ARDORINO, F. (2002). *Issues and conflicts about water management in South Africa. The example of the Steelpoort River Basin.* Msc report. IWMI-Cemagref-Cirad-Cnearc.

English version (first draft)

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List of abbreviations

BBM…………………	Building Block Methodology
CEMAGREF………..	Institut de recherche pour l'ingénierie de l'agriculture et de l'environnement
CIRAD……………..…	Centre de coopération Internationale en Recherche Agronomique pour le Développement
CMA………………..…	Catchment Management Agency
CNEARC…………...…	Centre National d'Etudes Agronomiques des Régions Chaudes
DEAT………………..…..	Department of Environmental Affairs and Tourism
DWAF………………..	Department of Water Affairs and Forestry
IFR……………………	Instream Flow Requirements
IWMI…………………	International Water Management Institute
IWQS…………………	Institute for Water Quality Studies
MAR………………..…	Mean Annual Run off
NWA…………………	National Water Act of 1998
ORF…………………..	Olifants River Forum
TLC…….…………….	Transitional Local Council
WMA…………………	Water Management Areas
WRC………………..…	Water Research Commission

1 Introduction

The National State of the Environment of South Africa (DEAT, 1999) assessed **freshwater resources in the country as stressed and polluted.**

South Africa is considered as an arid or semi-arid country, with only 8.6% of the rainfall available as surface water. This is one of the lowest conversion ratios in the world. Freshwater resources are scarce and highly variable in time and space. (DEAT, 1999)

Available freshwater resources are already almost fully-utilised and under stress. At the projected population growth and economic development rates, it is unlikely that the projected demand on water resources in South Africa will be sustainable. Water will increasingly becoming the limiting resource in South Africa, and supply will become a major restriction to the future socio-economic development of the country, in terms of both the amount of water available and the quality of what is available. At present many water resources are polluted by industrial effluents, domestic and commercial sewage, acid mine drainage, agricultural runoff and litter. (DEAT, 1999)

In the same time period, recent political changes in the country, and the advent of democracy lead to numerous legal reforms. The New Water Act (RSA-NWA, 1998), based on the principles of sustainability of use and equity of distribution has completely reformed the water law in South Africa, and new institutions will be built to allow for a participative and integrated basin water management, **putting forward the fulfillment of basic human needs and environmental requirements, called "the Reserve", including quantitative and qualitative aspects**. All allocations from rivers have to give preference to the Reserve and international obligations. Authorizations for other uses may follow and will be given to promote social and economic development.

The new management framework will have to deal with a resource facing more and more pressures. Institutions who will be built to achieve those new objectives will have to allow the integration of different stakeholders points of views.

2 Context and objectives of the study

A research program has been initiated at IWMI to assist the Department of Water Affairs and Forestry (DWAF) in the establishment of future catchment-based management institutions, involving users' participation, the Catchment Management Agencies. The present study has been supported by CNEARC, and CIRAD-CEMAGREF PCSI program.

The Olifants river basin has been chosen as reference basin, because it represents main stakes of concern in the country. Firstly, it is considered by DWAF as water stressed, and no new water authorizations are being given. Secondly, rivers have been highly impacted by human activities and main pollution problems are encountered and attributed to different sectors : agricultural pollution, domestic use pollution related to informal settlements and sewage treatment works, various impacts of industry, mainly due to the mining sector. Main water users are present in the basin, and new developments are to be expected in the area.

The present study is dealing with the Steelpoort subbasin, because it seems to be representative of water management issues occurring in South Africa.

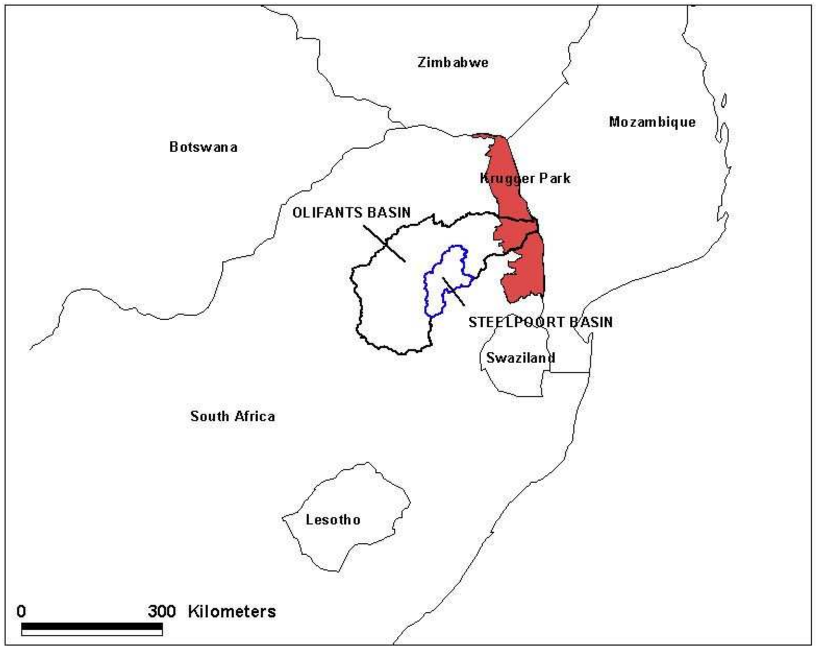

Figure 1 : Steelpoort basin location

Main water users are involved in the basin. The area experiences quick and huge developments of the mining industry and the basin presents environmental and water quality stakes. The situation is rather complex : if localized pollution problems are well known today, diffuse pollution sources are also to be taken into account and the pollution state of the basin is globally misunderstood.

The main objectives of this study is to understand the current management framework of the Steelpoort basin, to point out current and future difficulties that might be amplified with new requirements related to the NWA.

The study therefore consists in describing the current management system and the main stakes as perceived by stakeholders, identifying difficulties and debated points related to the new management objectives. Understanding the different strategies should bring elements to facilitate stakeholders' information and participation to an integrated resource management.

3 Methodology

The study has been carried out between June and October 2002. It consisted in gathering information concerning the state of the basin, impacts of water users and the management system, then to confront the different stakeholders points of view to identify management problems or points being debated.

Information has been collected about :

- recent political historical context, basin development and geographical situation of main water users to present a broad description of the contrasts related to natural and human characteristics of the basin,
- hydrological data related to the demand and supply balance and pollution problems to present a state of knowledge on the basin and its current management.

Starting from those data, collected by literature review and interviews, management principles and their implementation are being discussed, and points to be debated are identified.

3.1 Data collection about the basin state of knowledge and the management system

Historical and geographical general data presenting the context and the study area specificity have been derived from the literature review.

Data have been collected about water resources, water uses and impact of those uses starting from an important bibliography available about the Olifants basin (mainly consultants' reports for DWAF).

Users impacts can be estimated through the water demand and supply balance and the evaluation of water resources quality and pollution sources.

Quantitative and qualitative aspects have been examined through :

- the information system : indicators being used (measure points, data validity and relevance), data and analysis being produced
- the basin water management system (organization, available resources).

Depending on the information sources, evaluations can be different concerning the demand and supply balance for example.

Information sources are consultants reports, national databases and maps concerning :

- hydrosystem functioning, water resource demand and supply,
- pollution sources, ecological state of the basin,
- legal texts,
- implementation policy, recommendations, national strategy,
- environmental needs evaluation methodologies as developed on South Africa,
- ecological reserve evaluation on the Steelpoort basin

and interviews at DWAF (water quality manager at national level, local water resource and abstraction control manager, local water quality and pollution control manager).

3.2 Stakeholders points of view collection

Points of view were gathered through meetings at DWAF or interviews with water users and other interested parties (environmentalists, researchers, consultants working for DWAF or mining companies).

3.2.1 Interviews selection

34 interviews have been done, with 19 water users and other stakeholders.

Water users have been chosen following geographical criteria (upstream and downstream parts of the basin) or socio-economical criteria (commercial farmers, small-scale farmers in the former homeland, villagers).

Interviews are referenced and localized in the following table and map :

	Références	N
DWAF Pretoria	DP1, DP2, DP3	3
DWAF Groblersdal	DG1	1
DWAF Nelspruit	DN1, DN2, DN3	3
Municipalities	M1, M2, M3, M4	4
Commercial Farmers	CF1, CF2, CF3, CF4	4
Small scale farmers	SF1, SF2	2
Mines	Mi1, Mi2, Mi3, Mi4	4
Villagers	V1, V2, V3-1, V3-2, V3-3	5
Consultants, researchers	C1, C2, C3	3
Environmentalists	E1, E2, E3, E4	4
Total		34

Table 1 : Interviews references

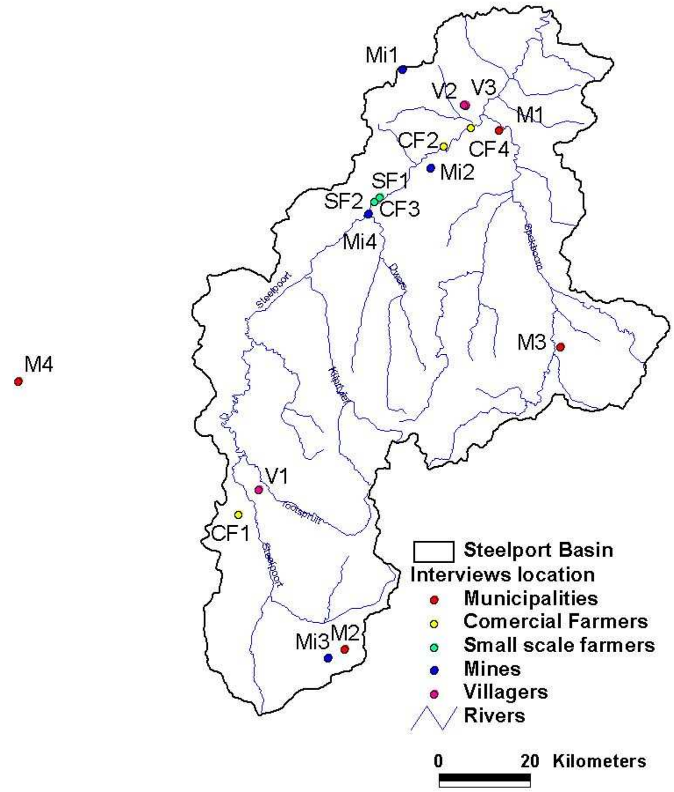

Figure 2 : Interviews localisation

Meetings were hold at DWAF national level with people involved in water management : implementation policy writing, water quality management, project planning. Contacts were made with teams in charge of water management at local level : water quality management and pollution control, water quantity management and abstraction control.

In municipalities, officers in charge of water management have been met. The basin is covered by six municipalities, the main ones have been met : Greater Tubatse, Greater Groblersdal, Thaba Chweu and Highlands. Municipalities are presented on the map below :

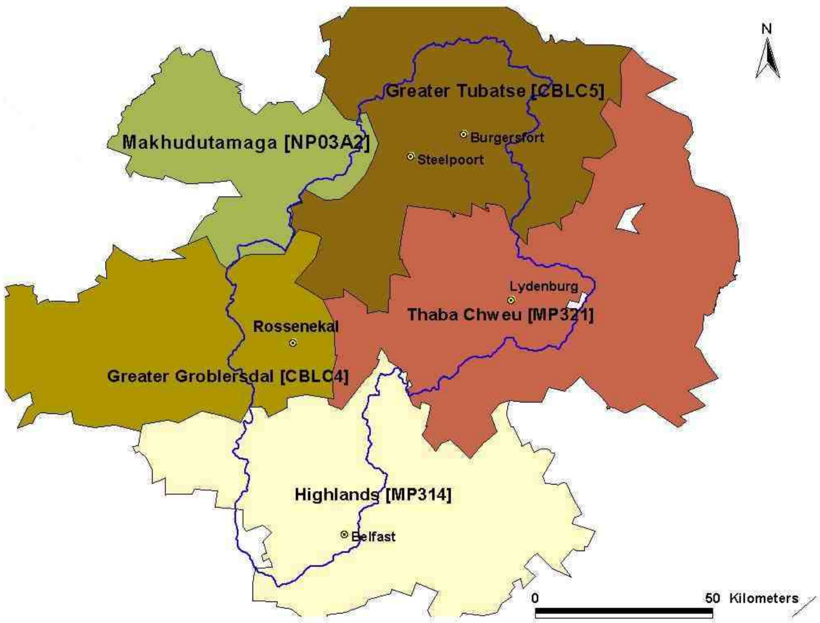

Figure 3 : Municipalities covering the Steelpoort basin

Commercial farmers were chosen preferably in the central part of the basin. One of them (CF3) is renting the land to a mining company (Mi4).

Small scale farmers were met in the field. (SF1) was a young farmer. At Boschkloof irrigation scheme (SF2), a meeting was organized by the chairman of the irrigation committee, ten middle aged men were present. There are few small scale irrigation schemes in the catchment, and those were chosen because of their position in central Steelpoort and the proximity with other users : mines and commercial farmers.

For the mining companies, appointments were made with environmental managers for mines currently in operation in the catchment (Mi1, Mi2, Mi3) or with the development project manager of the company planning to develop activities in the catchment (Mi4). Mi4 contact was given by CF3.

Villagers were met at home, or near taps in the villages, individually or in group, men and women.

Consultant and researchers contacts met to address specific questions :

- a researcher from Rand African University who has studied heavy metal impacts on aquatic ecosystem in the Olifants basin(C1),
- the chief executive officer of the Lebalelo water user association, created and funded by mining companies to build a water pipe transferring water from the Olifants to the Steelpoort basin (C2)
- a research manager from Water Research Commission involved in the Reserve evaluation and implementation (C3).

Environmentalists specialized in biomonitoring and state of the rivers were met at Kruger Park Nature Conservation Department (E1, E2) and specialists in wetlands and aquatic ecosystem preservation were met at Mpumalanga Park Boards (E3, E4).

3.2.2 Interviews development

A questionnaire (see annex 1) was used as a guideline and addressed the following topics :

- surface and groundwater resources and uses
- water availability and quality problems
- potential tensions and conflicts
- institutions.

Each of the people we contacted accepted the interview except the Vantech mining company, which had serious pollution problems and is currently involved in a court case about that. This company has often be quoted during interviews and is currently at the center of a debate about pollution.

We felt in general that people could speak freely about questions asked when information was available to them. With mining companies, some information, like production figures, was said not to be available because of a hard competition context.

If commercial farmers accepted the interview, they were concerned about which organization was sponsoring the study. CF2 started the interview with asking me about what I knew about this catchment. He was convinced I was working for a mining company. He explained latter on he had already been contacted by consultants working for mines.

DWAF gave lots of technical reports and implementation policy references. Some reports were still in progress, and we worked with Draft versions. Local information concerning pollution in the catchment was difficult to find and no written information was available at DWAF regional office concerning pollution problems.

The Memorandum of Understanding between DWAF and IWMI facilitated the access to water users registrations (annex 6).

Maps :

A map (1:250 000) has been used during interviews to identify the catchment, and ask interviewees to locate water availability and pollution problems.

Those information enabled to draw maps and localize, from stakeholders' points of view, availability and pollution problems.

Languages :

Most of the people met could speak in English. Some commercial farmers felt more comfortable speaking Afrikaans, but there was always someone in the family who could help during interviews. Tebogo Seshoka, research assistant at the IWMI, helped to organize appointments, and translated interviews with those villagers and small scale farmers who spoke only Sepedi.

3.3 Analysis

Data collected are presented by theme and source (literature review or interviews) to allow for points of view confrontation.

A first step consisted in identifying main issues mentioned by stakeholders' groups. For each group, we detailed the stakes of concern, available and missing information, tensions and conflicts reported, and alliances with other users.

Points of view are being confronted with the basin state of knowledge in order to identify differences and points to be debated.

The management system observation as a complex decision process comes from concepts introduced in (Leroy, 2001). "Public decision is being built in a process involving technical and economical studies, administrative procedures or juridical appeals, alliances and political pressures, media treatment of the problems and public opinion reaction."[1]

In our case study, we examine "problems" or divergences coming from the literature review, mentioned in interviews or coming from the confrontation of the different points of view. This discussion leads to propose some tools that could help in the future dialogue process.

4 Results

4.1 Hydrosystem characteristics

The Steelpoort basin is one of the seven tertiary subbasin of the Olifants, and covers 7139km^2, which represents 13% of the Olifants river basin. It encompasses 3 subbasins : Upper Stelpoort, Central Steelpoort and Lower Steelpoort.

<u>Topography :</u>

The basin lies between 1500 and 2400 m above sea level. The Steelpoort river valley lies between 900 and 1200 m above sea level, and the western part between 1200 and 1800m.

<u>Vegetation :</u>

Two vegetation types occur, namely grassland, that covers the southern half of the area, and savanna that extends northwards from Lydenburg.

Grassland vegetation has a uniform physical appearance. Trees are uncommon, both because of the nature of vegetation and because trees have been used for firewood. Micro climates exist in gorges and near rivers, with characteristic unique vegetation compositions, including indigenous trees.

The vegetation in the savanna comprises perennial woody plants, adapted to drought and fire.

<u>Climate :</u>

Average temperatures show moderate fluctuation, average summer temperatures vary between 19 and 22°C, while in winter averages are between 13 and 19°C.

Rains occur in summertime between October and March. Mean annual rainfall varies between 630 and 1000mm. Storms are frequent in the basin and mountain regions have low infiltration and high erosion. Evaporation is very high and can reach 2000mm.

[1] (Mermet, 1998)

Infrastructures :

The basin has few storage capacity with few dams storing more than 1 million m^3.

Their situation and characteristics are given in the table and map below :

Barrage	Capacité (million m^3)
Belfast	4,39
Unknown 1	1,56
Unknown 2	1,04
Der Brochen	7,3
Spitskop	1,61
PTC du Plessis	1,1
Buffelskloof	5,38
Total	**22,38**

Table 2 : Storage capacity of the Steelpoort basin

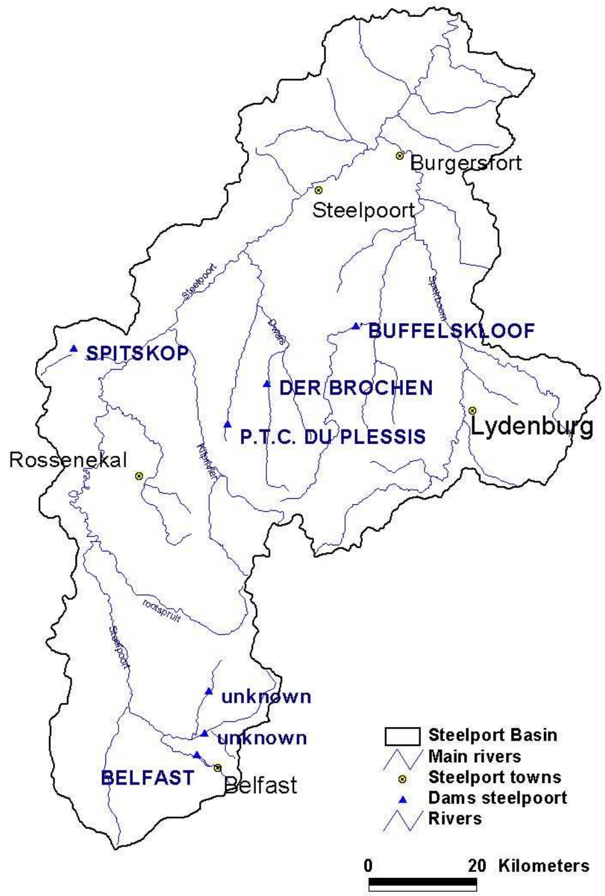

Figure 4 : Main rivers and dams

42 dams which capacity is comprised between 0,05 and 1 million m^3 represent a storage capacity of 10,74 million m^3. The little dams (<0,05 million m^3) capacity is evaluated to 8,9 million m^3.

4.2 Water usages

4.2.1 Usage distribution highly impacted by recent political history[2]

From the 17^{th} century till the end of the apartheid, resources uses in South Africa have largely been dictated by racial segregation.

