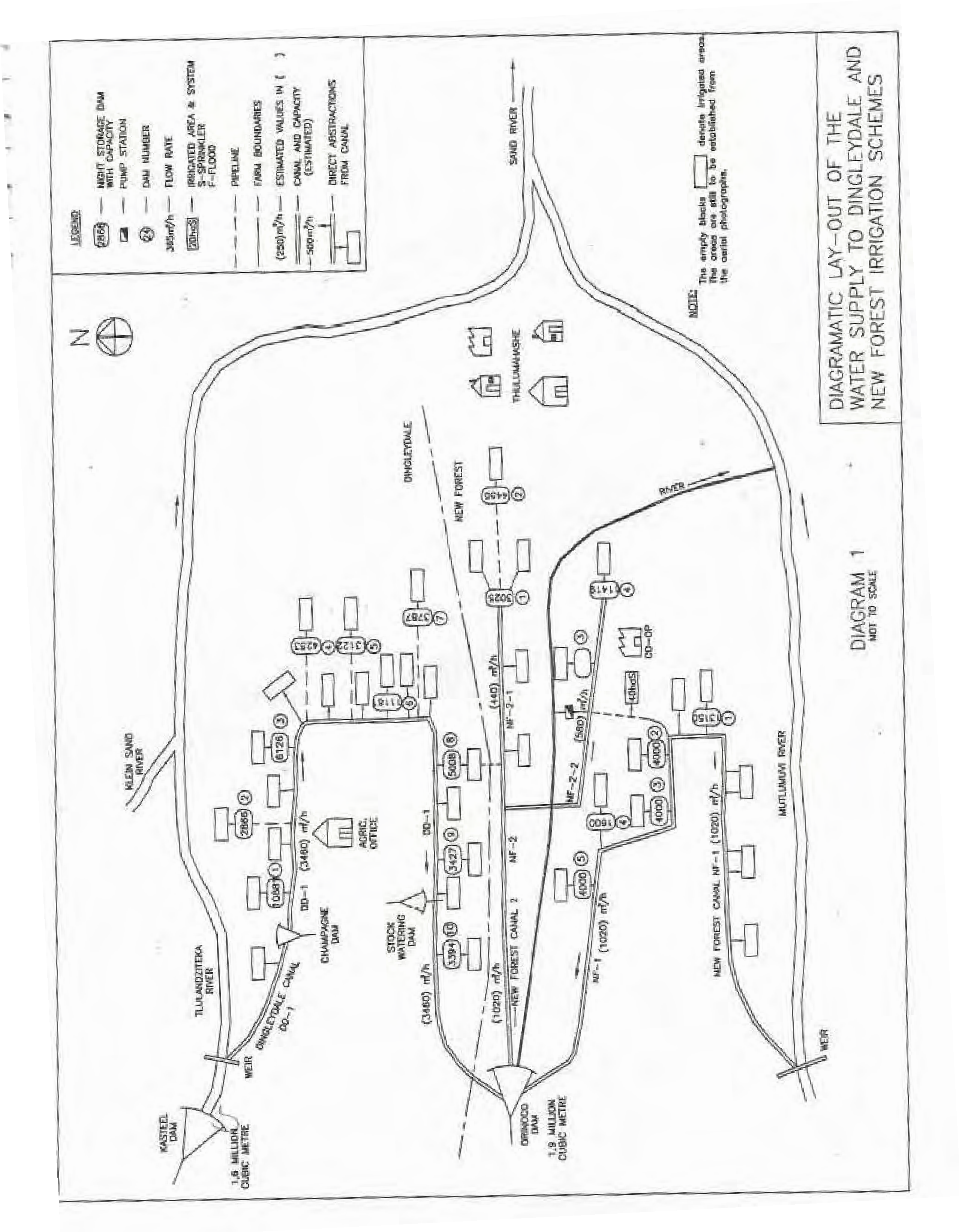
<u>Inyaka dam</u>
Source: natural runoff only
Water user: domestic and irrigation
Description: large storage dam on the Marite River (see section 8.2)
Current state: recently constructed

Table adapted from Pollard *et al*. 1998, DWAF 2003, RSA (undated, circa 1980), and AWARD 2008