Under apartheid, almost every economic activity was heavily regulated and the allocation of resources, subsidies, and state funds was politicized and based on racial classifications. Since the early part of the 20^{th} century, the white agricultural sector was favored politically and granted numerous subsidies to secure a strong rural voter base. This allowed the white

[2] (IWMI, WP1), (IWMI, WP2)

agricultural sector to construct dams and irrigation canals and to develop irrigated and non irrigated agriculture. Irrigation water was supplied to irrigation farmer at heavily subsidized tariffs, which while frequently leading to the inefficient use of water, allowed white farmers to develop a financially viable agricultural sector.

While white farmers were favored politically, black farmers and communities were actively discriminated against. The homeland policies of the successive Nationalists governments ensured that the majority of the population was confined to approximately 13 percent of the total land area of South Africa. These black communities were settled on marginal land with few resources and frequently had little or no access to water.

The nominally autonomous homeland governments were able to develop their own agricultural policies and in many cases, ambitious and economically inefficient communal agricultural schemes were developed with the support of South Africa. Irrigation schemes were built up for social and food security purposes in the early 1960s. In the 90s, the very poor performance and economic success of small-scale irrigation schemes has been stated despite huge investments. But the economic success has never been the clear and unique objective underlying the past and present development policies for smallholding irrigation schemes : food security remained the main objective, and crops had few market opportunities. The management agencies were facing financial and social problems and expected farmers to pay back production costs and services. At the same time, consultants were hired to set up rehabilitation plans, sophisticated technologies were introduced, which required higher capital and operation and maintenance costs.[3]

Since the democratic elections in 1994, the homelands fell away and the land was re-incorporated into South Africa. The dissolution of the homeland governments and the gradual changes in agricultural policy in South Africa has left many of the black irrigation projects in disarray. In the Northern Province, 171 small scale irrigation schemes are considered moribund and inactive for many years. Several causes are mentioned as *"infrastructure deficiencies emanating from inappropriate planning an design, poor operational and management set-up, inadequate technical know-how and capacity on the part of the beneficiaries and the government assigned extension officers, lack of people's involvement and participation, inadequate institutional structures, inappropriate land tenure arrangements." "From the 1990s, provincial governments set up rehabilitation and management transfer programs, trying to curtail the heavy financial burden of smallholding irrigation schemes, most of them not being part of the commercial stream of the agricultural sector. On the other hand, departments would like to promote the emergence of small-scale commercial farmers along with maintaining the community subsistence function of the schemes. Still, all rehabilitation and reactivation efforts face the same dilemma, i.e. the match between a social and an economic approach to these schemes."* [4]

4.2.1.1 Nineteenth century

In the nineteenth century, settler occupation lead native peoples occupy sizeable tracts of land. With the development of the mining industry, those 'native reserves' became reservoirs of migrant labor. The 'native reserves' were both a rural base for migrant workers, and places where the African population could be controlled under a separate legal and administrative system. Reserves were defined by the Land Acts of 1913 and 1936, which divided the country into legally designated white and black territories and imposed severe restrictions on the property rights of blacks especially the tenants on white farms.

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[3] (Perret, 2002)

[4] (Perret, 2002)

4.2.1.2 The Native Land Acts

Under the *1913 Natives' Land Act*, 7 percent of the national territory was reserved for exclusive black population and Africans were prohibited from acquiring land outside these areas. The 1936 Native Trust and Land Act allowed for the extension to 13 percent of the national territory ad created the South African Native Trust (later Development Trust) to acquire the necessary land. The Trust was also in charge of the development of the reserves and put in place an authoritarian system of "betterment" to prevent erosion.

4.2.1.3 1948-1994 : The apartheid era

After 1948, when the racist National Party took the power, and especially since 1958, Africans were denied all political rights in 'white' South Africa. They became citizen of 10 ethnically based nations, situated in the reserves. Political power within the homelands was composed of headmen and chiefs, under the control of the Department of Bantu Affairs.

The "betterment" imposed strict limitation on land cultivation and attempts to reduce the numbers of livestock. Violent opposition took place in Sekhukhuneland.

In the 1960s and 1970s, more people were removed to homelands, including tenants evicted from white farms and other black people staying outside the homelands in towns.

The homelands were poor and underdeveloped, and depended on transfers from the government of South Africa. The communal system of land tenure was controlled by tribal authorities and until 1970s, most households had some access to arable or grazing land with so small plots that agriculture contributed a relatively minor proportion of household subsistence requirements.

At the end of the apartheid, homelands were home to over 40% of the entire South African population with extremely low incomes high rates of infant mortality, malnutrition and illiteracy relative to the rest of the country.

4.2.2 The Lebowa area

Lebowa was a self-governing territory (homeland) during the apartheid era.

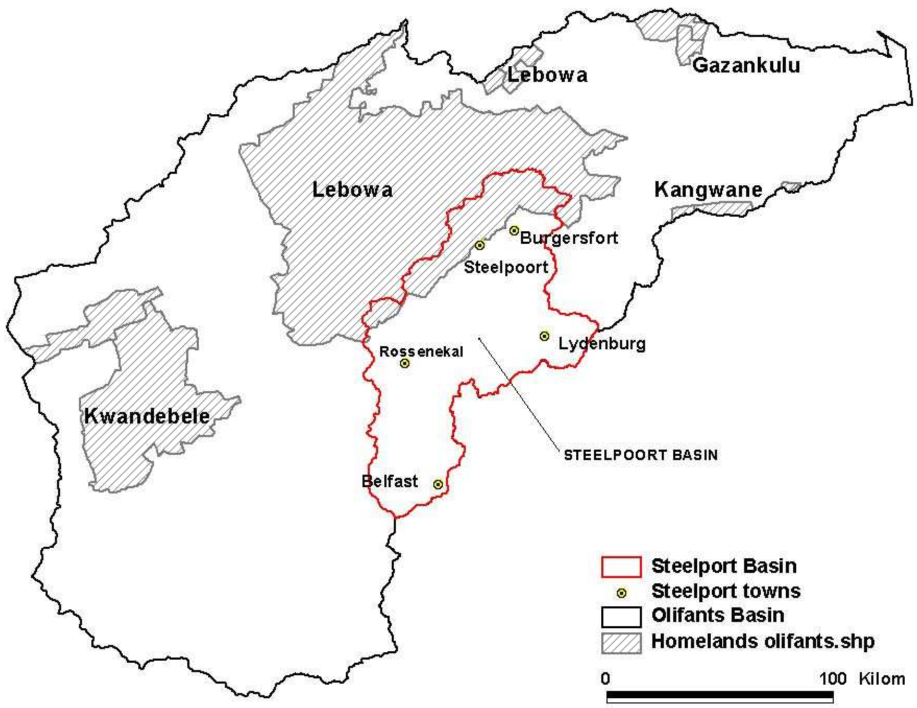

Figure 5 : Olifants and Steelpoort basins former homelands.

Lebowa has, since 1994 been integrated into the new democratic state of South Africa and the laws and political divisions of the new state ate applicable.

The settlement system of the former self-governing territory of Lebowa consisted of[5]*:*

- *proclaimed township, established in terms of the Regulations for the Administration and Control of Township, 1962. Tubatse was one of them. Streets were provided and rudimentary services were installed. Inhabitants were able to obtain ownership (Deeds of Grant)*
- *closer settlements, which were established in terms of the Land Regulations, 1969 to cater for people without farming rights. Permission to Occupy certificates (PTO's) was issued to owners of the sites. These settlements were semi-urban environments located in rural areas and were characterized by an absence of economic base; The size of closer settlements varied from 500 to more than 20 000 persons. Communal taps were provided at central points along the streets. No formal sanitation facilities were provided.*
- *betterment rural villages were established and linked to a programme of agricultural planning whereby people were grouped together in a village according to a grid shape. Within a planning area, a planning ward constitutes a residential area, grazing camps, arable land and in some cases a closer settlement. Water is provided by means of handpumps and/or wells. No formal sanitation facilities are provided.*

[5] (DWAF, 01/1999a)

- *traditional villages where agricultural planning has not taken place and that consisted of scattered homestead surrounded by arable land for use by households. Grazing land is communal and is divided into grazing camps. No services are provided and residents are responsible for their own water and sanitation provision."*

The Bapedi (Northern Sotho) are the primary tribe occupying land in Sekhukhuneland, part of the Lebowa located in the basin. The prominent language spoken is Sepedi (Northern Sotho).

Prior apartheid, Paramount Chief Sekhukhune, a member of Bapedi tribe, governed Sekhukhuneland. He was imprisoned during the apartheid regime for his outspoken opposition to apartheid policy. During his incarceration, the previous government divided his land into what were called clans, which are essentially extended family groups. These clans were reportedly bribed into denouncing Chief Sekhukhune and making one of the clan members the new chief for each of the newly appointed areas. Generally, the new chiefs were former aides to Sekhukhune.

Today, "traditional" leaders' powers within rural area seem to be questionable. The Government of South Africa recognizes traditional chiefs in the SA constitution. The Green Paper on local government includes traditional chiefs in its governance structures. Tensions remain between new democratic system and the "traditional" system.

The most common form of land tenure in the area was a communal tenure system under which an individual could be issued a Permission to Occupy (PTO). The chief, who holds the land in trust, grants this permission, through agreements with the previous government. These agreements were considered legally valid, although this has caused some disquiet amongst the democratically elected leaders in local government (previously Transitional Local Councils, now Local Governments).

Most rural people considered the PTO as a safe form of tenure and believed themselves to be protected through this agreement.

The current land reform is not being studied here, but concerns the studied area, since several "Land claims" are currently taking place. In the former homeland areas, land is registered in the name of the state. There is no legal recognition of communal tenure systems. The communal land tenure is currently being reformed in South Africa[6], and the reform is being criticized : *"Experience indicates that titling would be expensive, time consuming, dominated by land grabbling elite, and not create tenure security."*[7] More than 8000 claims are in progress in the Limpopo province, and address about 60% of the Sekhukhune district municipality.

[6] (DLA, 2002)

[7] (Cousins, 2002)

4.2.3 A contrasted landscape and major development stakes

The main contrast of the basin is the distinction between an economical underdeveloped area, corresponding to the former Lebowa homeland (cf. fig 7), located north of the Steelpoort river, and a developed area south of the river. This demarcation fits with the current border between the Limpopo and Mpumalanga provinces.

Figure 6 : Settlements in the former Lebowa

The former Lebowa area is characterized by steep slopes, few surface water resources and high population density, which is still increasing.

About 350 000 people are living in the catchment, with 70% located in the former homeland area, which represents only 20% of the total basin area.

High population densities appear on the following map :

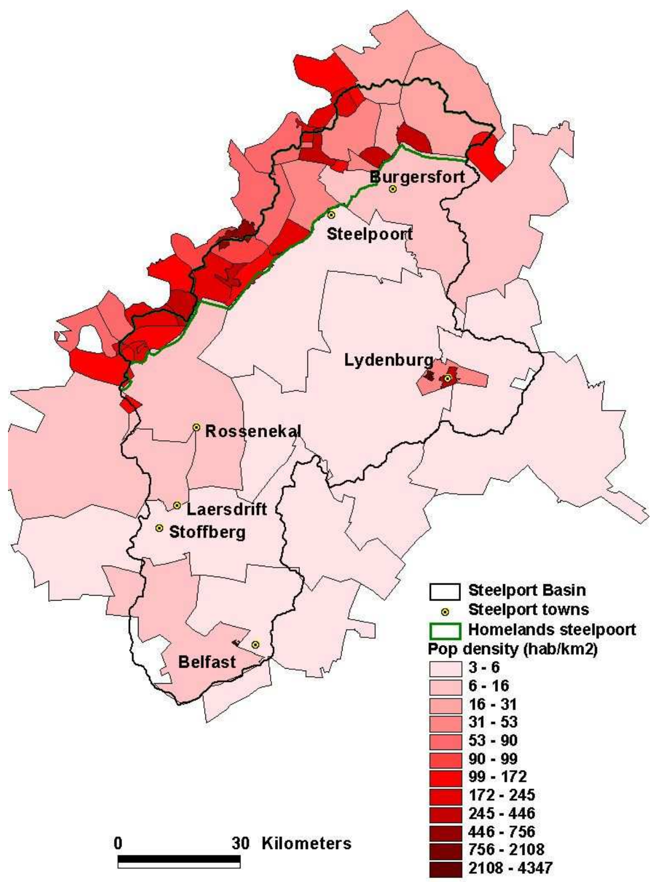

Figure 7 : Population density (hab/Km^2) (1996 Census)

Occurrences of land with important rock outcrops and steep slopes render a large position of the Steelpoort catchment unsuitable for irrigation development and human settlement. The result is that the potential arable land in the valleys is under pressure from conflicting demands for human settlements[8].

A central spine is remarkable along R555, R37 (North from R555) roads and along Dwars river, with a high density of mining industries, related to abundant platinum resources.

A rural, high densely populated zone, poor area lies north R555. This was part of the former Lebowa "homeland" area. Important settlements areas are situated there, with Bothasoek where population is still increasing.

Farming and conservation areas are found south R555 (cf. fig 11). The area is mountainous and is crossed by the Spekboom river. Areas along the river are commercially farmed and highly productive.

Figure 8 : Irriguation dans les régions montagneuses le long de la rivière Spekboom

The remainder of the area is high-lying, dryer and less productive. Self-sustaining farming occurs but not in as greater numbers as the northern rural areas.

Most upper Steelpoort and upper Spekboom are important places for tourism and trout fishing with small dams development, and commercial afforestation.

Figure 9 : Afforestation in upper Steelpoort.

Figure 10 : Trout fishing along Spekboom.

Urban areas are Steelpoort, Burgersfort, Lydenburg and Belfast.

The maps presented bellow show those areas, locate main water users (fig 11) and short term developments (fig 12) related to new mining companies (one of them is the greatest platinum

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[8] (DWAF, 1991)

mine in the world) and the related increase in population due to human resources needed in Burgersfort and around Botashoek.

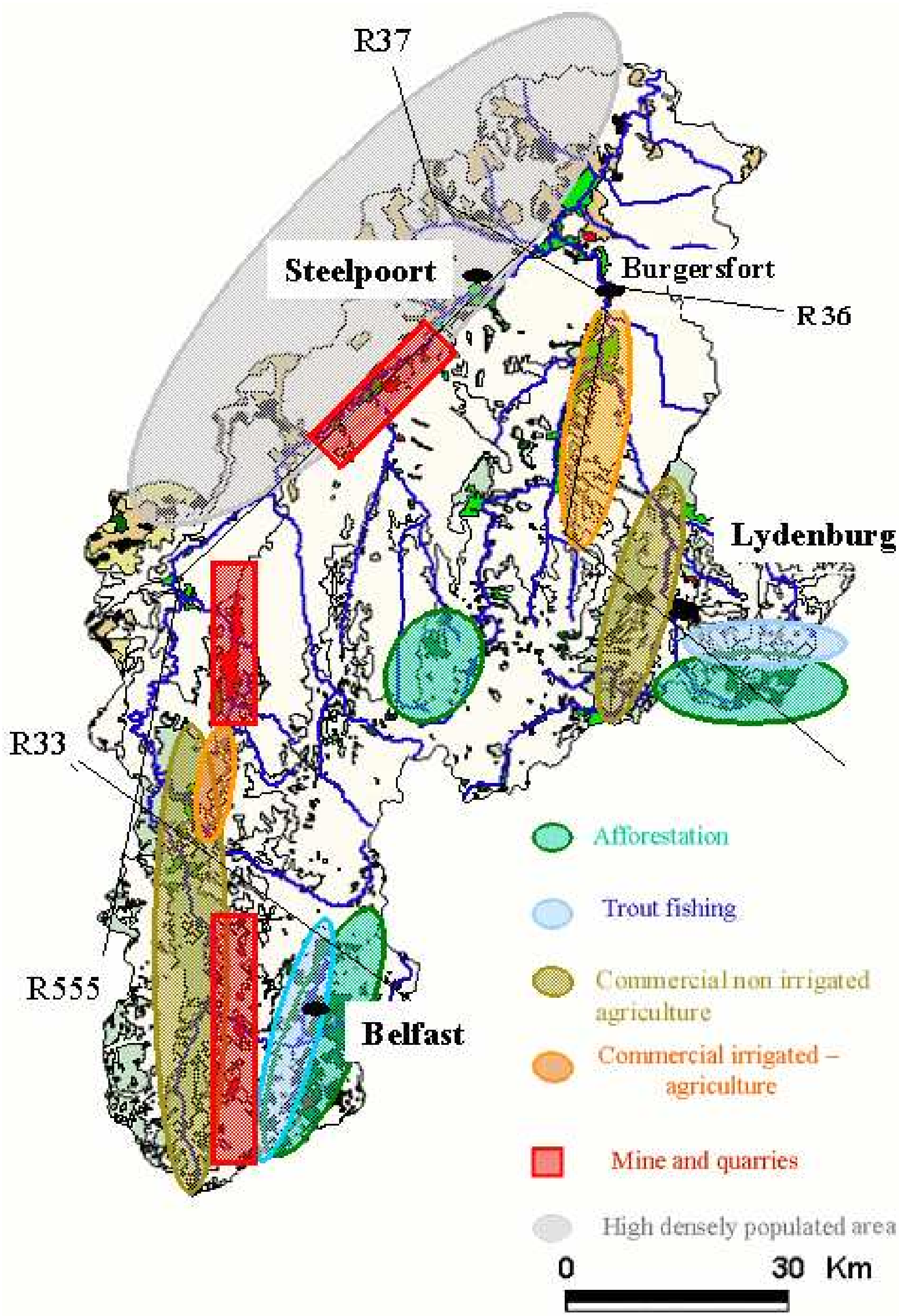

Figure 11: Main water users

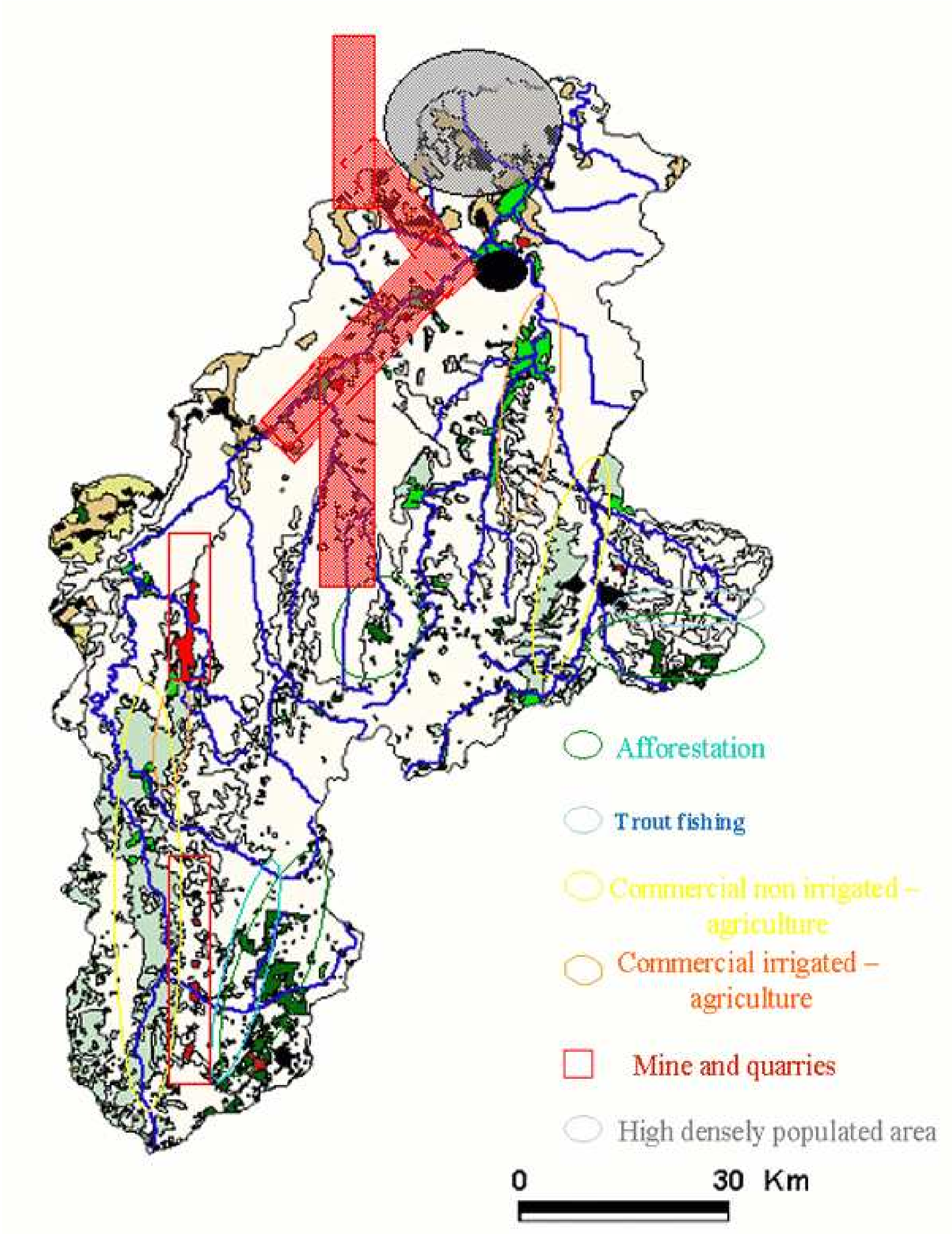

Figure 12: Short term development in the basin

This basin appears as a territory with various water users, and massive as well as rapid developments.

Major economical, social, and environmental stakes are to be taken into account in the analysis of the water management system of the basin :

- Economical stakes are important : existing mines extensions, implanting of new ones, are the driving forces of the economical development of the area, and impact largely on water resources (competition with agricultural uses, pollution sources)
- Social stakes are major since the main part of the population living in the former Lebowa homeland does not have any access to potable or irrigation water and relies upon surface water (resource availability and quality).
- Environmental stakes are also of concern, due to the localization of the basin upstream Kruger Park, and due to the specificity of natural resources in the catchement (biodiversity conservation).

In this context, the achievement of basic human needs and environmental needs as defined by law under the Reserve notion will necessitate the meeting of conflicting interests.

4.3 How to evaluate and manage water uses impacts on the system ?

The law[9] defines the following activities to be submitted to authorization : abstraction, storage, diversion of a water course, activities that lead to stream reduction (for ex. pines or eucalyptus commercial forestry), activities impacting on the resource, on river beds, banks or other rivers characteristics, groundwater modification and recreational activities.

We will present in this part, using available information about the state of the basin, the information and management system, dealing with quantitative and qualitative aspects of the resources.

The basin is considered as stressed by DWAF[10], and it is difficult to have a clear idea of the water demand and supply balance.

In normal periods, the stress of the basin has to be qualified : it is mainly due to the rainfall seasonal variability, and stressed periods are limited to two months a year.

Estimations of supply and demand balance are based on uncertain data. Uncertainties are related to the few physical measures concerning river flows (5 gauging stations, with two of them considered as unreliable) **and especially uncertainties concerning water demands** : agricultural demand was estimated in 1991 at 82 million m^3, with a 2010 projection at 140 million m^3, last estimation for the year 2000 indicate 69 million m^3. This decrease in water volumes can be explained by the modernization of irrigation techniques.

Industrial demand is difficult to estimate : data concerning mining sector water demand are not easy to obtain, and future projection problematical due to the context of high competition (Mi1 does not want to give production figures) and political choice choices that will have to be made *("Mines are a quick solution to get out of poverty, DWAF and politicians support them"* DG1). Industrial water demand was estimated at 5 million m^3 in 1991, 17 million m^3 in 2000. Following interview data, this demand could reach 50 million m^3 in 2012 (cf personal communication with O. Rossow, Lebalelo association Chief Executive officer).

The lack of knowledge of water users by DWAF could be attributed to the former management system, when water resource was a private good. The current registration process of water users will allow for better estimation of water demand. This process is tough,

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[9] (DWAF, 1998)

[10] (DWAF, 08/2002)

and accurate evaluations can be expected after 5 years (personal communication with M. Watson, DWAF).

But if this balance is difficult to evaluate, and is the base of a new dam design and future water volumes reallocation, the question of meeting the Reserve objectives is even more difficult : it will not only consist in increasing the storage capacity of the basin but also in supplying water of the required quality to meet domestic and irrigation needs in the poorest areas[11]. This question is going beyond the problem of available amount of water : it deals with water quality and its supply to population located in "rural areas" with high density populations.

4.3.1 A stress related to the high seasonal variability

It is worthy to point out that hydrological data of the basin (and in South Africa in general) are essentially simulation results, and based on few gauging stations (cf. gauging stations table 3 and their location fig 13). **Moreover, most important gauging stations are often not reliable and there are no gauging stations downstream Steelpoort river and its main tributaries**.

Gauging station	River or dam	Subcatchments involved	Record period	Data reliability
B4H003	Steelpoort	B41A to B41D	1957 – 1995	Bad
B4H007	Small Spekboom	B42D	1968 – 1995	Good
B4H009	Dwars	B41G	1966 – 1995	Bad
B4H010	Dorps	B42A + B42B	1979 – 1995	Good
B4R004	Buffelskloof dam (inflow)	B42F	1972 – 1995	Good

Table 3 : Gauging stations used in the models (DWAF, 01/1999b)

Demand and supply evaluations have been provided by consultants for DWAF. Related uncertainties have not been estimated, and the lack of physical data could be taken into account in those uncertainties estimations.

Rainfall records were created for quaternary subcatchments, after selection of representative groups of rainfall stations. Monthly time series of rainfall were derived for each subcatchment. Evaporation losses from dams and evapotranspiration losses from the catchment vegetation were evaluated for each subcatchement.

The hydrological model has been calibrated with the five gauging stations indicated in *table3* and models were used to :

- calculate mean monthly net lake evaporation, reduction in runoff due to afforestation,
- calculate mean monthly net irrigation demands,
- perform storage-draft-frequency analysis,
- calculate historical mean monthly catchment rainfalls (expressed on % MAP)
- simulate on a monthly basis the movement of water through an interlinked system of catchments, river reaches, reservoirs and irrigation areas.

Results are given as present day and naturalized MAR (mean annual runoff) by quaternary subcatchments (table 4 and 5).

The country has been divided into about two thousand hydrological units, corresponding to quaternary subcatchments. Fig 14 presents the18 Steelpoort subcatchements.

[11] (Schreiner, Van Koppen)

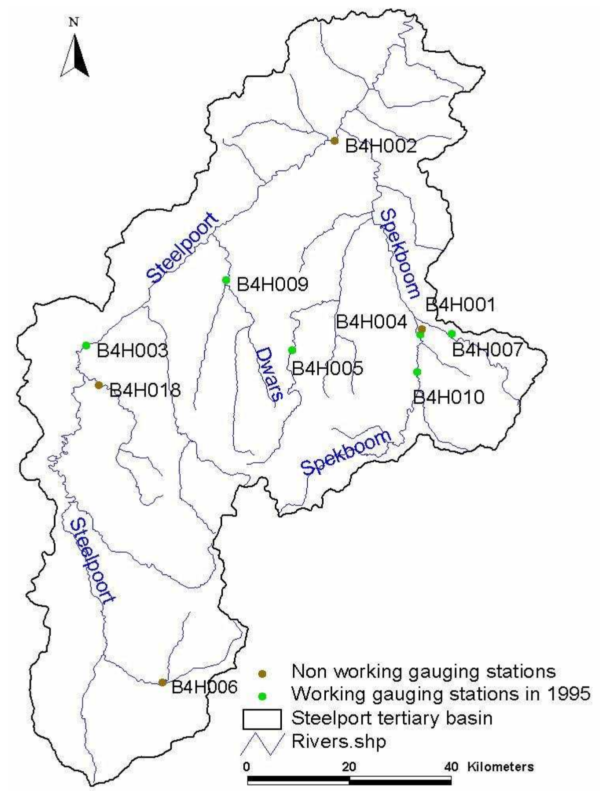

Figure 13: Gauging stations

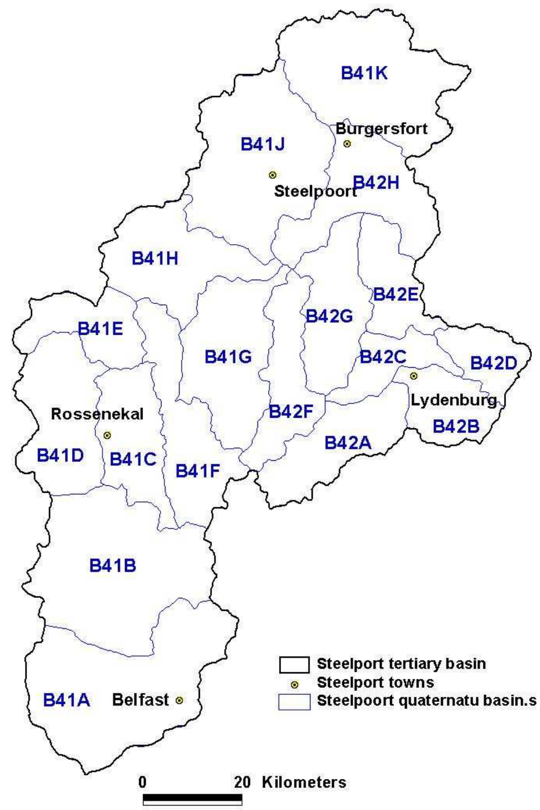

Figure 14 : Quaternary subcatchments

Data	Time period	Localization	Comment

Mean annual precipitation (mm)		Gauging stations	
Average rainfall	1920-1995	B41A, B41B, B41C, B41D, B41E-B41H, B41F, B41G, B42A, B42B, B42C, B42D, B42E, B42F, B42G, B41J-B41K-B42H	Monthly data as % of MAR
Mean Annual Evaporation		Evaporation stations	
Evaporation : A-pan, Symons-pan (mm/month)		Quaternary sub-catchment	Monthly data
Impoundments Irrigation schemes			Dams capacity, surfaces Area, average annual usage
Crop factors		Quaternary sub-catchment	By crop, weighted crop factors
Water usage by Irrigation		Quaternary sub-catchment, irrigation sub-module	Area, gross demand, shortages, supply, losses, return flows
Water usage by afforestation		Quaternary sub-catchment	Area, demand
Mining and domestic water demands		Quaternary sub-catchment	Industrial activity, domestic abstraction
Naturalized Streamflow (million m^3)	1957-1995 1968-1995 1966-1995 1979-1995 1972-1995	B4H003 B4H007 B4H009 B4H010 B4R004	Calibrated values (WRSM90 model) : MAR, Standard deviation, index of seasonal variability, monthly hydrographs, yearly hydrographs, mean monthly flows
Mean Annual Runoff		Quaternary sub-catchment	Natural incremental, Natural cumulative, Present day cumulative

Table 4: Available data (DWAF, 01/1999b)

Catchment	Observed MAR	Calibrated MAR	Simulated Natural MAR	Simulated Present day MAR
B41A	-	-	50,74	44,86
B41B	-	-	100,65	92,86
B41C	-	-	19,40	17,08
B41D	122,94	127,47	139,48	129,27
B41E	-	-	143,69	133,32
B41F	-	-	27,88	27,83
B41G	19,33	19,64	27,20	19,00
B41H	-	-	207,56	182,44
B41J	-	-	222,78	187,25
B41K	-	-	406,22	311,89
B42A	-	-	37,09	36,69
B42B	69,26	69,09	74,40	67,32
B42C	-	-	82,60	75,31
B42D	26,36	26,40	26,80	26,80
B42E	-	-	116,80	93,85
B42F	22,26	22,19	29,95	9,14
B42G	-	-	40,43	29,39
B42H	-	-	166,43	112,69

Table 5: Naturalized and Present day simulated Mean Annual Runoff (DWAF, 01/1999b)

Results consist mainly in simulated data, also for present day values, for which MAR by subcatchement have been evaluated. **Demand and supply balance is made at catchment level rather than at river level.**

Water demands evaluations :

Naturalized volumes estimations need water demands evaluations for each sector. Those intermediate results illustrate the different sectors impacts on water resources and shortages met by irrigation (cf annex 3).

But shortages estimations are simulated and do not probably reflect the real farmers strategies during draught years. The table giving irrigation water demands (annex 3) shows shortages in every irrigated area, but those values probably do not mean that crops are being lost. Those values are based upon crops with averaged areas on the period 1920-1995. Moreover, those values do not take into account the use of groundwater resource. Those results are more to be considered as global indicators of the stress in the subcatchments. Farmers met confirmed lack of water in dry season.

Subcatchment example :

To illustrate shortages with a monthly evaluation of water demand by irrigation, a short evaluation has been performed using (DWAF, 01/1999b) data for a quaternary subcatchment, located downstream the Steelpoort basin. Water demand is being compared to present day MAR values.

B41J encompasses commercial farming (central Steelpoort irrigation board) and mining industry. Main crops are lucern (63%), citrus (7%), beans (9%), cotton (9%) and wheat (9%). In this basin, shortages (0,74 million m3) are experienced in August and September (cf detailed calculation in annex 5).

This kind of result has to be considered with the related uncertainties, both concerning supply and demand values, but illustrates the need for a quantitative monitoring of water abstraction and river flows (§4.3.5).

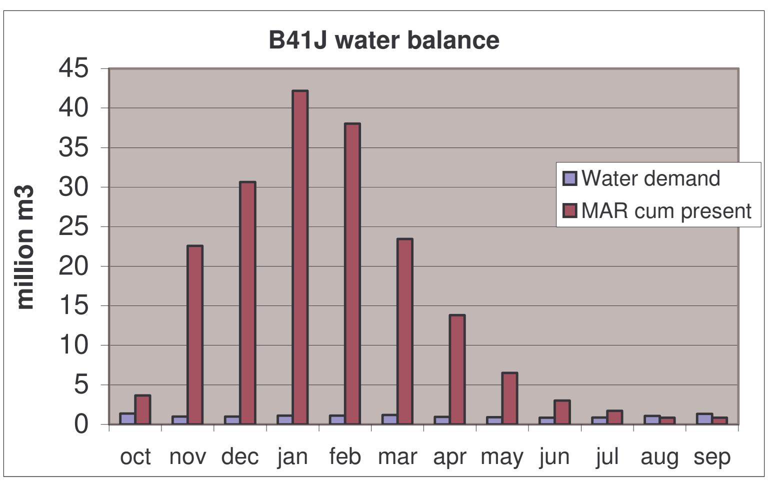

Figure 15 : Water demand and supply balance in B41J subcatchment

Shortages are related to seasonal variability. To deal with this problem, a solution would be to increase the storage capacity of the basin today largely underdeveloped by comparison with other South African basin. This solution, envisaged by DWAF, seems to be largely expected by water users.

4.3.2 Agricultural sector : the main water user

Irrigation in commercial farming areas is managed by irrigation boards, localized fig. 16.

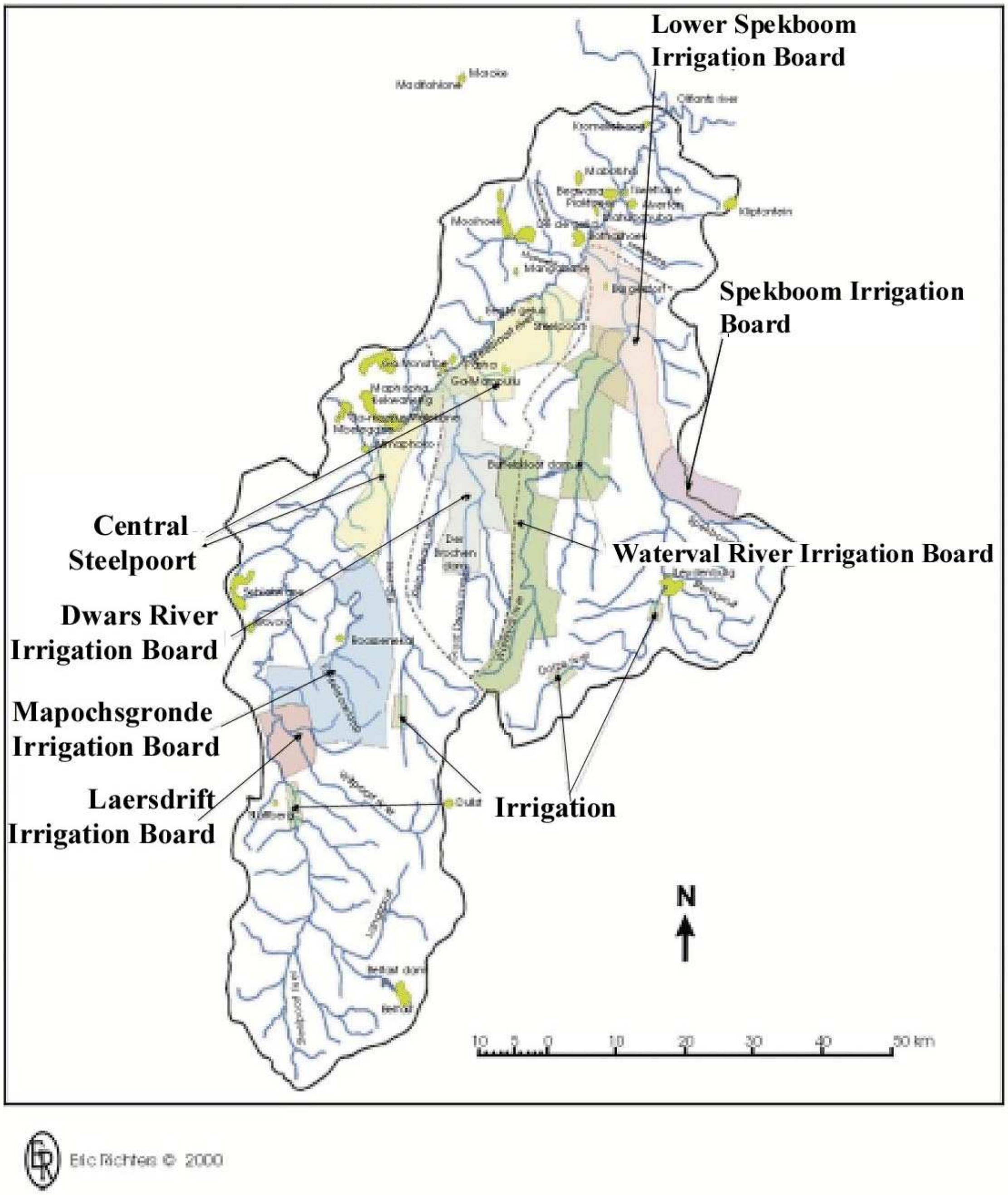

Figure 16 : Irrigation boards (IWMI, WP17)

Table 6 presents, for each irrigation board, the irrigated areas and associated main crops (following DWAF, 01/1999b).

Irrigation boards	**Subcatchement**	**Irrigation area (km^2)**	**Main crops**
Laersdrift	B41B	1,6	Maize 50% Beans 30% Peas 20%
Mapochsgronde	B41C	2,9	Maize 50% Beans 30% Peas 20%
Dwars	B41G, B41H	12,2	Lucern 50% Wheat 25% Maize 10% Beans 5% others 10%
Central Steelpoort	B41H, B41J	5,6	Lucern 63% Wheat 9% Cotton 9% Beans 9% Citrus 7%
Lower Spekboom	B42E, B42H	22	Wheat 21% Citrus 25% Lucern 18% Cotton 16% Maize 15% others 5%
Spekboom	B42E	11,4	Wheat 21% Citrus 20% Lucern 20% Cotton 18% Maize 15% others 6%
Watervals	B42F, B42G, B42H	14,7	Lucern 38% Wheat 21% Citrus 16% Maize 15% others 10%

Table 6 : Irrigations boards irrigated areas and main crops (following DWAF, 01/1999b).

Irrigated areas decreased from 12000 ha in 1988 to about 8000ha in 1997[12]. Following the DWAF study[13] and interviews (CF2, CF3), the decrease of irrigated agriculture is partly due to mining companies who are buying agricultural lands to increase their water entitlements (CF3) or for housing purposes (CF2).

Estimations of agricultural water demand are about 85 million m3 in DWAF reports[14], or 75 million m3 without the Tswelopele irrigation scheme that are not functioning anymore.