Dam	Water source	Catchment area (km^2)	MAR (Mm^3/a)	Gross storage capacity (Mm^3)	Net storage capacity (Mm^3)	Former administrative authority	*Designed for user* <u>(current user)</u>
Acornhoek	Small tributary of Klein Sand River	116 ha	1.16	1.1	0.80	Lebowa	<u>*Domestic*</u>
Casteel	Tlulandziteka River	73 ha	0.73	1.6	1.35	Lebowa	<u>*Agriculture*</u> (Dingleydale)
Champagne	Small stream + DD irrigation canal			0.28		Lebowa	<u>*Agriculture*</u> (Champagne scheme)
Edinburgh	Sephiriri River + Mphyayana River	281 ha	3.34	3.3	2.42	Gazankulu	*Agriculture* (Allendale + Dumfries) + <u>domestic</u>
Inyaka	Maritsane River and Marite River	209	100	123	120	-	*Environment* + *Agriculture* + *Domestic*
Orinoco	Tributary of Mutlumuvhi River + irrigation canal (DD+NF)	107 ha	1.07	1.9	1.62	Gazankulu	<u>*Agriculture*</u>

The Zoeknog dam which was built by the then Lebowa Government failed in 1993 and is not described in table.

Appendix E: Schematic layout of Dingleydale and New Forest irrigation scheme



Source: ARC-LNR. (1999). *New Forest and Dingleydale irrigation scheme overview and development potential*, Pretoria

Appendix F: Summary of the Teba irrigation refurbishment proposal

Title:
Funding application for the proposed refurbishment of the New Forest and Dingleydale irrigation schemes.

Background:
The farmers, through the Management Committee, have approached MABEDI (Maruleng and Bushbuck Ridge Economic Development Initiative) and Teba Development to assist them in applying for funding to refurbish the canal irrigation systems. This is seen as the major factor limiting the success of the farmers. Other critical areas such as advice, access to inputs and markets are currently being addressed by the MABEDI programme *(not described in this report)*.
The tragedy of the commons is apparent on a number of irrigation schemes where an ever decreasing quantity of water reaches the farmers as a result of leakages throughout the unmaintained supply system. The large number of users and the vastness of the supply networks compound problems associated with maintenance and the organization that such maintenance requires. These previously dependant farmers have neither the resources nor the incentive to organize themselves. The result is a combination of unreliable supply throughout the year and inconsistent supply to the various users.
Based on the above description of the irrigation schemes and the current economic initiative that is being driven by MABEDI, their proposal focus on the need for the refurbishment of the irrigation canals in the two irrigation schemes, New Forest and Dingleydale.

Aim:
To improve supply reliability and overcome poor usage and wastage of water within the irrigation schemes, thus increasing water use efficiency. Therefore all the canals, dams and infrastructure in both irrigation schemes need to be refurbished.

Community Managed Contract
The proposal is based on a Community Management Contract approach whereby the project is managed by the Water Users Associations'/management committees. The committees will be empowered in the construction, running and maintenance of the irrigation schemes. They will be responsible for the appointment of labour, consultants and will be accountable for the entire process. The committees have requested Teba Development to be the lead consulting agent for the design, engineering and management of the refurbishment due to the already existing relationship between Teba Development, the farmers and the community through the MABEDI programme.
I conclusion: The community facilitates and manages the refurbishment of the canals. They oversee the entire process from the appointment of contractors to the establishment of a sound maintenance and management plan. The proposal uses a labour intensive methodology to create employment and impart skills to local beneficiaries. All labour will be trained on site. The reason for using local employees is twofold. Firstly it addresses the issue of poverty and unemployment and secondly it assists with skills transfer and capacitates the local community with the necessary skills to maintain the canals in the future (increase ownership).

Budget:
The total cost of the project is R38.57 million and will be completed over an 18 month period.

Table 1 Proposed project costs and capital outlay requirements (in Millions of Rands, excl. VAT)

Section	Description	Dingleydale	New Forrest	Total
A	Fees and Supervision	1.85	1.85	3.70
B	Canal Materials	16.20	6.65	22.85
C	Other Materials	3.82	2.28	6.11
D	Labour	3.46 +	2.44 +	5.91 +
Total		25.33	13.23	38.5

The cost of the refurbishment per hectare: Dingleydale: R38.000
New Forest: R29.000

Rehabilitation:
The canal system is in major disrepair. It is assumed that between 65 and 75% is lost in the mainline and infield canal, with 25 to 30 % available for use in the field. The canal lengths have been divided into various canal maintenance requirement categories. The replacement, repair and minor repair lengths are determined visually by assessing each concrete panel (see table 2 and 3).