[12] (IWMI, WP17)

[13] (DWAF, 01/1999b)

[14] (DWAF, 1991), (DWAF, 01/1999), (DWAF, 2000)

Increase expected in 1991 water demand did not occur, and late DWAF evaluation consider it would rather stabilize. This stabilization can be attributed to the high development of the mining sector and to modernization of commercial farmers irrigation techniques.

Few data are available about irrigation in the former Lebowa homeland. The (DWAF, 1991) study concerns only South Africa in 1991, and irrigation projects in the homeland were not treated. Following (IWMI, WP17), small scale irrigation schemes, vegetable gardens and brick-making projects were found in the basin, but lack of information prevent from evaluating water volumes of concern.

Figure 17 : Example of small scale irrigation : Boschkloof irrigation scheme

4.3.3 Water demand and supply balance difficult to evaluate

Global estimations of water demand and supply balance have been published[15] since 1991. The National Water Resource Strategy[16] has been published in 2002 and submitted to public debate.

Those estimations are based upon hydrological data presented §4.3.1. But results differ, and evaluation methods are sometimes not presented. Three estimations have been proposed (cf tables 7, 8 and 9).

Water demand			Dams capacities
	1987	**2010 projection**	
Irrigation	81,9	140,3	
Forests	8	14	
Domestic and industrial	5,9	9,2	
Mines	4,7	14,6	
Stock watering	4,2	5,7	
Evaporation	**19**	**19**	
Total	**123,7**	**202,8**	**33,4**

Table 7 : Water balance, (DWAF, 1991) (million m^3/a)

[15] (DWAF, 1991), (DWAF, 01/1999), (DWAF, 2000)

[16] (DWAF, 08/2002)

Water demand		Natural MAR	Present day MAR	Dams capacities
	1997			
Irrigation	89,5			
Domestic and industrial	10,8			
Forests	6,6			
Total	**106,9**	**406**	**312**	**53**

Table 8 : Water balance, (DWAF, 01/1999b) (million m^3/a)

Water demand			Natural MAR		Yield of Dams
	1995	**2010**	**1995**	**2010**	
Irrigation	85,2	91,2			
Mining/industrial	9,7	9,7			
Afforestation	6,6	8,7			
Urban	4,6	6,6			
Stockwatering	4,6	5,7			
Evaporation	40,2	40,2			
Total	**150,9**	**162,1**	**397**	**397**	**35**

Table 9 : Water balance, (DWAF, 2000) (million m^3/a)

Those tables do not allow to conclude about water shortages in the basin. In reality, shortages are related to rainfall seasonal variability and the small storage capacity of the basin (few dams).

In 2002, the national strategy concerning water management relies upon a different evaluation of water demand and supply. Demands volumes are being comparted to the "yield" of the basin, that is the firm available amount of water. Yield estimation for the Steelpoort basin is presented like this in the national strategy :

Natural resource		Return flows			Yield total
Surface water (1)	Underground water	Irrigation	Urban	Industrial	
42	14	3	1	1	**61**

(1) Surface resource has been estimated after provision for impacts of : ecological part of the reserve, river losses, alien vegetation, dryland agriculture and urban runoff.

Table 10 : Yield estimation

DWAF experts made clear that the firm yield corresponds to a value met 98% of the years. It is evaluated in a stochastic way with simulated Mean Annual Runoff values. It is evaluated at a basin scale (that is specific to South Africa) and takes into account dams yield, surface and underground water resource, irrigation return flows, urban and industrial runoffs. Underground water yield is based upon aquifer recharging at 98%.

Water demand evaluations are here quite different as they refer to the impact on the yield. That is why afforestation demand previously estimated at 8 million m^3, is now only 1 million m^3 regarding its impact on the yield.

Water demand		Water availability		
Type of use	**2000**	**MAR**	**Ecological Reserve**	**Yield**
Irrigation	69			
Urban	3			
Rural	5			
Mining and other industries	17			
Afforestation	1			
Total :	**95**	**396**	**94**	**61**

Table 11: Water balance according to (DWAF, 2002) (million m^3/a)

The following fig 18 illustrates the water demand and supply balance, as evaluated in the national strategy for the year 2000. A projection for the year 2012 is proposed, based upon information given in interviews (Lebalelo Chief executive officer).

This illustrates a stress of the basin. But the yield notion does not take into account real users strategies : water abstractions by individual users for example increase the yield value and are not taken into account in the national evaluations. Farmers have their own strategies (borehole, small dams) to face dry periods.

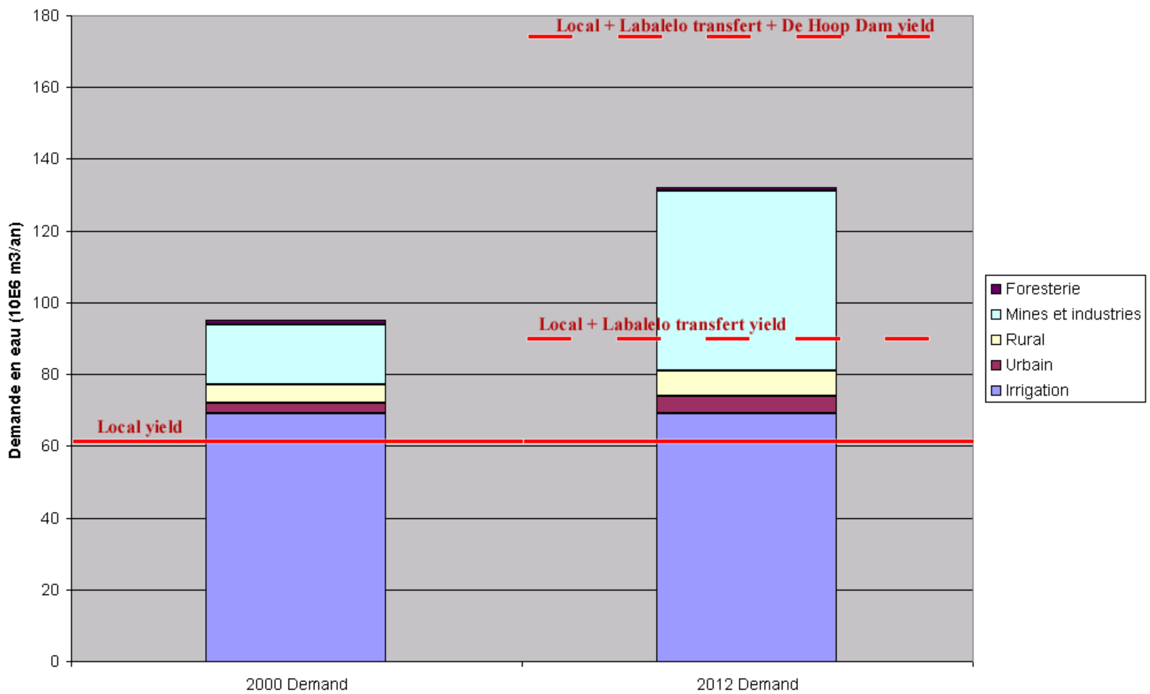

Figure 18 : Demand and supply balance for 2000 and 2012 years.

The yield notion is interesting because it allows for a direct evaluation of water demand and supply balance of the basin (by comparing the yield to the demand value). But a lack of transparency on the evaluations hypothesis in publication submitted to public debates could make conclusions hardly convincing.

Estimations of available amount of water and water demands are based upon hypothesis and methods that evolved during the past ten years, and for which uncertainties have not been evaluated. The national strategy for water management is based on those estimations and

will lead to development choices and reallocation decisions. Those choices will be validated once uncertainties have been evaluated and accepted.

4.3.4 Arguments for a new dam

All DWAF studies state the need for increasing the storage capacity of the basin and the building of a new dam to meet water users requirements. Different arguments have been proposed (cf table 12).

If the building of a new dam on the Steelpoort river would be beneficial for all the sectors (irrigation, domestic water supply, ecological needs and inducstrial needs), the sole mining sector could afford its financing. Following the National Strategy, irrigation should benefit from reallocation from existing users, in fact, current reallocations are rather going from agriculture to mining sector, and ecological needs would be met through water demand management (usage limitation of other sectors).

Since 1991, the building of a new dam is envisaged on Steelpoort, and design options have been presented in 1999.

	DWAF, 1991	DWAF, 1999	DWAF, 2000	DWAF, 2002
Catchment developement	The study stated the available resource in the region as largely **underdeveloped.** Existing major impoundments are situated in the upper reaches of tributaries to the Steelpoort river. Development of the underutilized resource of the Steelpoort could be beneficial.	The system analysis provides guidelines for cost estimation of alternative dams on the Steelpoort river and to assist in the selection of sites.		Further resource development through the construction of new infrastructure will be very expensive and **unlikely to be affordable for irrigation**. Water for irrigation as a means to rural development and poverty relief will therefore have to be sourced largely through reallocation from existing users.
Water competition	46% of the runoff is generated above the confluence with Dwars : region sparsely developed with low concentration of people and limited irrigation, while limited mining activity is concentrated near Roosenekal. 16% of the resource is generated downstream on Dwars before Spekboom confluence. **Large scale mining and irrigation** occur in this part of the catchment and compete mainly for the resource of **Groot Dwars.** Mines are buying up riparian farms in order to secure water rights and contributed to the constrution of Der Brochen dam to obtain reliable water resource. Competition for water is fierce, especially in the **vicinity of Steelpoort** where most of the **human settlement** associated with the mines occur.	For each dam option, it was necessary to quantify the storage capacity required, to at least assure supply water to users who cannot tolerate shortfalls, like **industrial and domestic users.** Total water requirements for rural communities were based on 100l/c/d, while IFR, afforestation, irrigation and mining demands also had to be accommodated.	The water balance shows **excess of water available for further development**, supporting the ecology and downstream users. The **spatial and temporal distribution of the runoff** in the area as well as the distribution of water demands makes the **provision of water difficult**.	**Deficits are apparent** in the catchment. This is a**ttributable to the provision for ecological component of the Reserve**, prior to which the system could be regarded as in balance. Water therefore needs to be freed up through compulsory licensing and supporting measures as water demand management, to meet ecological requirements (approximately 20% savings will be required to meet current shortfalls and provide for the ecological component of the reserve).
Future benefits / impacts of a dam in Steelpoort	In certain areas, mining and irrigation activities compete for the available resource, which necessitates an equitable supply at improved assurance levels to all use sectors. In 1991, the building of a dam on Steelpoort is envisaged to **face high demands for irrigation in central Steelpoort and settlements' needs**.	Behaviour of the system is very **sensitive to IFR releases** to be made. Dam will benefit to **the whole community including social and ecological environment.** Environmental negative impacts are listed.		**Water for new mining development** can be provided from the raising of Flag Boshielo dam, construction of a dam on Steelpoort or from the proposed Rooiport dam.

Table 12 : Arguments for a new dam

4.3.5 Current resource management

Surface water :

Current quantitative resource management is performed at DWAF Groblersdale office. **The team is in charge of abstraction control and operations tasks**.

Operation tasks :

It consists in operating Mapochsgronde (Tondeldoos, Vlugkraal), Buffelskloof and Der Brochen dams, and a purification plant located at Witbank.

- Both Mapochsgronde dams are used for small scale irrigation schemes. Farmers settled there in 1902 and irrigated surfaces are comprised between 1 and 150 ha (DG1).
- Buffelskloof dam provide water for Watervall and Spekboom irrigation boards.
- Der Brochen has been built in the 80s by the Dwars irrigation board. Since 1993, water is mainly used by mining companies.

Dams operation is being done with electronic measures points located downstream the dams. Other catchment's dams are managed by irrigation boards for agricultural purposes, or municipalities for domestic use (Belfast dam, PTC Du Plessis) et irrigation committees in the Lebowa area.

There are few irrigation schemes in the Lebowa area and few infrastructures, and probably some irrigation projects exist, not taken into account into national databases[17].

Abstraction control :

Abstraction control has been organized after declaration of Government controlled areas, by Gazette in 1974 : authorized amount of water were declared for the most stressed rivers, and were related to cultivated areas : 7700m^3/ha/year for Steelpoort, 5000m^3/ha/year for Spekboom, 7700m^3/ha/year for irrigation schemes downstream Buffelskloof dam.

Between 1996 and 1998, people were asked to register for current lawful use. They were asked to declare water uses and irrigated area (cf registered users in annex 6). **800 water users have been registered yet in the Steelpoort basin, among them 400 agricultural users and 4 irrigation boards**. In the Lebowa area, the Boshkloof irrigation scheme has been registered with an annual volume of 1,8 million m^3.

Authorized volumes are those used in the past and are called "Existing lawful use". This notion of existing lawful use has been introduced to allow for past economical activities to go on till the reallocation phase (compulsory licensing)[18] expected in 7 years in the Steelpoort basin.

Abstraction control consists also in identifying illegal activities like dams building for trout fishing or irrigation of undeclared surfaces.

Those illegal uses are developing in the upper part of the basin and could in the future become a problem for central water users (mines, commercial farmers). River base flows seem to decrease whereas rainfalls were quite good last years. It seems that illegal uses are now impacting on the resource, but the lack of river flow measurements does not allow to show it clearly (DG1).

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[17] (IWMI, WP17)

[18] (DWAF, 12/2000)

There is also a lack of human resources for this abstraction control task : only two officers are in charge of controlling Olifants and Limpopo water management areas (cf annex 2). They intervene after denunciations coming from water users (DG1).

Water management is locally suffering from a lack of technical means (information system) and human resources, while current developments in the basin lead to increasing pressure on the resource.

Underground water :

There are few available information concerning groundwater. The (DWAF, 1991) study evaluates the aquifers recharging in Steelpoort at 296 million m3/year and gives a classification of the groundwater potential (cf fig 19).

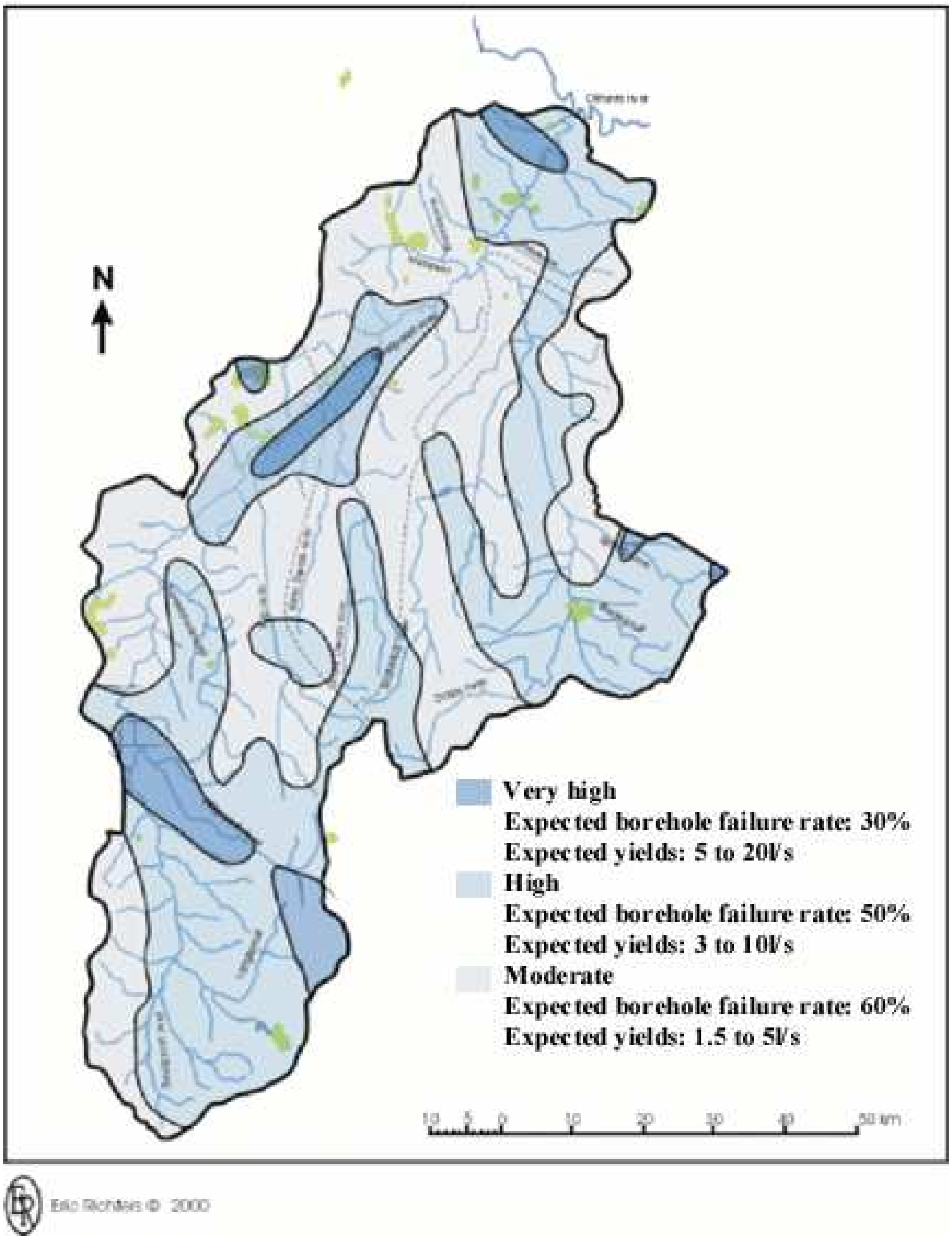

Figure 19 : Potential groundwater resources (IWMI WP17)

DWAF reports state groundwater resources as underdeveloped especially in the former Lebowa area where there are few boreholes[19].

4.3.6 Questions related to the reserve implementation

The NWA principles recognize basic human needs, environmental needs, the needs to share the resource with other countries, to promote for social and economical development, and the need to implement adapted institutions able to meet those objectives.

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[19] (IWMI, WP17)

The Reserve includes quantitative and qualitative aspects of the resource, needed to fulfill basic human needs, protect aquatic ecosystems, and ensure a sustainable ecological development.

The law foresees a reallocation phase that will put forward the Reserve and international obligations, and will give authorizations for agricultural and industrial needs.

The implementation of those principles has led in the Steelpoort basin to :

- the water users registration process, for which 80% of the main users are considered to be registered yet,
- the beginning of a verification phase, that will use for example satellite images to estimate irrigated areas,
- a first proposal of the ecological part of the Reserve.

The Reserve implementation will lead to the provision of a given amount of water in the rivers for environmental needs, and flow fluctuations for the ecosystems protections (Instream Flow Reuqirements : IFR).

The IFR notion appears in more and more legislations, both at national and international levels. The environmental flows science is relatively young (50 years) but more than hundred methodologies have been developed, and those kinds of methods are used in water management by more than 30 countries. In South Africa, this subject has been studied since the 80s, and as international approaches have not been judged satisfying, a specific method had been developed at Cape Town University : the Building Block Methodology (BBM)[20], with the support from DWAF and Water Research Commission.

The needed volumes for the ecological part of the Reserve have been defined in two points[21]. The IFR 9 site is located in the upper part of the catchment, and the IFR 10 in the downstream part. Proposed volumes are presented in the table 13 below.

In the case of a basin with few infrastructures, flows can not be controlled by operational rules of dams and the proposed values seem difficult to achieve without a dam to allow for the releases. The building of a new dam would facilitate the control of those base flows. Without a dam, they should be the result of water demand management, as it is proposed in the national strategy. But this seems rather unrealistic since the current abstraction control is still difficult to achieve and the water manager is expecting the situation to get worse with the increasing of illegal abstraction (§4.3.5).

[20] (WRC, 2000)

[21] (DWAF, 03/2002)

		O	N	D	J	F	M	A	M	J	J	A	S	Vol (10^6m^3)	% MAR
Normal Years	Low-flows (10^6m^3)	2,68	4,74	6,80	6,91	7,11	6,21	4,51	4	3,21	2,95	2,70	2,60	54,4	13,4
	Floods (10^6m^3)	0,85	0,75	1,94	10,8	1,88	0,76							19	4,7
	Total													**73,4**	**18,1**
Drought Years	Low-Flows (10^6m^3)	1,61	2,59	3,16	3,75	3,87	3,37	2,59	2,38	1,92	1,77	1,61	1,55	30,2	7,4
	Floods (10^6m^3)	0,21	0,85	0,24	2,11	0,12	0,81	0,17						4,5	1,1
	Total													**34,7**	**8,5**

Low flows and floods refer to monthly volume values.

Table 13 : Instream flow requirements , IFR 10

Moreover, the satisfying of basic human needs lead to the problem of water supply infrastructures, especially in the former Lebowa area. The problem here is less the required amount of water (to ensure 25L/p/day) than the quality and availability of this water.

The building of a new dam on the Steelpoort river (De Hoop site) would cost R150 million (C2). The water supply in the Lebowa area, with the water provided by the Lebalelo pipe, would cost R380 million more (purification plant and distribution system cost) (M1).

Questions related to the Reserve implementation are here :

- **the building of a new dam or water demand management to meet ecological water requirements ?**
- **which funds for the potable water supply in the Lebowa area ?**

4.3.7 Pollution sources

It is admitted that surface water quality in the Steelpoort has a direct impact on domestic usage (salinity, microbiological contamination, sedimentation) and agricultural uses (salinity, sedimentation)[22].

General assessments can be given about bad rivers quality and potential water users impacts on water quality have been described in several studies[23] :

- Mining activities increase natural drainage processes resulting from the geological surface and underground dissolution as well as pollutions due to physico-chemical dissolutions, and lead to accidental pollutions that are not always well known,
- Domestic water uses are pollution sources (effluents),

[22] (DWAF, 01/1999c)

[23] (DWAF, 1995a), (DWAF, 1995b), (DWAFR, 1996a), (DWAF, 01/1999c), (WITS), (WRC, 1999), (WRC, 2001)

- Agricultural uses increase erosion, due to overgrazing for example, increase the transport of nutrients and toxic elements with the use of fertilizers, pesticides and herbicides, and diffuse pollution sources.

Waterborne diseases in the catchment (cholera, bilharzioze) indicate microbiological pollutions, and untreated water is often unacceptable for domestic use.

Water quality could deteriorate in the future due to the current developments of the basin and the increasing population leads to a growing pressure on the resource, both on quantity and quality aspects.

Nevertheless, it is quite difficult to have a precise understanding of all the pollution problems in the basin : information about quality and pollution sources are scattered and incomplete.

After a description of users impacts on water resources in the basin, we present here the different available information sources and quality evaluations. The current quality management and pollution control system is then described and the Reserve quality requirements reported.

4.3.7.1 Domestic use (sewerage)

In general, domestic water use and the resulting effluent can increase the concentrations of TDS, nitrates, nitrite, dissolved organic carbon, faecal coliform, ammonia, total alkalinity and other pollutants such as detergents and inorganic waste. Stormwater runoff from towns and villages is another source of pollution, which relates to waste management practices, the topography, the land use and the layout/planning of streets, gutters and stormwater drains.

Most villages use stabilization ponds for the treatment of sewerage. The effluent is then disposed of by means of irrigation or discharge. High silt deposits in the ponds, management problems and general overloading of the treatment process may be the main reasons why more than 60% of the effluent samples taken did not comply with standards[24]. In many cases, the effluent exceeded limits for suspended solids, organic load, ammonia, nitrate and other variables. Occasionally, raw water sampling has detected high levels of faecal contamination, which may partly come from uncontrolled sewer treatment or originate from livestock, which drink freely in streams, rivers and dams. Rural settlements make use of pit latrines, which threaten to contaminate the groundwater sources of the area.

4.3.7.2 Mines

High concentration of heavy metal have been observed in river courses. A research program has been conducted by the zoological department at Rand Afrikaans University and conclusions have been published in the WRC report[25], which underlines that observed levels exceed legal limits and could impact on aquatic organisms health. **Following the measurements, concentrations in water and sediments of metals (Copper, zinc, aluminum, iron, nickel, manganese, lead, chromium) exceed acceptable values for aquatic ecosystems[26] in several points of the Olifants river basin and downstream the confluence with the Steelpoort river. No sample has been taken in the Steelpoort basin within this program.**

Stormwater runoff from mining sites could be contributing to the mineralization of the surface water and the accidental spillage from slurry dams will always be a possible point source of

[24] (DWAF, 01/1999c)

[25] (WRC, 1999)

[26] (DWAF, 1996b)

acids, minerals, trace elements (iron, manganese, molybdenum, zinc), sodium, chloride and other treatment chemicals used in mineral processing.

Main mines in the basin are producing platinum, chromium, vanadium and coal and have specific pollution problems (Mi1, Mi2, Mi3, Mi4):

- Platinum extraction can increase sulfates and nitrates concentrations,
- Chromium extraction leads to the problem of potential accidental Chromium 6 pollutions : in smelters, chromium 3 is turned to chromium 6, carcinogenic product. The process is contained, but remains an accidental pollution source as it already happened on the Samancor-Tubatse site. Smelters can also emit gazes (SO2/SO3, H2SO4) that will solve in rainfall inducing pollutions.
- Vanadium extraction can lead to aquifers accidental pollutions (pollution of the Vantech site).
- Coal mines have acidification problems : boreholes and underground extraction lead to a pH decreasing, that creates oxidation of the pyrite (FeS2) hold in coal and induces sulfate transportation. Acidic conditions lead to iron, fluoride and manganese dissolving. This problem is famous (Acid mine drainage) and subject of numerous current researches.
- Erosion and runoff in abandoned quarries lead to important quantities of sediments in the rivers.

For the moment, solutions mentioned to maintain underground pollutions consist in extracting the water and store it in evaporation dams or use it for flowers irrigation (coal mines and acid water).

Figure 20 : Extracted water being stored before irrigation (Glisa Coliery Mine, Mi3).

4.3.7.3 Agriculture

(cf description of agricultural sector §4.3.5, annexes 3 and 4).

Incorrect tillage practices result in uncontrolled runoff and soil erosion, increasing the total dissolved salts and suspended solids in the surface water. Irrigation is known as a diffuse source of nitrates and phosphates. Over-irrigation leaches dissolved fertilizers into the groundwater and streams and may result in surface runoff which carries sediment, fertilizer, organic waste, pesticides and herbicides into streams and rivers. Nutrient enrichment of the water can lead to excessive algal and microphyte growth which add to water purification costs.

Figure 21 : Steelpoort river eutrophication.

Animal waste can disperse into nitrates, ammonia, organic matter and a possibility of waste related bacterial contamination. In the former Lebowa most of the livestock drink at streams, rivers and springs. Water pollution along rivers and at springs pose a definite health risk to the domestic water users from the same sources. Stormwater runoff could also be a way of bringing the animal waste from the surrounding grazing areas into the streams and could be interpreted as a diffuse source of pollution.

Figure 22 : People and cattle drinking water.

4.3.8 Underground water quality

Several factors can affect underground water quality : it can be related to pollution sources but also to the geology and age of the aquifer. There are few data about groundwater quality. Following DWAF studies[27] older water has higher sodium and chloride concentrations while younger water is rich in calcium bicarbonates.

Agricultural practices and seepage from urban and industrial effluent disposal are impacting on groundwater quality by increasing nitrates, phosphates and ammonia. In worst cases, herbicides, fungicides, rodenticides and even bacterial contamination can be found in groundwater. Groundwater which acquired its chemical imprint from one area can move down a hydraulic gradient to another area and may even end up in the river sand bed or spill into surface water form springs.

Limited groundwater sampling was done in the middle reach of the Steelpoort River. Boreholes sampled were generally located close to mining operations. Without prior treatment, the boreholes examined in the study area are [28]generally unsuitable for domestic use, due to high concentrations of sodium, chloride and TDS. These would result in taste and corrosion problems. The groundwater was also found to be unsuitable for irrigation and livestock purposes due to high salinity and nitrate/nitrite concentrations.

During interviews, contamination problems of groundwater have been reported : Chromium 6 at a chromium mine (Mi2), acid pollution for a coal mine (Mi3), Vanadium pollution at Vantech site. An important Platinum mine that has just settled in the catchment describes an extraction process that is going through several aquifers. **None of the people met talked about the risk of pollutants being transported by groundwater movements**.

4.3.9 Scattered information sources based on several indicators

Looking for more detailed information about water quality and pollution sources lead to examine different information sources :

- physico-chemical data are produced by DWAF (DWAF IWQS, water quality on disc) and available on the web (cost R300).
- an estimation of ecological river health is available on the CSIR web site and is the result of a program initiated by DWAF in 1994 : South African River Health program.
- local analyzes are performed by mining companies and sent to DWAF, either for a license authorization of a new site, or as part of an Environmental Management Program Report, performed by each mining company[29]. Municipalities are also sending pollution control results to DWAF.
- Specific research programs are concerning heavy metal pollution impacts. A program has been performed by the Rand Afrikaans University ten years ago in the Olifants river basin[30], but the program is now finished and data are not collected anymore.

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[27] (DWAF, 1995a), (DWAF, 01/1999c)

[28] (WRC, 2001)

[29] (Samancor, 2002)

[30] (WRC, 1999)

4.3.9.1 Physico-chemical data

DWAF maintains a hydrological information system and the Institute for Water Quality Studies is in charge of the quality part of the database.

Data are manually collected at specific gauging stations and the following indicators are being evaluated : EC (conductivity), TDS (Total dissolved solids), pH, Na, Mg, Ca, F, Cl, NO2-NO3, SO4, PO4, TAL, SI, K, NH4, TP, KN.

Measure points are located on the map below :

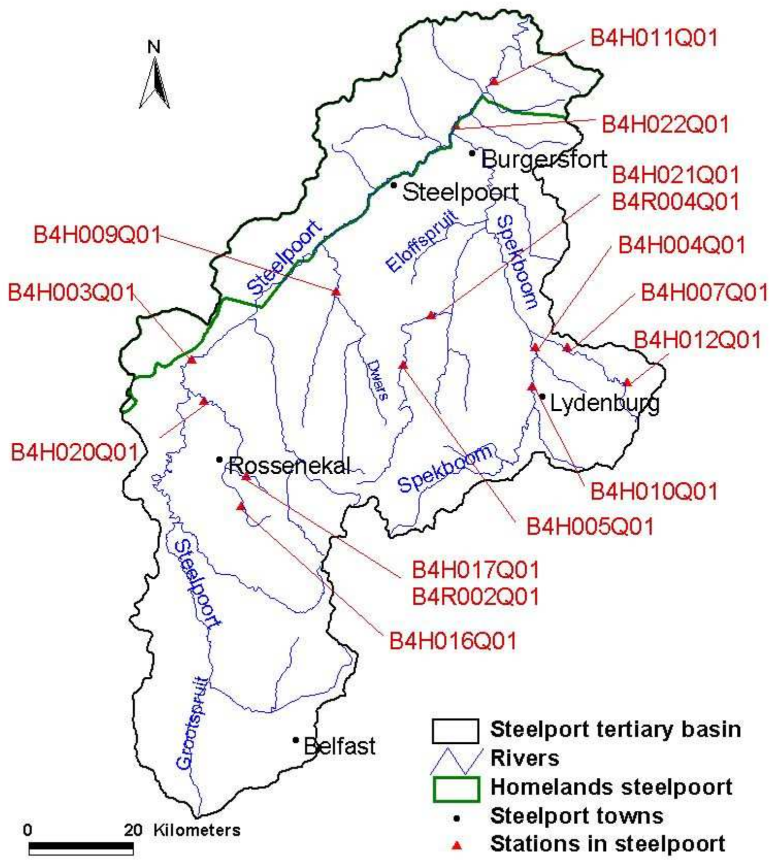

Figure 23 : Surface water quality measure points

Physico-chemical analysis consist in comparing mean values of the concentrations to thresholds defined in Water Quality Guidelines[31], observing tendencies and variations in time and space, and identifying potential punctual pollution problems.

In 1999, the analysis show that water quality is not always fit for irrigation and domestic use, specially in the downstream part of the river, just before the confluence with the Olifants river (cf table 14). **There are incidences where maximum measured concentrations for EC, chloride, sodium, sulphate and pH exceed the ideal water quality requirements.**

During periods of cessation of flow in the mainstream the water quality may deteriorate. No record of these incidences are available as no sampling is generally done when there is no flow in the river. The implication for water quality is that critical periods are likely to be

[31] (DWAF, 1996b)

during these periods of no or very low flow, when the river is reduced to a string of stagnant pools, in which evaporation and animal waste wastes combine to increase the concentrations of ion levels that are unacceptable to the riverine biota and to the people who depend on the river.

The table below illustrates results obtained with data collected till 1997.

	Steelpoort Median concentrations											**Guidelines**		
	B4H016	B4H017	B4H003	B4H009	B4H005	B4H021	B4H010	B4H004	B4H012	B4H007	B4H011	Domestic	Irrigation	Aquatic
EC mS/m	16	16	26	42	14	21	13	19	5	9	49	0 – 70	0 - 40	
PH mg/l	7,6	7,8	8,0	8,2	7,9	8,1	7,8	8,1	6,5	7,4	8,3	6,0 - 9,0	6,5 - 8,4	
Nitrate mg/l	0,13	0,10	0,09	0,10	0,09	0,12	0,09	0,08	0,02	0,04	0,83	0 – 6	< 5	< 0,5
Ammonia mg/l	0,06	0,05	0,04	0,04	0,03	0,04	0,03	0,03	0,07	0,04	0,05	0 – 1		< $7e10^{-3}$
Phosphate mg/l	0,016	0,014	0,011	0,016	0,013	0,016	0,011	0,016	0,000	0,009	0,011			
Fluoride mg/l	0,1	0,1	0,2	0,1	0,1	0,2	0,1	0,2	0,1	0,1	0,2	0 – 1	< 2	< 0.750
Chloride mg/l	6	5	8	5	4	4	4	5	3	4	34	0 – 100	< 100	< $0,2\ e10^{-3}$
Sodium mg/l	5	5	12	13	3	6	4	7	2	3	41	0 – 100	0 – 70	
Sulphate mg/l	5	5	9	7	5	7	5	8	2	4	18	0 – 200		

Table 14: Steelpoort median concentrations and water quality guidelines objectives, sources : (DWAF, 1999) for water samples collected up to 1997, Water Quality on Disc database for samples collected up to 1995.

19 indicates that an occurrence at least has been observed exceeding domestic target value

49 indicates that the mean value exceeded irrigation target value.

4.3.10 Lack of means at local level for the effective pollution control

The DWAF office in Nelspruit is in charge of quality management, pollution control and industrial license approval.

Quality management consists first in identifying for each water user : resources used, water usages, quality management performed by the user, pollution prevention measures, and effluent quality. The office is currently implementing a monitoring network that will define measure points upstream and downstream each user impacting on the resource.

The monitoring system provided by DWAF central level (§4.3.9.1) does not seem to be used because of databases transfer problem.

Pollution problems currently identified by the regional office were not available under written format. Problems mentioned in interview were :

- sewage plants that do not comply with water quality requirements, and sometimes overflow in rivers (for ex: at Lydenburg)
- old quarries, in upper reaches of the basin, leading to siltation, high nitrates concentrations,
- coal mines that may contribute to high sulfate concentrations, low pH causing heavy metals concentrations,
- settlements with pit latrines, causing high nitrates concentrations,
- groundwater of poor quality (for example near Mopetsee), and high metal concentrations,
- difficulties in depolluting after an accidental pollution, like at Vantech site.

A important task is also industrial licenses approval. The process can last between 6months and 2 years, and represents 100 working days at DWAF. 14 licenses are currently being examined in the Steelpoort basin and 20 are expected in the short term.

The team suffers from lack of human resources with only persons in charge of pollution control in two river basins. They have to define the monitoring network, take samples on the field, send them to laboratories and analyze the results.

The team receives information about water quality sent by water users : mines, municipalities in charge of sewage plants, as well as their own analysis, but they do not have enough human resources to analyze all these data and publish a state of water quality and pollution problems in the basin.

When pollution problems are encountered (downstream users complaining to DWAF for example) DWAF asks to water users to meet legal requirements, and problems can quickly be solved (sewage plants repairing when the reason is a technical default) or lead to negotiations or court cases. A manager explains that court cases against mining companies in an other basin and the “torture” it was to follow this action because of the few means at DWAF compared to the powerful mining companies. He prefers now to negotiate directly with the mines about depollution measures.

4.3.11 The development of “shared” quality objectives

The ecological reserve proposal leads to the definition of water quality objectives, that have to be defined depending on the present state of the rivers (Present Ecological State). This state is described as a change from the reference condition, and the degree of change is described by one range of classes (Classes A to F, E and F classes indicate a current state ecologically unsustainable). The ecological state was expressed in the components: habitat (integrity), biophysical (fish, riparian vegetation, aquatic invertebrates and geomorphology) and water quality (chemistry) integrity.

Evaluations have been done by experts using the following indicators[32] :

- South African Scoring System for **aquatic invertebrate fauna** (presence of families of aquatic invertebrates : snails, crabs, worms, insect larvae, mussels, beetles)
- **Fish** Assemblage Integrity Index (numbers of species of fish, different size classes, health of fish)
- **Riparian Vegetation** Index (State of riparian vegetation : vegetation removal, cultivation, construction, inundation, erosion, sedimentation and alien vegetation, output is a percentage deviation from natural or unmodified riparian conditions)
- Index of **Habitat Integrity** (examples of habitat types are pools, rapids, sandbanks, stones on the riverbed, and vegetation fringing the water's edges, availability and diversity of habitat are major determinants of whether a given system is acceptable to a specific suite of biota or not). IHI has been developed to assess the impact of major disturbances on river reaches. These disturbances include water abstraction, flow regulation, and bed and channel modification. This index accounts for both the condition of the riparian zone and the in-stream habitats.

Trajectories of change were described for each component : describing the current trend of changes in the river in present conditions, short term (5 years) and long term (10 years).

Ecological Importance and Sensitivity of the river was established, taking into account abiotic and biotic components. The social importance of the river was taken into account within the context of ecological importance and sensitivity. The sociological assessment was restricted to the dependence of people and communities on a healthy riverine ecosystem for their basic needs, but did not include their social dependence on the river for commercial or subsistence farming. This evaluation was not available in the draft version of the report[33].

Taking into account the Ecological importance and Sensitivity of the river reach and constraints to its restoration potential, the specialists provided *Ecological Classes* for all components for which PES classes were determined, specifically related to what could be achieved in the short term and long term.

Resource quality objectives were then derived for each IFR site, either numerical (flow and water quality) or narrative (biota, geomorphological).

First evaluations for the Steelpoort basin[34] lead to a river currently in a class D *"mostly due to mining related impacts and lack of catchment management. The ecological importance and sensitivity is high and the trajectory of change is negative."* The report concludes that *"due the difficulty in addressing the problems in the catchment, improvement will be unrealistic and the ecological class of the basin is therefore set at a class D."*

Results are presented in table 15.

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[32] (WRC, 2001)

[33] (DWAF, 03/2002)

[34] (DWAF, 03/2002)

Components	PES	TRAJ	Status quo short term scenario	Status quo long term scenario	Short term EMC
Geomorphology	D	----	?	E	D
Riparian vegetation	D	----	D	E	D
Fish	D	----	D	E	D
Aquatic invertebrates	D	----	D	E	B
Nutrients	B				C
TDS	C	----	D	E	B
Toxics					D
PH	E		E	E	C
Water quality	B		C		D
Habitat integrity (in)	D	0	D	E	D
Habitat integrity (rip)	E	0	D	E	D
Ecostatus	D	----	D	E	D
Long term EMC					D

Table 15 : Steelpoort PES : Present Ecological State, TRAJ : trajectory of change, Status quo scenario and Ecological Class (DWAF, 03/2002)

The following step in the process consists in defining water quality objectives for each of the river and debate them with water users. Preliminary objectives are currently being proposed for the Dwars river and DWAF will organize a forum to discuss them with users in the following months, to discuss about objectives and means to achieve them.

4.3.12 Discussion

Some questions can be raised about the ability of the current management system to meet initial objectives in satisfying 1) basic human needs and 2) environmental needs.

Those objectives are not conflicting since environmental needs will lead to improve water quality, a major part of the population depending on it for its domestic needs. Amount of domestic water is besides largely smaller than environmental needs[35]. But the important means that will be needed should lead to prioritization in actions that will be done.