Table 2 Repair and replacement lengths for Dingleydale canal system

Section	Replacement length (m)	Repair length (m)	Minor repair length	Siphon length (m)	Total length (m)
Main canal	2700	7500	13000	2300	25500
Infield canal 1 (larger)	14472.5	18607.5	8270	-	41350
Infield canal 2 (smaller)	24116.05	31006.35	13780.6	-	68903 +
				Total	135753

Table 3 Repair and replacement lengths for New Forest canal system

Section	Replacement length (m)	Repair length (m)	Minor repair length (m)	Siphon length (m)	Total length (m)
Main canal	1900	9500	12800	2300	26500
Infield canal 1 (larger)	7525	9675	4300	-	21500
Infield canal 2 (smaller)	11620	14940	6640	-	33200 +
				Total	110253

Replacement length: canal section needs to be removed totally and replaced
Repair length: 25 % of the canal section needs to be replaced, on average.
Minor repair: 5% of the canal section needs repair, on average
Along the canals foot bridges + vehicle/animal crossings +washing areas need to be installed to prevent future damages to the infrastructure.

Supervision
The labour will be sourced from the local communities. The Management Committee will be the link between the farmers on the irrigation schemes and the project. TEBA Development, who is the agri-business consortium partner in the MABEDI programme, will manage and mentor the project. Teba has sufficient management capacity to successfully implement this project together with the water user associations. A team of experienced Teba professionals will support the program. Teba has the intention of retaining a permanent presence in providing rural development services within these areas. The DoA has also shown their support to the farmers.

Future

The proposed implementation procedure could result in an additional 1,500 to 2,000 m3/h to available to farmers on the lower reaches of the canal as well as downstream users of the Sand River system

The community will be a key role-player in the process and their inputs will be vital to the success of the project. The Management Committee and the Water Users Associations will be further capacitated in organizational and management skills. This will ensure the sustainability of the project and more efficient water use on the irrigation schemes.

Farmers have stated that they are willing to contribute for the use of water once a reliable supply is secured.

Strong points of the proposal are:

- Farmer driven approach;
- Adjustments of the abstraction weirs in accordance to the Operating Rules[180];
- The refurbishment proposal is not a project on its own. The project is embedded in the much broader MABEDI project which focuses on a combination of several aspects: 1) input linkages, 2) market linkages, 3) extension services, and 4) infrastructure[181].
- MABEDI has proven to have the will, the skills and the capacity to refurbish the infrastructure[182].

Weak points of the proposal are:

- Teba believes in the strength of the irrigation management committees, I doubt if this can be justified;
- According to the proposal "... water is plentiful and sufficient for the irrigation schemes". However, crop water requirements are not calculated and water availability is not taken into account[183].

Conclusion

The refurbishment of the canals will be done is such a way that the farmers and community will be skilled in the work allowing them to successfully maintain and manage the canals in the future and take full ownership and responsibility for their biggest asset and opportunity.

[180] Personal communication senior ICMA official, 16 June 2009.

[181] From interview Managing Director, Lima Rural Development Foundation, 26 March 2009, Bushbuckridge.

[182] Most farmers are satisfied with the positive influence of the MABEDI project on their livelihood.

[183] Personal communication Lima engineer, responsible for the proposal, 21 April 2009.

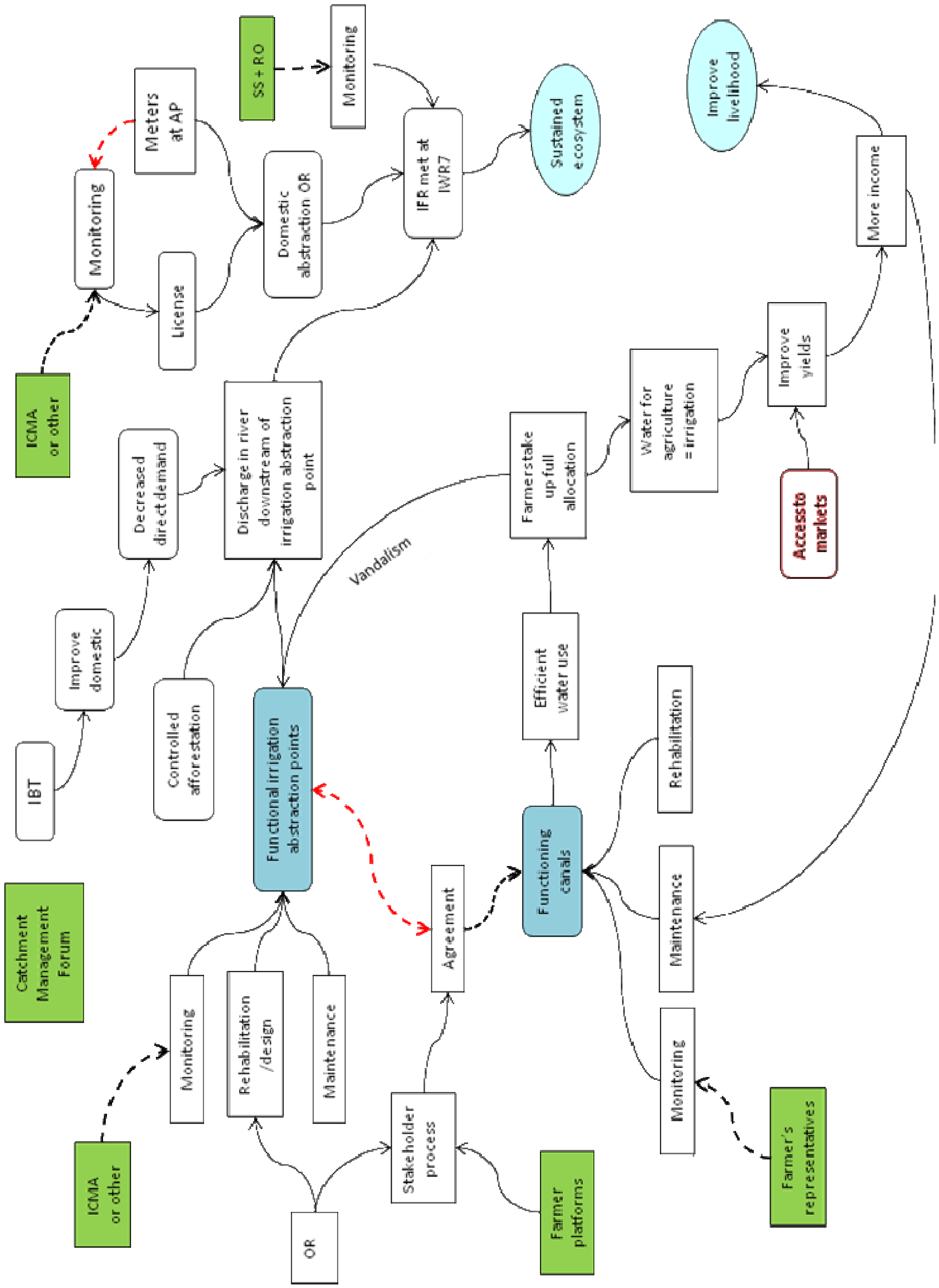
Appendix G: System diagram for the Sand catchment

Almost all the interviewed stakeholders argued that the inefficient irrigation schemes must be rehabilitated to increase downstream river flow in the river. The below presented system diagram shows that this is not a valid reasoning. Many more factors (e.g. stakeholder participation, adjusted abstraction weirs, controlled afforestation, and monitoring) than simply infrastructural rehabilitation need to be in place before more water is available for the Ecological Reserve.

A system diagram shows the relations between the different elements in the catchment. The logic of the system diagram is that an improvement in one element will lead to the following element(in the direction of the arrow). For example; (better) better functioning irrigation canals will lead to more efficient water use.

I will highlight the main items of this diagram:

- Healthy societies cannot exist without healthy ecosystems (i.e. healthy rivers);
- Most interviewed stakeholders argue that in order to reach this goal the canals infrastructure should be rehabilitated and the OR must be implemented. This diagram proves that this is not the case;
- For the canals and irrigation abstraction points to function, they must be rehabilitated, maintained and monitored;
- By rehabilitating the irrigation infrastructure the government shows its commitment to the farmers. Hopefully, this will prevent the farmers from tampering with the rebuild irrigation abstraction points. The rehabilitated infrastructure will considerably improve the distribution efficiency;
- By good functioning irrigation abstraction points (rebuild abstraction weirs and functioning OR), the volume of water in the downstream river increases during times of low river flows. But the water flow in the river is not influenced by irrigation abstraction only. Therefore, afforestation and domestic water use must also be controlled;
- Because of the higher incomes of the farmers they are able to pay for the maintenance of the irrigation schemes.
- There is no direct link between functioning canals (rehabilitated infrastructure) and more water in the river (more water for the ER);
- Many more factors (e.g. stakeholder participation and monitoring) than simply infrastructural rehabilitation need to be in place before more water is available for the Ecological Reserve;
- The OR must be integrated in the catchment planning process through stakeholder participation;
- The water monitor activities must be carried out by the responsible authorities.