For quantitative aspects, objectives will be met through infrastructures developments to supply water in disadvantaged areas, storage capacity increase and the building of a dam, or limitation in water uses, important transfers between basins. A transfer is already existing from Olifants river to Steelpoort river basin with the Lebalelo pipe[36]. This transfer is mostly beneficial to mining companies, who funded it, but points to supply water for communities

[35] With 25l/p/d, domestic water represents 3 million m^3. Environmental needs are comprised between 34 and 74 millions m^3.

[36] (Rouzère, 2001)

have been foreseen. This is not operational yet because infrastructure for treatment and supply have not been realized, and no one knows who will finance them.

Water demand management, as mentioned in the national strategy, can not be achieved now : on the contrary, abstraction control is difficult to perform and we saw (§4.3.5) that DWAF is suffering from lack of human resources to limit illegal abstraction developments.

About quality aspects and pollution control, work is currently being done to debate quality objectives and related needed resources. **If the state of the rivers and main pollution sources are known today, there is a lack of independent measurements by DWAF to control some major pollutions, particularly underground pollutions by mining companies**.

4.4 Water users and other stakeholders points of view

To help understanding stakes and difficulties in water management in the basin, we looked at water users points of view about the resource, usages impacts and concerned institutions. Points of view have been gathered through interviews with water users, institutions in charge of water management and pollution control, environmentalists, researchers and consultants.

Data are presented below, by themes and actors groups. Pollution problems mentioned in publications and during interviews are localized on maps. Points of view are then being discussed.

4.4.1 Points of view by actors' groups

Interview references have been indicated in the text :

- commercial farmers :CF
- farmers (SF) and villagers (V) in the former Lebowa
- mines (Mi)
- municipalities (M)
- environmentalists (E)
- DWAF (DP, DG, DN)
- Consultants, researchers (C)

4.4.1.1 Water resources : surface and underground water

All water users but one (SF2) use both surface and underground water sources. There is no borehole at SF2, they use water from the Steelpoort river brought by canals and stored in ponds.

The commercial farmers we met use surface water for irrigation and boreholes for cattle and domestic use. One farmer uses underground water for irrigation in "emergency cases" when surface water is too sandy (CF4).

When both sources are available, underground water is preferably used for domestic purposes. People who are drinking surface water do not have any borehole, but initially had a purification plant, that is now not functioning all the time (SF2), or lack of underground water supply (V3).

When asked about evolutions of water quantity for surface and underground water, all users answer they never had problems with boreholes being dried up. Few comments are made concerning evolutions of river flows : one user observed a decreasing in river levels in winter, due to the increasing number of farmers abstractions.

A change in the hydrology of the basin has been observed after 1995. Three interviewees observed that since 1995, exceptional rains occurred. After a dry period between 1982 and 1995, it has rained much more last years. One interviewee in charge of water management in the basin points out that in spite of those important rains, base flows are less important, but he says he has no scientific proof of it. He explained *"no physical data is available in the Steelpoort catchment, we have only simulated data."* (DG1)

4.4.1.2 Water availability

Almost all water users (13 out of 19) mentioned water availability concerns. There is a lack of water in winter and most of the users are complaining about rivers lack of water and attribute it to mines abstractions.

Those who are not concerned are : a municipality (M3) which uses a dam with enough yield for the demands, mines who have to extract excess of water form underground mining (Mi3) and mines who will benefit from water transfers from the Olifants, through the Lebalelo water pipe (Mi1, Mi2). All other users experienced lack of water or fear lacks of water in the near future.

Water availability problems mentioned are reported below :

- **Villagers and small scale farmers are suffering from lack of water for drinkable and irrigation purposes**. They report difficulties to pay electricity bills so that boreholes are not functioning anymore. *"The borehole has not been used since 3 years because the previous irrigation scheme has been using the pump without paying the electricity for one year."*(SF1) They are expecting infrastructures developments in the future. *"We hope the extension officer* (local employee of Dt of Agriculture) *would do something : they have to come and clean the canal. People are waiting for the canal to be repaired, now they are installing fences on the fields for agricultural purposes."* (V2) *"They will develop agriculture and are currently busy with putting fences there. They have no idea about water supply for irrigation"* (V32).
- **Commercial farmers**, who have already experienced lack of water for irrigation in dry seasons, and who **think the situation will get worse**. They are either thinking there is no solution *"When I must irrigate, I must irrigate"* (CF4) or say water abstraction should be regulated by DWAF (CF1). They are aware of the mining sector development, from which some will beneficiate in selling parts of their lands for water rights or housing development (CF2). They are expecting a dam in the Steelpoort river (CF4).
- **Municipalities are concerned with providing water to townships and rural areas**, and ask who is in charge of it and who will pay (M1, M2). Some are also expecting difficulties with the increase of population linked to the mining developments and expect a dam *"If a dam is constructed, thousands of people will have water in Jane Furse. But the question in the budget for this" (*M1).
- **Mining companies have developed strategies to ensure their access to water.** They are using water transferred from the Olifants river through the Lebalelo pipe or are buying farms and associated water entitlements. CF3 is now renting the land bought in the 80's by a mining company. This company (Mi4) plans to open a new mine there and will transfer water rights from agricultural to industrial use. *"Conversion of farm rights provide 70% of the volume for industrial use, if accepted. After this, farmers will have to apply for water."* (Mi4)

The situation is perceived as getting worse with :

- the development of new mines in the catchement, and the related increase of population,
- illegal abstraction from agriculture and trout fishing industry in the upper part of the catchment.

Availability concerns mentioned in interviews are presented below :

Water availability pb	Reasons	Interview ref
Underground water :		
- water table level might be too low or decrease		Mi4, V3-3
- not enough or	Under capacity of the system, no distribution rule, increasing number of people	V1, V31, V32
no water at the tap in villages	pb to pay electricity bills : boreholes or purification plant do not function anymore	SF1, SF2
Surface water :		
- Rivers stop in dry season	Mines abstraction Illegal abstractions from agriculture, trout industry	CF3, V31, V32, Mi4, E3, CF2, DG1
- Lack of irrigation infrastructures or do not function anymore		SF2, V2, V31, V32
- Not enough water in the future	New mines, increase of population, increasing number of farmers abstraction	CF3, M1, DP2 CF1
Both :		
- no infrastructure to provide drinkable water in rural areas	Who will pay ? who is in charge ?	M1, M2

Table 16 : availability problems

4.4.1.3 Water quality problems

Almost all water users (17 out of 19) mentioned water quality problems. People who did not mention any are a Groblersdale municipality officer, not directly concerned with the Steelpoort catchment (M4), and villagers who said they had no information about water quality (V12).

Commercial farmers know :

- **underground water pollution problems due to mines pollution, but think these are localized pollution problems**. They still use their boreholes for drinkable water and said they did not experience pollution problems at their place. One farmer had pollution problems on his farm, went on a court case with Vantech for this, and the mining company bought the lands concerned. This farmer moved and is not farming in the catchment anymore.
- **potential surface water pollution**. They wish they had more information about it. Air pollution is reported in the central Steelpoort (acidity). Possible impacts on tomatoes are mentioned

Pollution mentioned are visible pollutions : high silt level, inducing quick ageing of pumps, and soap in rivers, coming from people washing upstream.

If several past accidental pollutions due to mines are known in the catchment, nothing is said about the moving of the pollution plumes, except the Wapadkloof past pollution 10 years ago that killed all fishes in the river.

Main water quality problems mentioned by water users groups are described bellow.

Quality pb mentioned by commercial farmers	Reasons	Interview ref
Underground water pollution :		
Chrome 6	Tubatse	CF2
Vanadium *"J. proved the pollution" "At Kennedy's vale farm, boreholes's water is polluted by Vantech Platinum mine"*	Vantech	CF2, CF4,
Surface water potential pollutions : *"Rivers must be polluted"*		CF3, CF4
Fertilizers	Agriculture	CF1
Acidity, corrosion *"Sometimes, air smells like overloading batteries" "Corrosion can be observed on roof and fences, there are possible impacts on tomatoes, but we can't prove it"*	Mines, Vantech or Tubatse ?	CF3
Surface water pollution :	People washing upstream, sewage waste	CF1,
Soap *"Sometimes, it is like a washing machine"* Sand *"A pump here last 4 years"*		CF4
"During draught years, pollution was high, we had problems on the crops, it was not like it must be".		CF4
Global pollutions :		
Wapadskloof	Accidental pollution from a mine	
"Suddenly, all fishes disappeared"		CF1
"Now, you can't even touch the soil there"		CF2

Table 17 : quality problems mentioned by commercial farmers

Small scale farmers are complaining about :

- pollutions coming from people washing upstream, and agricultural uses. They were informed about the poor quality of surface water by DWAF, and know they have to purify water before drinking (Jik).
- serious consequences attributed to Vantech pollution : health effects on people living in the village, and cattle were reported. A court case has been launched against Vantech mining company. This case is controversial and detailed further (cf §4.4.2)

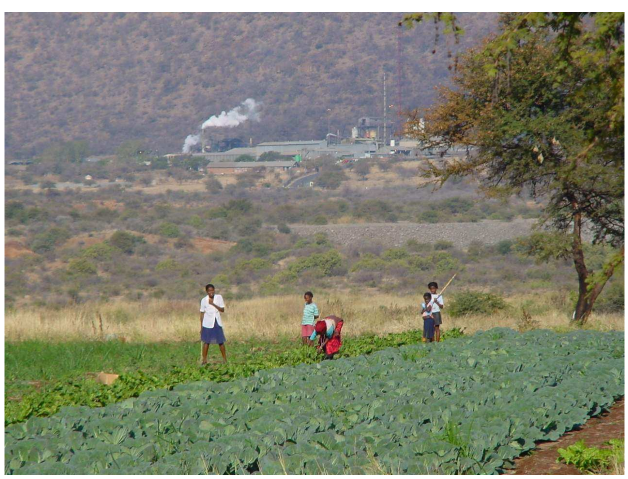

Figure 24 : Boschkloof irrigation scheme and Vantech vanadium mine

Quality pb mentioned by small scale farmers	Reasons	Interview ref
Underground water pollution : *"Water from boreholes taste salty"*		SF1
Surface water pollution : DWAF inspected the river and informed water is not good for domestic and livestock, told them to purify water before drinking. *"The water is not clean" "Water is soapy, sometimes tastes salty"* Algae, nutrients	*"Villagers living in the mountain polluted the water"* People washing upstream , Sewage waste from upstream, Nutrients from agricultural areas	SF1, SF2
Global pollutions : Air and rivers polluted, trace elements polluted the water : death cases of young calves, respiratory diseases, bronchitis	Vantech	SF2

Table 18 : quality problems mentioned by small scale farmers

Municipalities are concerned by the quality of drinking water and are currently being transferred the drinkable water supply function from DWAF. They have been implemented in 1999 and have now few resources.

They are in charge of running sewage plants that are sometimes under developed for the needs or dysfunctioning for technical reasons, leading to occasional downstream pollution.

Their main concern is to face the increasing amount of people living in the catchment and the under-capacities of sewage plants, due to lack of funds to upgrade the infrastructures. Those problems have been known for a long time : at Lydenburg for example, the decision to upgrade the plant had been taken in 1989, but they could never finance it.

Quality pb mentioned by municipalities	Reasons	Interview ref
Surface water pollution : Nitrates increasing		M1
Bacteria	Municipal sewage plants under capacities, *"Sewage water is discharged into the rivers"* M3 pb of increasing amount of people in RDP houses.	M2, M3
Global pollution Pollution at Wapadskloof	Previous mine	M2

Table 19 : quality problems mentioned by municipalities

Villagers are the most impacted people by water quality problems : in all the places we went, people drink water from rivers; and health problems are experienced. Diarrhea and cholera cases are reported, the poor quality of the river is widely known and people who can afford drilling a borehole do not use the water coming from the river anymore. Sources of pollution mentioned are mines located upstream and sewage from people.

Quality pb mentioned by villagers	Reasons	Interview ref
Underground water pollution :		
Dt of Health told people to purify		V1, V33
Surface water pollution :		
Dt of Heath told the water was totally polluted.		
Water quality is bad	Sewage of mines, oil discharge, sewage coming from people upstream	V2, V33
"In the river, we are competing with Donkeys"		V32
"We don't use the water from the Mopetsi river anymore, people had Cholera"		V2
"5 people died from cholera last year in Mashamtane" (Mopetsi)		V33

Table 20 : quality problems mentioned by villagers

Mining companies are performing water pollution control programs. They often mention pollutions coming from other mines and we heard about general pollution problems related ot platinum, chromium, vanadium and coal mines presented §4.3.7.

Specific problems encountered in the basin are : Tubatse underground Chromium 6 pollution, for which no risk of moving of the plume is assumed, Vanadium pollution by Vantech, or acid water coming from coal mine.

Each of the concerned mine seem to deny the groundwater communications with rivers, or say they have no information about it. We did not succeed in meeting Vantech mining company.

Quality pb mentioned by mines	Reasons	Interview ref
Underground water potential pollution :		
Chrome 6	Ferrochrome mines Mi1, Mi2	Mi1, Mi2
Sulfuric acid, nitrates, heavy metals (vanadium, iron)	Vantech	Mi2
Sulfate, nitrate	Platinum mine Mi4	Mi4
Underground water pollution :		
Chrome 6	Tubatse	Mi2
Vanadium	Vantech	Mi1, Mi4
Surface water potential pollutions :		
High sulfate, nitrate levels	Platinum mine Mi4	Mi4
Surface water pollution :		
Silt	Mapochs mine	Mi2
Nitrates	Agriculture and settlements	Mi3
Acidic conditions (Iron, fluoride, manganese dissolving) acidic water coming form the soil	Coal mine Mi3	Mi3
SO2/SO2, H2SO4	Tubatse Mi2	Mi4

Table 21 : quality problems mentioned by mines

4.4.2 Conflicts and tensions, alliances

The table 21 below summarizes tensions, conflicts and alliances that were mentioned by the different actors.

Tensions are divergences mentioned in interviews. Open conflicts are court cases or degradation of irrigation equipments in the fields. Potential conflicts have been mentioned about existing tensions that might get worse.

	Commercial farmers	**Small scale farmers**	**Villagers**	**Mines**	**Environmentalist**	**DWAF, Consultants, Researchers**
Tensions	**<-> DWAF** Registration has no sense : "*when I must irrigate, I must irrigate*" CF4	<-> TLC Nothing happen about water pb SF1	Chief <-> Municipality V2, V31 Competition between taps V32 Pb of increase of people, not paying, illegal connections, leaking V1		<-> farmers exploiting wetlands <-> trout industry <-> indigenous people cutting wood <-> mines drilling in wetlands E3, E4	**DWAF <-> Municipalities** about transferring sewage works, DP1 **DWAF <-> DME** about EMPR, DP1 **DWAF <-> DEAT** about EIA, DP1 Water service authorities : not clear between district and local municipalities DP2
Conflicts /Court case	**<-> Mines** Court case against Tubatse mine about illegal abstraction CF2, CF3 Court case against Vantech about pollution, CF2, CF3 Tubatse Mine <-> Dwaf : borehole not allowed CF3	**<-> Mines** Court case against Vantech about pollution SF2	When white farmers left, people came and cut the citrus. V31	Vantech <->commercial farmers, <-> communities Mi1		**DWAF <-> Mines** : court cases about pollution DP1, now prefer negociations DN1-2 Conflicts with ind because of water needs C3
Potential future conflicts						DWAF is expecting future conflicts *: "if upstream users go on building illegal dams, there will be no water left for big users downstream who will pay for water, like mines."* Tensions can be expected if local government do not achieve with drinkable water supply for everyone.
Alliances				Mine is involved with community's life : supply chief and nearest school with water, will supply slag, plant and equipement for the community to sell ferrochrome Mi1	Will create a reserve with mines and commercial farmers for conservation purposes	

Table 22 : tensions, conflicts or alliances mentioned by stakeholders

Tensions in the former Lebowa villages :

Tension concern villages, dissatisfied with local government promise about rehabilitation of irrigation schemes, and bad relationship between traditional leaders and municipalities (V2, V31). In a village, the chief is using a tractor and sells buckets of water he abstracts from the river. (R10 for 175l). He does not support the municipality for developing water infrastructures. Traditional leaders in the villages are no longer attending council meetings. A employee of the municipality says perhaps they want to be paid for this. In the same village, tensions exist inside the community, which as insufficient supply water system and where people are not organized to share the resource. *"People don't have water every day. There is a competition between the different taps, and people have to get up early to have water. There is no rule to distribute water. If there is no water, people just go to the river, but in the river, we are competing with donkeys."(V32)*

Tensions in commercial farming area villages :

Laersdrif is a village located in a commercial farming area. On one side of the hill, a church, a police station a shop and a few houses constitute the heart of the Afrikaner village. On the other side, African houses have developed just above the Steelpoort river. Tensions are mentioned about the population increasing and the arrival of African people who are not paying for water, and put illegal leaking connections to supply their houses. (V1)

Tensions mentioned by environmentalists :

During the 60s, the government trained farmers to drain the wetlands. Today, environmentalists (E3, E4) are trying to protect wetlands from farmers who are farming there. Some areas have been protected and a RAMSAR site has been declared : at Verloren vallei, in the upstream part of the Klipriver.

Trout fishing have also negative impacts on wetlands : illegal dams building, massive introduction of trouts being predators, and trout feeding inducing enrichment in phosphate and nitrates impacting on water quality.

Mines have also potential impacts on wetlands when drilling for exploratory purposes, which might affect rock clay and lead to rivers disappearing, as it already happened in the Blyde River basin.

Tensions or disagreement between state departments :

The process of mining license and environmental impact assessments approval involves Departments of Mine and Energy, Environment and DWAF. DWAF mentioned some cases when their points of view were not taken into account. A Memorandum of Understanding (MOU) has been signed between DWAF and department of Mine and Energy, a MOU has been proposed to the Department of Environment, but this one has not been signed. (DP1)

Open conflicts are recent court cases between mining companies and farmers about illegal abstraction of water or underground water pollutions, or degradation of irrigation equipments.

Samancor-Tubatse court case :

CF2 had a court case in 1984 with Samancor-Tubatse because of the mine abstracting illegally in the river. They were using boreholes next to the river. CF2 was previously chairman of the irrigation board. He had to engage a famous and expensive lawyer, and thought he would have to sell his farm. He finally won the case.

Vantech – J court case :

This court case is well known in the basin between J, commercial farmer, and the vanadium company Vantech, about underground water pollution. This court case seems to have ended to a non pollution verdict, but Vantech bought the polluted part of the farm (R1,7 million) and J left the basin.

Vantech-Boschkloof court case :

Small scale farmers reported also about a court case they had with Vantech in 1998 about pollution.

"During blasting a lot of dust is created which settles on leaves of plants and is later washed into the river during rainy season. This dust contains some trace elements, which contaminate the water. A certain yellow chemical which is put on top of the huge heaps is very contaminating and birds which fly over it die instantly. During windy days the chemical is blown to the village and on the river. This has caused some death cases and a lot of respiratory diseases especially bronchitis. Its effect to the livestock is felt by the death of the young calves. The court case is still in process and its main objective is to decrease the pollution and to compensate the affected community members. An inspector was sent to advise the mine to retain the smoke from the chimney facing downwards. The Department of Labour was also involved as a mediator between the mine and the mineworkers to make sure that mine workers' rights are respected but no success came out of the meeting." (SF2)

A Vantech ex-employee explained this case was very controversial. (Mi1) *"During the inquiry, 85 people were declared ill, and among them, 5 people died : 3 were murdered, and 2 had aids. Finally, 47 people were found ill due to the company, they were all working for the company, and did probably not follow the security orders."* He told us about an *organization called "environmental justice commission" who is "politically motivated and union oriented" and who organizes communities against mining companies. Their purpose is to convince ill people, HIV positive and AIDS ill people, that mining companies are responsible for their illness, and that they can be compensated in money through legal procedures against mining companies. This results in poor informed community people led by so called experts on pollution who have low credibility."*

This ex-employee decided to quit the company because of the opposition he had with his management about pollution questions. *"A big Vanadium pollution had occurred before 1982, when VANTEC bought the site. The company refused most of the proposed investments to solve pollution problems they felt not responsible for. Now, the pollution plume is moving, and some measures have been taken to slow it down (boreholes drilling and water subtraction), but the construction of a tailing dam has been rejected by the company. This position can be explained because this site will not be explored for a long time, and the company is planning major investments on a new site." (*Mi1)

DWAF point of view about this case is also that health effects on people living in the village is not caused by water pollution but rather concerns mine workers, and are due to bad working conditions. (DN1- DN2).