ICMA
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Improve
livelihood
IBT
Improve
domestic
Decreased
direct demand
Discharge in river
downstream of
irrigation abstraction
point
Controlled
afforestation
Functional irrigation
abstraction points
Vandalism
Farmers take
up full
allocation
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agriculture
= irrigation
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yields
More income
Access to
markets
Efficient
water use
Functioning
canals
Rehabilitation
Maintenance
Monitoring
Farmer's
representatives
Agreement
Stakeholder
process
Farmer
platforms
OR
Monitoring
Rehabilitation
/design
Maintenance
ICMA
or other
Catchment
Management
Forum

Appendix H: Summary of Champagne Citrus Estate Project Report

After SAFM left the farm DoA promised to support the farm. In close cooperation between DoA and the Community Property Association a business plan was written as an interim operational plan. report is written by an economist of DoA, Nelspruit. He represents Champagne at the department.

First phase (Feb 2009- March 2010)

- Hiring a temporal manager to push the farm to the next harvest season in 2010 *(finished)*
- Have consultants from DoA to verify and update the available asset registry *(finished)*
- Assist each employee with a clear job description and develop a performance asset system *(in progress)*
- Develop a temporal rescue plan with clear cost for each and every resource that is needed and to be used in the interim period *(in progress)*

Second phase (March 2010 – till end of contract):

- Inviting a strategic partner or having an investor for a long term around plan
- Replanting of the whole farm as most of trees are more than 50 years old, the lifespan of a citrus tree should be not more than 30years.
- Extending the farm, plenty of space for expansion

The project is requesting for a provincial grant from the Department of Agriculture and Land Administration (R1 million) and a grant from the Regional Land Claim Commissioner (R3 million). According to the business plan the project will be able to generate profit in the third year providing that a grant funding is injected.
The interim operational plan needs a total capital injection of R13.5 million.

Currently an interim operational strategy has been developed by DOA and a temporal manager is hired since March 2009.

Appendix I: Background on Operating Rules

Principles used to develop the OR

- Crops:

Perennial:	30%
Cash	70%

- Irrigation water requirement:

Field edge:	12,3 million m^3/a
Gross (at point of river abstraction)	14,5 million m^3/a
Net (after return flows)	12,2 million m^3/a

- Irrigated area in 1998:

Champagne North	120ha
Dingleydale and Champagne South	780ha
Orinoco	240ha
New Forest	160ha
Zoeknog	100ha
Allendale and Dumphries	90ha +
Total:	1,490ha

- water requirement at Exeter for ER: 33,8 million m^3/a
- water requirement at Exeter for ER: 6,9 million m^3/a (very dry year)

Revised canal diversion in interim period

Formulas are drawn by Charles Sellick to calculate the revised canal diversion in the interim period when BTP is not in full operation. Two different formulas are designed to adjust the ratio for abstraction upstream and from the diversion canal:

- Abstraction upstream of the diversion weir:
  Revised canal diversion (% of flow arriving in the river) = a / (b - upstream domestic use)
  Where the upstream domestic use is the total cumulative upstream domestic use (both as direct river abstraction and canal abstraction) in million m^3/a.
- Abstraction from the diversion weir:
  Revised canal diversion (% of flow arriving in the river) = c * (d + domestic use from canal)
  Where the domestic use from the canal is the total use from the particular canal in million m^3/a.

The above mentioned constants differ for each of the three affected diversion sites and are given in the table below:

Abstraction site	Constant			
	a	b	c	d
New Forest canal	116	2.33	43.0	1.16
Dingleydale canal	644	9.91	10.0	6.44
Edinburgh canal	304	8.69	11.5	3.04

Calculation of amended proportions

Table: Abstraction capacity of the Water Treatment Works

Source:	Charles Sellick, 2004			BBW	Own observation		
Plant	capacity (m^3/day)	capacity (Mm^3/a)	capacity incl 10% losses (Mm^3/a)	Capacity (Mm^3/a)	capacity (m^3/day)	capacity (Mm^3/a)	capacity incl 10% losses (Mm^3/a)
Zoeknog WTW	2.646	0.97	1.06	-	2.765	1.00	1.10
Edinburgh A WTW	1.296	0.47	0.52	1.12	1.440	0.53	0.58
Edinburgh B WTW	1.620	0.59	0.65	1.10	2.880	1.05	1.16
Sandriver WTW	1.296	0.47	0.52	0.89	1.050	0.38	0.42
Thulamahashe WTW	3.024	1.10	1.21	6.95	9.120	3.33	3.66
Dwarsloop WTW	4.795	1.82	2.00	1.07	460 *	0.17	0.19
Shatale WTW	756	0.28	0.30	1.72	1.700	0.62	0.68
Acornhoek WTW	3.024	1.10	1.21	3.89	6.054	2.21	2.43
Dingleydale	453	0.17	0.18	-	72 *	0.01	0.01
Total	**18.910**	**6.87**	**7.65**	**16.74**	**26.151**	**9.29**	**10.22**

* The difference in figures can partly be explained by different pumping hours per day. According to the ICMA datasheet from Charles Sellick the pumps are running 18–21 hours per day. However most of the operators told me that they operate the pump 24 hours per day.
But despite the effect of the different daily pumping hours some numbers are still quite different. Unfortunately I was not able to discover the source of the capacities of the data from Charles Sellick.

Revised New Forest canal diversion
- Abstraction upstream of diversion weir: Zoeknog WTW: 1.10 Mm^3/a
Revised canal diversion (% of flow arriving in the river) = a / (b - upstream domestic use)
Revised canal diversion (% of flow arriving in the river) = 116 / (2.33 -1.10) = 94%
The maximum allowable abstraction at each abstraction point is 65%
94% is larger than the maximum of 65%; the revised canal abstraction percentage is **65%**

Revised Dingleydale canal diversion
- Abstraction upstream of diversion weir: Sandriver WTW: 0.42 Mm^3/a
Acornhoek WTW: 2.43 Mm^3/a
Revised canal diversion (% of flow arriving in the river) = a / (b - upstream domestic use)
Revised canal diversion (% of flow arriving in the river) = 304 / (9.91 -2.85) = 43%
- Abstraction from diversion weir: Dingleydale WTW: 0.01 Mm^3/a
Revised canal diversion (% of flow arriving in the river) = c * (d + domestic use from canal)
Revised canal diversion (% of flow arriving in the river) = 10 * (6.44 + 0.01) = 65%
The maximum allowable abstraction at each abstraction point is 65%
43% is smaller and 65% equals 65%; the revised canal abstraction percentage is **65%**

Revised Edinburgh canal diversion
- Abstraction from diversion weir: Sandriver WTW: 0.42 Mm^3/a
Revised canal diversion (% of flow arriving in the river) = c*(d + domestic use from canal)
Revised canal diversion (% of flow arriving in the river) = 11.5*(3.04 + 0.42) = 40%
The maximum allowable abstraction at each abstraction point is 65%
40% is smaller than the maximum of 65%; the revised canal abstraction percentage is **43%**

Appendix J: Water Management Scenario's

Together with a consultant three different solutions (scenarios) to meet the Reserve in the Sand catchment were modelled. These scenarios would be tested on the ability to meet the Ecological Reserve. The hydrological model designed by the consultant predicted the outcomes of the different scenarios on the Reserve.

Scenario 1: Current situation
Domestic water is supplied through the Bosbokrand Transfer Pipeline to the Sand catchment.
Irrigation abstraction at maximum capacity which is what is currently happening

Table 1: Maximum canal capacity

Irrigation abstraction site	Maximum canal capacity (m^3/s)
Champagne	0.127
Dingleydale	0.962
New Forest	0.283
Edinburgh	1.15

Scenario 2: Irrigators only abstract required amount of water
Domestic water is supplied through the Bosbokrand Transfer Pipeline to the Sand catchment.
The irrigators only abstract the water required. Since Edinburgh scheme is not in use anymore no water is diverted to Edinburgh Dam, which is currently the case

Table 2: Irrigation water requirement

Irrigation abstraction site	Water required (Mm^3/a)
Champagne	2.56
Dingleydale	8.70
New Forest	4.67

Source: Mallory, 2009

Scenario 3: Implemented Operating Rules
Domestic water is supplied through the Bosbokrand Transfer Pipeline to the Sand catchment.
Irrigation abstraction according to the Operating Rules; the proportional diversions rule.
The Operating Rules only come into effect when the river flow drops to the level indicated under "River Flow".