Irrigation equipment degradation :

Around Bothashoek, previous irrigation infrastructures are not functioning anymore : a canal from the Steelpoort river to two dams used for irrigation. A white commercial farmer owned the land bordering the former Lebowa homeland, on the same side of the Steelpoort river, and farmed wheat, maize, and citrus. *"In1995, people* (upstream the commercial farm were living people form Lebowa) *blocked the canal and used the water for their own irrigation purposes. (V2)". "In 1996, when the white farmer left, there was a conflict. People came back on the land and cut the trees. Some workers previously employed by the white farmer left, some stayed." (V3)*

Now, infrastructures are still visible, the canal is broken where it previously crossed the Mopetsi river, and dams are not functionning anymore.

Potential conflicts :

DWAF is expecting an increase in conflicts related to water in the near future. Illegal dams are developing in the upper part of the catchment and will decrease the amount of available water to users located in central parts (commercial farmers, mines).

4.4.2.1 Points of view about institutions

Points of views about institutions were gathered through questions about information and users expectations :

- Is there a water quality control in the basin ?
- Are people aware of the registration process ? who is in charge of water management?
- Do people know about Catchment Management Agencies ? What are the users expectations for future water management institutions.

Information about water quality :

Small scale farmers told DWAF informed about the poor quality of the water (SF1, SF2). *"DWAF came to inspect the river. They informed the community that the water is not good for domestic use and livestock so they gave each household ten sachets of water purification substance and when it is finished the community was advised to buy bleach."* (SF2) Villagers were informed by Dt of Health (V1, V33) who also advised to purify the water.

Commercial farmers seem to have less information.

Mines follow a water quality control process and send their analysis to DWAF.

Management process :

All water users but one (SF1) were registered at DWAF. Water abstraction control has been mentioned by commercial farmers, one saying it is impossible to regulate, the other expecting DWAF to stop illegal abstraction.

Institutions concerned by water management :

People do not know who is in charge of water supply in rural areas. Some mention local governments, that they still call TLC (Transitional Local Councils have been replaced by Local Governments). Others mention village chief as responsible for water management (V2, V31), and the municipality from which they expect water management improvement.

Water users associations :

The NWA put forward the development of water users associations. Local experiences have been more or less successful :

- mines mention the Lebalelo water user association.
- The process of water license entitlements will concern water users associations. Irrigation boards who structured till now commercial farming are in the process of turning to water users associations, that leads to some attempts involving small scale farmers to increase their representativeness (CF3). This process could last between 5 and 10 years and the basin scale. (DN1, DN2).
- An attempt to create a water user association in the former Lebowa has been mentioned at Boshkloof irrigation scheme : meetings have been organized to involve mining companies and commercial farmers, supported by a consultant. This was unsuccessful.

The Olifants River Forum :

The Olifants River Forum has been organized to involved interested parties in protecting ecological systems. Its members represent mining companies, National Park Boards, municipalities, research institutes. The ORF could become a catchment committee in the basin within the catchment management agency process.

It was mentioned by a municipality, a mine, environmentalists (3/4), and DWAF.

Some recognize ORF provided information (Mi3), *"The ORF has been very active in organizing workshops and performing studies in the past"* (Mi3). Some were more sceptical about the impacts of those meetings. *"We participated to the ORF, but there are so many problems, they don't know how to tackle them: indigenous plants, people washing in the water …It is not worth the time spent, nothing came out" (M4).*

Environmentalists explained ORF was stronger in the past :*"In the past, the ORF was quite strong, dealing with water management. But then the CMA process came in, it was rather promising. DWAF tried to build something that would replace the ORF. But nothing came out, and now the ORF is not so active"* (E1*). "The CMA process put efforts to get the Forum more representative, but then people never met, they had no energy anymore" (E2).*

A reason for this could be the hydrology that was better last years. *"Anyway, there is no need currently to manage in common the rivers, but next draught will be crucial*"(E2). This argument was also given by DWAF and commercial farmers.

Steelpoort Producer Forum :

Mines have created the Steelpoort producer forum to address development questions in the area, involving municipalities (Mi4) : land reform, water supply, waste treatment, electricity, housing … One of the objective is to *"open up communications with the mayor, municipal councils and municipality officers*."[37]

This forum illustrates the mines wish to be associated to municipalities to propose a common development strategy.

4.4.2.2 Conflicts and their treatment

Pollution problems and rivers quality degradation mentioned during interviews show (cf table 23):

- serious underground pollution problems due to mines, often unknown, with potential impact on water users and no proposed solution by the administration. Conflicts are managed by mines themselves : court cases, polluted land buying.
- Surface water availability problems , potentially aggravating and that could be solved with the building of a new dam and/or water demand management, limioting watyer uses by compulsory licensing,
- Pollution problems due to under capacity sewage plants overflowing directly into the rivers, for which municipalities are currently trying to find adequate financing for upgrading the equipements.
- Aquatic ecosystem and wetlands degradations, related to important development of agricultural and mining sectors in the basin and due to the high and still increasing population density. Environmentalists of Mpumalanga Park Board try to limit those impact by protecting specific areas.

Those concern illustrate water users and other stakeholders expectations toward future water management institutions :

- Needs for more information and pollution problems discussions (CF3, SF1, V12)
- Needs for more abstraction regulation and control (CF1),
- Need for a quality monitoring. "*Catchment Management Agency should take th e responsibility of water monitoring. It should be compulsory and will be paid by the water users. In Steelpoort, communities are poor, but there are lots of mines."* (E3)

[37] (Steelpoort Valley Producer Forum, 2002)

Pollution and state of the rivers impacts			Conflict	
Indicators	**Responsibility**	**Affected persons**	**Conflict level : Severity and (evolution)**	**Treatment**
Eaux souterraines				
Chrome 6	Chromium mine	?	?	?
Vanadium	Vanadium mine	Farmers	☹☹☹	Miner buying polluted land
Sodium, Chlore	Mines	?	?	?
Nitrate	Agriculture	?	?	?
Acidity (localized)	A coal mine	The mine	no conflict, mine trying ot contain pollution	
Decrease of water table level (unknown)	Platinum mine	?	?	?
Surface water				
Flow decrease due to: Illegal dams	Farmers, trout fishing	Farmers, people living in ex-lebowa	☹☹ (↑)	DWAF : DWAF registration and verification process (7 years) « compulsory licensing »
Flow decrease due to: Increase of abstraction	Mines		☹☹☹	
Siltation	- Overgrazinf (ex-Lebowa) - Dryland agriculture - River banks agriculture	Commercial farmers Environmentalists	?	?
Soap	People living in settlements	Inhabitants, farmers	☹	?
- Ammonium, - Nitrates, - Phosphates, - Bacteriological pollution	Lack or under capacity of sewage plants	People drinking surface water	☹ (↑)	DWAF asks for repairing if technical problems Municipalities : try to update plants
		Downstream users (Lydenburg for ex.)	☹☹	
Sulfate Nitrates, alcalinity	Coal mines de charbon and old granite quarries	?	?	?
Eutrophication	- Agriculture, - Domestic use	Environmentalists	☹	?
Riparian vegetation	Agricultural uses, mines, inhabitaints (firewood)	Environmentalists	☹ (↑)	?
Fish population decrease	Siltation Accidental pollutions (Wapadskloof, 10 years ago)	Environmentalists Fishermen	☹	?
Wetlands disappearing	Farmers, mines (exploratory drilling)	Environmentalists	☹	RAMSAR site

Table 23 : Conflicts and their treatment

Conflict level:
- ☹ : problem mentioned by users ;
- ☹☹ : denunciation from users to DWAF ;
- ☹☹☹ : court case

4.4.3 Geographical representation of water pollutions information

The table 24 summarizes all the pollution problems mentioned in reports or in interviews, those information have been represented on the figures 1 : pollution problems mentioned in reports, and figure 2: pollution problems mentioned in interviews.

The difference between the two maps illustrates the need for more analysis and debate concerning pollution problems in the basin.

	(DWAF, 1991)	(DWAF, 1999)	(DWAF, 2000)	Interviews commercial farmers	Interviews DWAF	Interviews municipalities	Interviews villages	Interviews mines
Mines	Detrimental effects on water quality	Possible trace metals, micro pollutants, mineralisation of surface water , possible accidental spillage : acids, minerals, iron, manganese, molybdenum, zinc, sodium, chloride	TDS (middle Steelpoort, Klein, Groot Dwars) Sodium, Chloride (Lower Steelpoort)	Vantech platinum pollution Wapadskloof pollution "you can't even touch the soil" "killed all the fishes 10 years ago" Tubate : chrome 6 pollution Acid in air, corrosion (central Steelpoort) silt	Silt, nitrates (quarries) Sulfate, low pH, heavy metals (coal mines) Possible pb with chrome mine High metal concentration in groundwater near Mopetse (attributed by mines to geological formation) Vantech pollution	Accidental pollution at Wapadskloof	Conflict and court case with Vantech mine Polluted dusts contaminate water Pollution has lead to death of young calves Sick patient in the village	Platinum : may induce sulfate and nitrates high levels Vantech pollution plume, contaminated groundwater Possible Chrome 6 pb Tubatse : SO2/SO3 Coal mines : acidic conditions, iron, fluoride, manganese dissolving Possible nitrates, sulfuric acid, SO2, vanadium, iron
Agriculture	Turbid river at confluence with Olifants	TDS, possible nitrates, phosphates, possible organic wastes, pesticides, herbicides, algal growth	TDS (middle Steelpoort, Klein, Groot Dwars) Sodium, Chloride (Lower Steelpoort)			Nitrate growing		Nitrates
Domestic use / sewage plants		Suspended solids, faecal contamination, alkalinity, detergents, inorganic wastes (uncontrolled sewer treatment, livestock)			Ammonium, nitrates, phosphate, organics pollution Fecal choliform (cholera cases)	Bacterial contamination Sewage discharges, not enough capacity		
Rural settlements	High silt load (overgrazing)	Bacterial contamination of groundwater		Pollution	Nitrates (health effects on infants)			Nitrates
General comments	Steelpoort upstream Klip : acceptable Waterval, Spekboom : good quality Mining and agricultural activities have detrimental effects on water quality and TDS increase	**Water not always fit for use in lower Steelpoort : EC, chloride, sodium.** **No bacteriological data but bilharzias cases** **Groundwater, not potable** in middle steelpoort: sodium, chloride, nitrate/nitrite	Spekboom in a good state Ecological state of Steelpoort fair to unacceptable		Salts, chloride, Nitrates, Ammonia, algae developement			

Table 24 : pollution problems mentioned in DWAF reports and during interviews

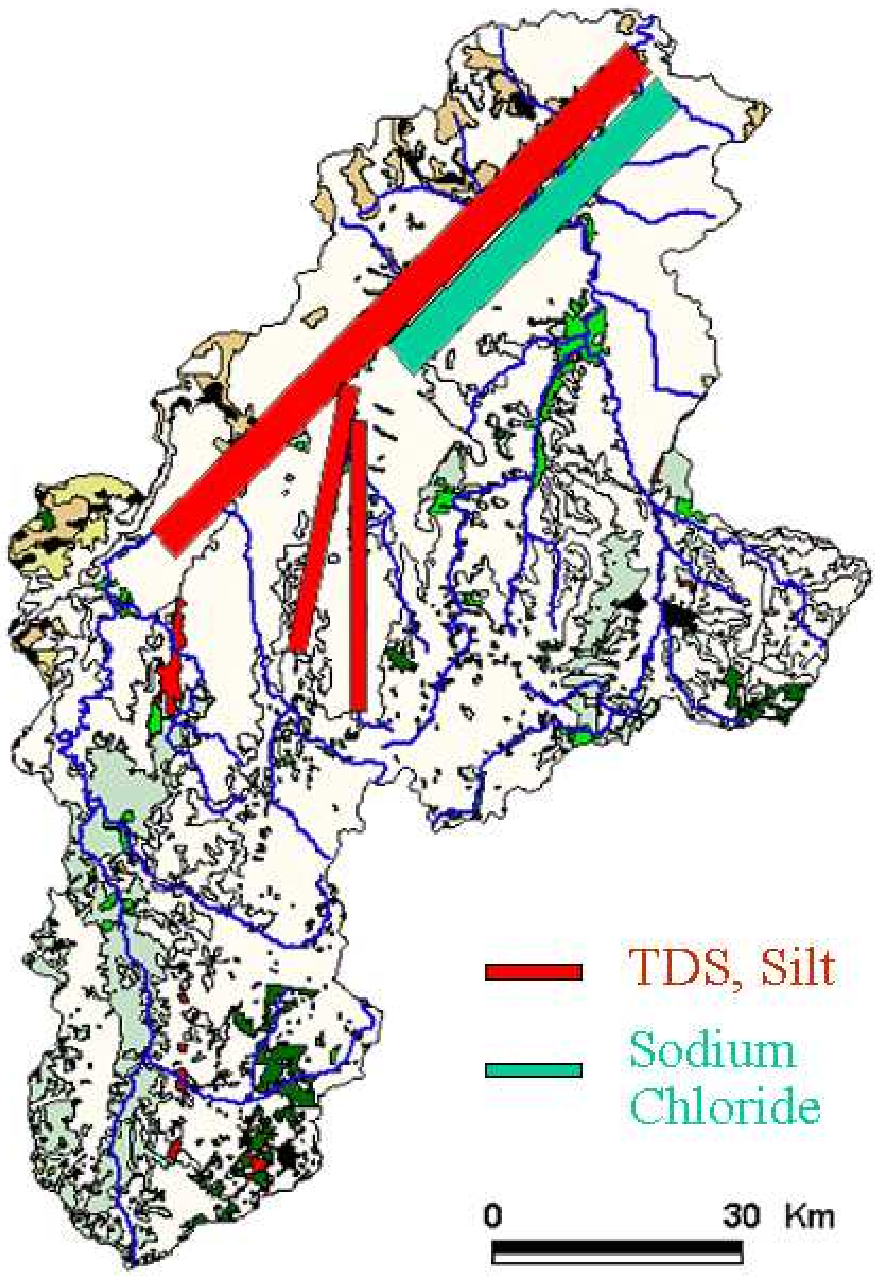

Figure 25: pollution problems mentioned in DWAF reports

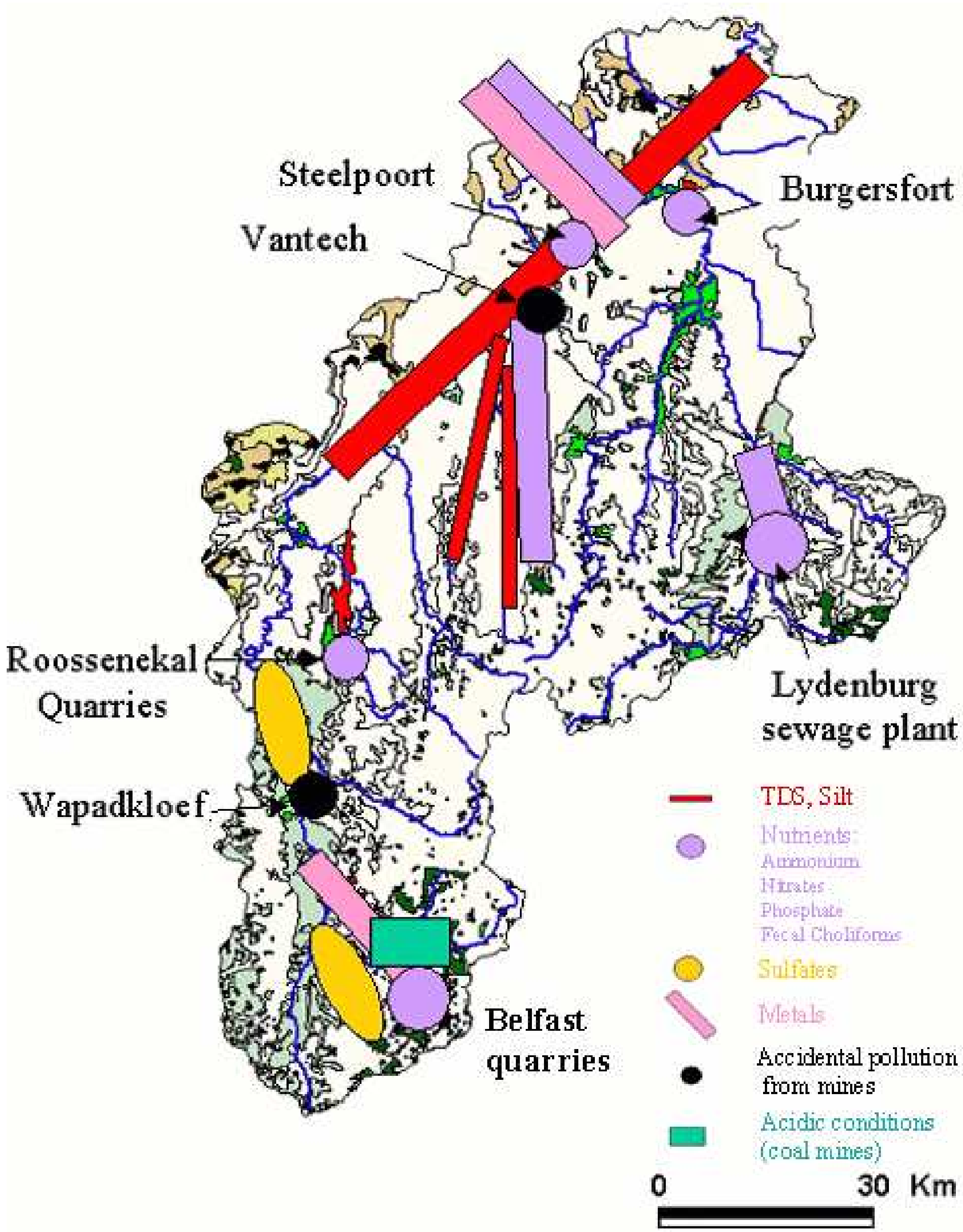

Figure 26: Pollution problems mentioned in interviews

4.4.4 Points of view divergences that might get worse

We present below main stakes related to water resource for each stakeholders group, available information sources, tensions, conflicts and alliances mentioned (cf table 25).

Stakes are being discussed and completed by confrontation to the state of knowledge coming from published information presented before.

Actors groups	**Stakes**	**Information**	**Lack of information**	**Tensions, Conflicts / *alliances***
Villagers, small scale farmers	Access to drinkable water and irrigation water, now	Availability : no water in the rivers. Quality : soapy and sandy water, salty taste. Diseases : Diarrhea, Cholera. Dt of Health, DWAF : use Jik to purify the water.	Pollution Infrastructure development	Court case with mines about pollution Tensions between Chief and municipalities Tensions with TLC about lack of infrastructures
Commercial Farmers	Irrigation water in the future (need for a dam)	Decreasing level of rivers Soapy and sandy water Localized pollutions Dead fishes	Development of new mines Groundwater and surface water pollution	Court cases with mines about abstraction and pollution Tensions about illegal abstraction of other farmers
Mines	Water rights for future developments Pollution containment	Local quality analyses	Groundwater, diffusion of pollution sources	*Water supply to communities, chief, Equipment to use Ferrochrome slags*
Municipalities	Water supply : lack of funds, water resource (need for a dam) Sewage upgrade : lack if funds	Local quality analyses		
DWAF	Abstraction control Pollution control Project planning (Dams) CMA		Rivers flow measures : lack of data, lack of man power for abstraction control Lack of data and man power for pollution control Lack of info about future needs of mines, population growth	Tensions with municipalities about transferring infrastructures Tensions/conflicts about illegal abstraction and pollution (Trout industry, Mines, commercial farmers)
Environmentalists	Conservation Involving private sector	Biomonitoring programs	Lack of man power to gather and treat information (database) Lack of study about toxicity, heavy metals	Tensions with commercial farmers, trout industry about wetlands *Create a reserve with mines and commercial farmers*

Table 25: Tensions, conflicts and alliances mentioned by stakeholders

The main stakes that were reported about water management in the catchment concern :

- resource availability and infrastructures development
- pollution control,
- access to information,
- management system : abstraction and pollution control,
- environment.