Table 3: Operating Rules

Canal	Capacity (m^3/s)	% Releases	River flow (m^3/s)
Champagne	0.127	35%	0.19
Dingleydale	0.962	35%	1.48
New Forest	0.283	50%	0.57
Edinburgh	1.150	65%	3.28

The next graph shows the outcomes of the different models on the ability to meet the Reserve in the Sand catchment. The dashed line shows the Environmental water requirement at EWR8 site, downstream in the Sand catchment.

Table 1: Ability to meet the Reserve

Scenario	Reserve met	Reserve not met	Non-compliance (%)
1	December – February	March - November	75
2	September – April	May – August	33
3	September - June	July and August	17

In conclusion: implementing the Operating Rules improves the quantity of the water downstream in the catchment. However, the Reserve is still not met in July and August.

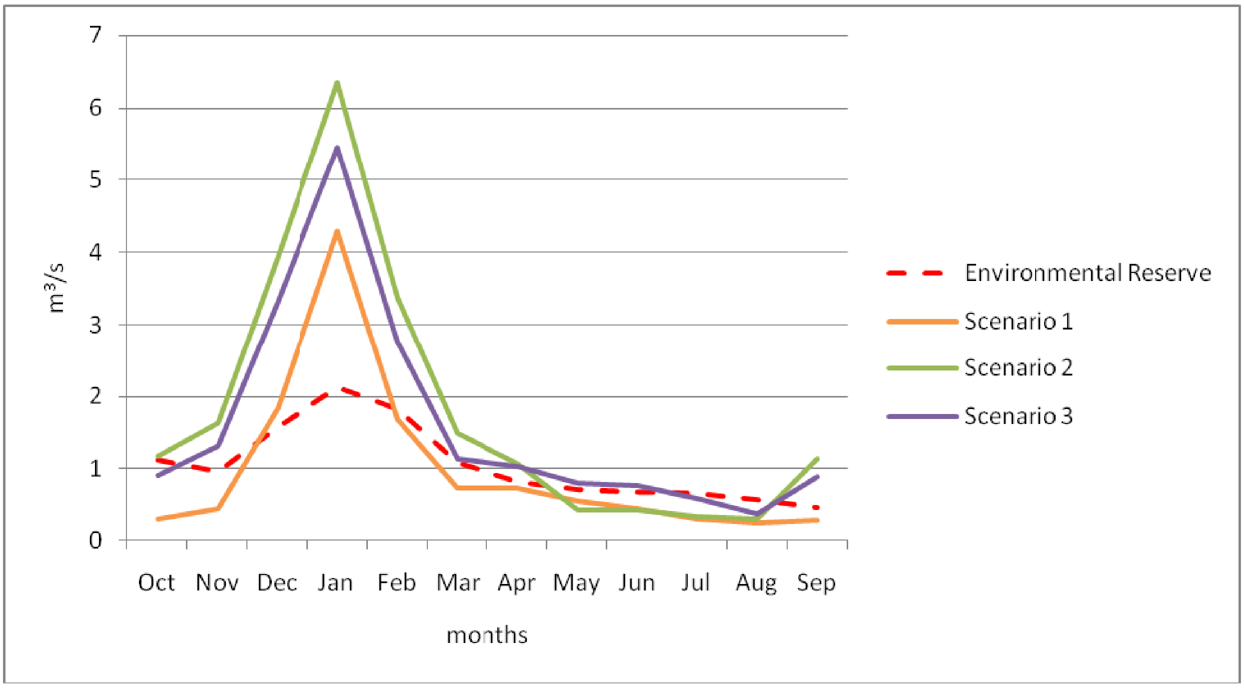

Figure 1: Impact of the scenario's on the Environmental Reserve
Source: author, 2009

Appendix K: Average monthly flows at Exeter (X3H008A01)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968	0,72	1,42	3,01	1,64	0,71	0,76	0,39	0,31	0,22	0,06	1,27	1,62
1969	2,29	2,98	4,28	5,13	1,49	0,7	0,5	0,34	0,2	2,47	1,4	2,71
1970	0,5	0,61	0,07	0	0,07	0,23	0,38	0,12	0,02	0,04	0,4	0,73
1971	6,58	4,3	2,95	4,68	1,53	0,86	0,52	0,3	0,47	0,96	1,85	5,91
1972	-	10,14	15,42	-	5	2,47	-	-	-	-	-	0,69
1973	0,85	0,99	0,83	1,62	0,53	0,42	0,34	-	0,13	-	2,46	-
1974	-	-	-	-	-	-	2,27	1,13	-	-	-	-
1975	-	-	-	-	-	-	-	-	-	-	-	-
1976	-	-	-	-	-	-	-	-	-	-	-	1,54
1977	0,72	-	-	-	2,34	-	1,11	0,96	1,47	1,06	0,74	2,8
1978	-	-	-	7,05	2,74	1,96	1,65	1,11	0,75	1,45	3,21	2,64
1979	2,69	1,57	4,9	-	-	-	-	0,53	0,5	0,52	-	-
1980	-	4,66	8,13	3,34	1,02	0,64	-	0,6	0,59	0,67	2,48	6,63
1981	7,73	-	-	-	-	-	-	-	-	-	-	-
1982	-	-	-	-	-	-	-	0,62	0,27	0,14	0,25	0,13
1983	0,37	-	0,59	0,55	0,24	0,1	0,04	0,06	0,03	0,02	-	-
1984	-	1,58	3,28	2,49	-	-	1,47	0,5	0,45	0,43	1,64	2,34
1985	2,41	7,04	7,85	-	-	-	0,44	0,27	0,18	0,1	1,08	1,35
1986	1,66	3,62	1,41	3,39	1,86	0,63	0,35	0,36	0,22	0,06	0,13	-
1987	1,52	0,46	3,34	-	0,24	0,19	0,08	0,11	0,36	1,62	0,48	8,88
1988	7,09	5,43	-	-	1,25	0,95	0,95	0,61	0,34	0,36	0,56	0,62
1989	0,46	5,79	3,43	0,99	0,99	0,97	0,34	0,23	0,14	0,15	1,23	5,38
1990	2,81	-	2,84	3,78	1,17	-	-	-	-	-	-	-
1991	-	-	-	1,73	0,74	0,95	0,4	0,18	0,09	0,06	-	0,37
1992	0,07	0,08	0,05	0,36	0	0	0	0	0	0	0,96	2,7
1993	3,95	2,39	7,85	1,85	0,7	0,18	0,13	0,09	0,03	0,12	0,31	2,58
1994	2,24	2,65	1,46	0,64	0,18	0,11	0,13	0,05	0,03	0,20	0,27	0,95
1995	2,74	1,51	0,67	0,82	0,98	0,12	0,06	0,06	0,02	0,00	1,72	4,63
1996	10,93	14,54	14,94	6,80	7,07	3,06	1,98	1,90	0,80	0,48	0,54	1,61
1997	3,65	3,39	10,19	6,11	2,16	0,99	0,77	0,76	1,25	0,65	0,26	-
1998	5,09	3,11	3,15	1,60	0,72	0,41	0,63	-	-	-	4,15	15,35
1999	14,47	24,59	12,70	6,07	3,37	1,97	1,50	1,13	0,67	0,62	2,17	5,45
2000	24,43	47,71	37,59	19,56			4,09	-	-	1,67	3,52	6,24
2001	4,13	7,54	3,87	3,58	2,51	1,50	1,09	0,75	0,45	0,81	9,98	14,01
2002	3,64	9,51	3,76	3,45	1,45	1,26	0,82	0,86	0,55	0,87	0,91	1,43
2003	1,12	0,34	0,35	0,45	0,14	0,13	0,09	-	-	-	-	0,13
2004	2,25	7,47	6,86	5,23	1,22	0,51	0,37	0,26	0,13	0,02	0,18	1,12
2005	1,70	0,59	1,01	0,76	0,64	0,24	0,24	0,12	0,00	0,00	0,35	0,48
2006	9,71	14,47	30,96	11,40	3,01	1,57	1,10	0,74	0,47	0,35	2,94	0,75
2007	3,45	1,76	0,73	2,40	0,39	0,28	0,29	0,14	0,04	0,40	1,08	4,37
2008	4,75	1,48	0,93	1,30	0,46	0,28	0,22	0,16	0,09	0,09	1,00	3,16

Source: adapted from DWAF river flow website, see footnote 108