4.4.4.1 Resource availability and infrastructures development

Resource availability problems are the most important in rural areas where people have no access to water for domestic and irrigation purposes and important infrastructures will have to be developed.

We saw that the storage capacity of the basin will have to be increased. If everyone agrees about the need of infrastructure development, nobody knows really who will finance and who will be in charge of it. Such questions were asked by municipalities, people in villages, and DWAF officers.

Following interviews results, the building of a dam in central Steelpoort seems to be a solution for farmers and municipalities. If environmentalists point out the negative impacts of a dam, they also agree it would perhaps be the sole solution for implementing the reserve : ensure base lows and releases to meet environmental needs. This dam would be beneficial for rural water supply and agriculture. Mines are said to be autonomous with the Lebalelo water transferred from Olifants.

Various DWAF reports arguments show uncertainties concerning the potential beneficiaries and financing sources of a future dam :

In 1991[38], *"the building of a dam on Steelpoort is envisaged to face high demands for* ***irrigation*** *in central Steelpoort* ***and settlements' needs****."*

Dams options were evaluated in 1999[39] to *"at least assure supply water to users who cannot tolerate shortfalls, like* ***industrial and domestic users".*** *"Behaviour of the system is very sensitive to* ***IFR releases*** *to be made"* and *"dam will benefit to the whole community including* ***social and ecological environment."***

According to the National Strategy[40], *"Further resource development through the construction of new infrastructure will be very expensive and* ***unlikely to be affordable for irrigation****. Water for irrigation as a means to rural development and poverty relief will therefore have to be sourced largely through reallocation from existing users." "Deficits are apparent in the catchment. This is attributable to the provision for ecological component of the Reserve, prior to which the system could be regarded as in balance." "Water therefore needs to be freed up through compulsory licensing and supporting measures as water demand management, to meet ecological requirements." "****Water for new mining development*** *can be provided from the raising of Flag Boshielo dam, construction of a dam on Steelpoort or from the proposed Rooiport dam."*

If every one agree there is a need for storage capacity increase for all the sectors : irrigation, domestic water supply, ecological requirements and mining industry, only the mining sector will afford the financing of a new dam. Irrigation is said to be found through reallocation of

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[38] (DWAF, 1991)

[39] (DWAF, 1999)

[40] (DWAF, 2002)

water rights[41] as in reality, those reallocation are currently happening from agriculture to mining sector, and ecological requirements should be met through water demand management.

Arguments developed during the last ten years show the need for an open debate about different development strategies and their financing in the basin.

4.4.4.2 Pollution

Pollution issues deal with :

- accidental pollution containment. The current solution to this problem is water abstraction to prevent the pollutants diffusion.
- upgrade of sewage plants,
- lack of information about pollution states, their causes and effects, particularly concerning underground water, considered as locally polluted but remaining the main source of drinking water, for people who can afford boreholes. Needs for more information about toxicity and heavy metals impacts have often been mentioned.

There is a need for improving existing systems and a better management and containment of pollution sources (from mining industry and domestic uses, in developed and disadvantaged areas) but also a need for the information system improvement.

4.4.4.3 Management : abstraction and pollution control

Management difficulties are often attributed to lack of resources :

- information system inadequate to manage river flows and quality
- lack of human resources for field controls and analysis,
- need for more studies concerning : toxicity, heavy metals.

Abstraction control is difficult today and the manager explains it could get worse in the near future. Next drought could lead to important shortages.

A pollution control network is being developed now but local teams are lacking of human resources and have to answer quickly to mines demands for license approval.

4.4.4.4 Environment

Environmental issues mentioned in the catchment are :

- biodiversity : *"There is a floristically unique area along Dwars river and in the Sekhukhune land. It is a center of endemism because of heavy metals present in the soils."* (E3)
- wetlands are an issue for environmentalists at Mpumalanga park board and also for DWAF, where a "Working for Wetlands" program is being developed. Verloren Vallei, located upstream Klipriver, as been declared a RAMSAR site.
- Aquatic ecosystem protection : biomonitoring is being done at Mpumalanga Park Boards along Steelpoort, Spekboom and Dwars rivers looking at fish populations, invertebrates and riparian vegetation.
- the Reserve implementation with the definition of rivers quality objectives with water users, base flows and releases. A research topic identified by Kruger Park consists in integrated rivers management or how to deal with dams operational rules to implement the Reserve (Cf. personal communication with F. Venter, rivers specialist, researcher at Kruger Park).

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[41] (DWAF, 2002)

Environmentalist try to involve the private sector in the creation of a reserve with mines and commercial farmers, along Dwars river. The main stakes is to protect biodiversity and fencing the reserve to prevent local people from making use of natural resources and cutting trees. **Here, environmental protection is conflicting with basic needs of the population.**

International needs and volumes to be reserved for the Mozambique have not been published at the Steelpoort basin level.

4.4.4.5 Potentially increasing tensions

Looking at water management in the basin shows difficulties in abstraction and pollution control, related to lack of resources at DWAF regional offices for both aspects.

The basin knows important current economical development with new mines that will increase the pressure on water resources. Solutions like the building of a new dam will not be efficient in the short term.

The ecological reserve implementation requires to keep important flows (total amount comprised between 35 and 75 million m^3 each year) in the rivers to meet environmental needs and leads also to increasing pressures on the resource.

Resource management will thus lead to limit water demands in coming years, and a reallocation phase is anticipated (compulsory licensing). But for this system to be acceptable on water users points of view, it will necessarily have to be based on clear estimations of the water demand and supply balance that would be comprehensible.

The problem of domestic water supply seems to be given high priority in a catchment with high economical disparity like the Steelpoort basin : how to supply drinkable water to the whole population.

4.4.5 Recommendations

The necessary redistribution to meet objectives enounced by law will be linked to multiple negotiations and tools can be provided to enhance the process :

- The monitoring system could be improved with flow measurements downstream main rivers in the catchment and would help understanding the basin functioning.
- Hypothesis underlying water demand and supply balance estimations could be clarified before starting the reallocation process :
    - Yield estimations,
    - Updated values concerning agricultural and industrial water demand, related uncertainties.
- Concerning pollutions sources, several information are available at DWAF, mining companies, environmentalists and universities. A common discussion about those information should allow for a better understanding of pollution problems, that are important since the main part of the population in relying upon surface water for their domestic use. This understanding could be a real negotiation tool at the basin level.

5 Conclusion

A diagnosis about water management in the Steelpoort basin is proposed looking more specially at water quality and pollution problems.

The agricultural sector is still the main water user, but the basin knows today important economical developments with the rapid implanting of new Platinum, Chromium and Vanadium mines.

An important part of the former Lebowa homeland population has still no access to potable water and is reliant on surface water for its domestic use. This population is also increasing because of current industrial developments.

The pressure on the resource is increasing but the study of the hydrology in the basin shows that the resources would be sufficient with a dam on the Steelpoort river, envisaged for about 10 years at DWAF.

Looking at the current management system and objectives concerning basic human needs and environmental needs shows that important means will be needed :

- infrastructure developments to increase the basin storage capacity and supply water in the former homeland area,
- implementation of a pollution control and management system, taking into account heavy metals concentrations and that would allow for a better understanding of underground water quality.

To become effective, expected changes in the management system will necessarily have to involve water users : common quality objectives definition and means to be made use of, resource reallocation, that are among the objectives of the future catchment management agencies.

Few negotiation places are to be seen at the moment concerning water management issues at the basin scale : the stress on the resource leads to local arrangements (mines buying farms), divergences lead to conflicts (court cases) and tensions could get worse with the current developments.

Alliances can be observed :

- mines join together with municipalities to define common development options, inside the Steelpoort Valley Producers Forum,
- environmentalists try to involve commercial farmers and mines in the definition of a protected reserve,

In this context of high pressure on the resource and as new environmental objectives are being defined, the study of local tensions and conflicts suggests the need for tools that would facilitate the dialogue : a common information system about available resources and their quality would enhance the dialogue between very different water users. Similarly, an open debate about development choices in the area and associated infrastructures would meet the users expectations but will be difficult to realize with the hard competition context between mines, who are the main actor of the development. Here, water management and the new law framework give effective means to choose development directions : water users license approval, water quality control, polluter–pays principle.

The study of dialogue processes occurring at a more local scale, the identification of involved actors will help understanding stakes related to the current changes : it will be interesting to study how water users will organize themselves during the next draught period and to question the real incentives of the law. For example, if given amount of water are defined in licenses to allow for a better sharing of the resource between farmers, no real measures are in place to ensure this sharing : volumes are not being measured and farmers do not seem to be ready to change.

In another context, in the former Lebowa area, tensions inside communities and between institutions (chief, municipalities) show a lack of organization in the sharing of the resource. But a more detailed analysis of the current changes in the basin would allow to propose real enhancement proposals.

References

Cousins, Ben (2002), "Reforming communal land tenure in South Africa – Why land titling is not the answer – critical comments on the Communal Land Rights Bill, 2002", Programme for Land and Agrarian Studies, School of Government, University of the Western Cape

DEAT(1999), "National state of the Environment Report, South Africa" http://www.environment.gov.za/soer/nsoer/issues/water/index.htm

DLA (2002), "Pushing back the frontiers of poverty through land reform and sustainable development" Department of Land Affairs

DWAF (1991),"Water resources planning of the Olifants river basin, study of development potential and management of the water resources" Basin Study Report, vol3, part 5, situation assessment : subcatchment B400, DWAF, 1991

DWAF (1995a), "Olifants-Sand Transfer Scheme Pre-feasibility study, Annex H : Water quality situtation assessment", Ninham Shand Inc for DWAF

DWAF (1995b), "A surface water quality assessment for the middle Steelpoort catchment", report B240/00/0000/REQ/1995, Institute for Water Quality Studies

DWAF (1996a), "A surface water quality assessment for the middle Steelpoort catchment", IWQS-DWAF, Report No B240/00/0000/REQ/1995

DWAF (1996b), South African Water Quality Guidelines (second edition), Volume 1 : Domestic water use, Volume 2 : Recreational water use, Volume 3 : Industrial water use, Volume 4 : Agricultural water use (irrgation), Volume 5 : Agricultural water use (Livestock watering), Volume 6 : Agricultural use (Aquaculture), Volume 7 : Aquatic ecosystems

DWAF (1998), "National Water Act, 1998", Act No 36, 1998

DWAF (01/1999a), Prefeasibility Study on Bulk water supply in the Middle Olifants and Steelpoort River area, Demographics, DWAF-Consultburo

DWAF (01/1999b), Prefeasibility Study on Bulk water supply in the Middle Olifants and Steelpoort River area, Hydrology of the Steelpoort river Catchment, DWAF-Consultburo

DWAF (01/1999c), Prefeasibility Study on Bulk water supply in the Middle Olifants and Steelpoort River area, Water Quality, DWAF-Consultburo

DWAF (07/2000) "Proposal for the Establishment of a Catchment Management Agency for the Olifants Water Management Area : Appendix A : Technical Situation Assessment, first Draft, July 2000", DWAF Mpumalanga

DWAF (12/2000) "Water use authorisation process for individual applications" DWAF, Edition 1 final draft fro implementation and use, revision 3, December 2000.

DWAF (03/2002), "Olifants river ecological water requirements assessment- Ecological reserve report", BKS ACRES, draft paper

DWAF (08/2002) "National Water Resource Strategy", Proposed first edition, DWAF, August 2002

IWMI WP1 (1999), "Rural women's association : an assessment of the success factors and sustainability"

IWMI WP2 (1999), "Land tenure on the arabie-olifants irrigation scheme"

IWMI WP17 (2001), " Hydro-Institutional mapping in the Steelpoort River Basin, South Africa"

Jewitt, G (2001), "Can integrated water resource management sustain the provision of ecosystem goods and services ?" School of Bioresources Engineering and Environmental Hydrology, University of Natal, South Africa

Leroy, M (2001) "Enseignement à la négociation, M.Sc. DAT : UV 104", CNEARC

MPS (07/2002) "Sekhukhune Mining Corridor, Draft spatial plan", compiled by Maxim Planning Solutions, June 2002

Mermet L. (1998) "Place et conduite de la négociation dans les processus de decision complexes : l'exemple d'un conflit d'environnement", La négociation, Situations et problématiques. Connaître et pratiquer la gestion. Nathan.

Perret S, (2001) "New water policy, irrigation management transfer and smallholding irrigation schemes in South Africa : institutional challenges" FAO Conference on irrigation management transfer, Sept 2001

REPUBLIC OF SOUTH AFRICA - National Water Act – Act No 36 of 1998

Rouzère, H (2001) "Les agencies de bassin en Afrique du Sud, Composantes de la négociation dans le cas de l'Olifants River », Mémoire ENGEES, Septembre 2001

Samancor, (2002), "Environmental management program report, Samancor Tubatse Mines, Numine project", Eko Rehab, August 2002

Schreiner B., Van Koppen B., " Catchment Management Agencies for poverty eradication in South Africa", DWAF-IWMI

Steelpoort Valley Producer Forum (2002), "Working group report N°2, February 2002"

WITS, www.mining.wits.ac.za/FinalReport-ToContents, "Mining and mineral processing activities impacts on water resources"

WRC, (1994) "Surface water resources of South Africa, 1990", WRC report No 298/11/94

WRC, (1999) "Lethal and Sublethal effects of Metals on the Physiology of Fish : an experimental approach with monitoring support" Department of Zoology, Rand Afrikaans University WRC Report No 608/1/99

WRC, (2000) "Environmental Flow Assessments for Rivers : manual for the building block methodology", King JM, Tharme RE, De Villiers MS, Freshwater Research Unit, University of Cape Town, July 2000

WRC, (2001) "State of the Rivers Report, Crocodile, Sabie-Sand & Olifants River Systems", River Health Programme, WRC report No TT 147/01, 03/2001

Annexes

Annex 1: Farmers questionnaire

Agriculture

Name :

Address :
phone :

Productions, surfaces :
Cultural density :
Number of persons working on the farm / irrigation scheme :
Marketing :
Fertilization :
Soils :
Major constraints :
Other incomes :

Water use

- What are the water uses ? / What are the current resources for each use ? Quantities

Irrigation : (resource, quantity)
Livestock, Game : (resource, quantity)
Afforestation, Rainfed surfaces :
Domestic consumption : (resource, quantity)
Infrastructure and equipments :
(history of the development of water infrastructure, management and water use)

- pumps, canals
- storage
- distribution
- irrigation equipments
- drainage

Hydro system :

- water course flows and their evolutions
- groundwater localization

Concerns about water

- What are the water problems in the region ? Are there quantity or quality problems in the region ? What changes have taken place over time ? When were the problems first noticed ?

- What are the reasons and origins of those problems ?
- What are the information sources to evaluate the problems and their origin ?
- What are the indicators used ?
- What are the related consequences and the importance of those problems ? (health effects, effects on crops, livestock, impacts on the environment …)
- What are you doing about those problems ? what are others doing about it ? Are state institutions dealing with those problems ?
- What are the water quality requirements for each kind of water use ?
- What are the impacts of the activity on the water quality ? (short term / long term)

Organization and institutions

What are the institutions concerned in water management ? what are the relationships and interactions with those institutions ? (history)

Water distribution and operation of water schemes :

Maintenance of water schemes :

Modification of existing schemes and development of new schemes :

Measures against floods and erosion :

Measures against pollution :

Are there links with other water users ? Are there any water user associations in the area ? Are you involved in a water user association ? Do you intend to be a member ?

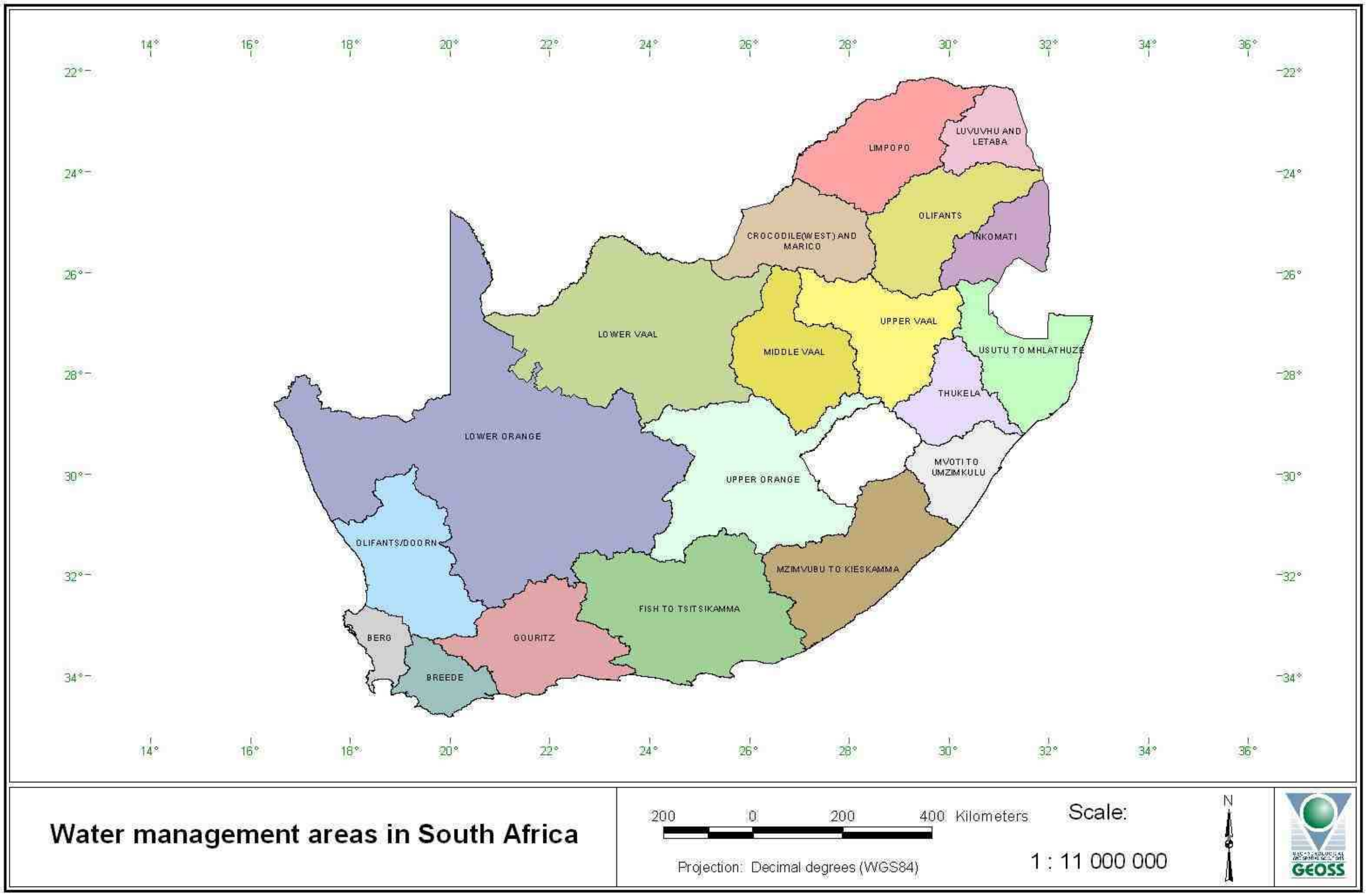
Are you aware of the legislation about water management and the CMAs establishment ? Have you been involved in the process ? (information, meetings ….)

What are the expectation on future management of the sub-basin (information needed, organization, at what scale ?)

Future

Plans and objectives for the future ? (short / long term)

Annex 2: Water Management Areas



Annex 3: Irrigation, the main water user

Source : (DWAF, 01/1999b)

Estimations of the demand for irrigation were made taking into account 60% water losses due to poor earth canal water transfers. Irrigated areas were scaled up with a factor of 2,5, to compensate water losses. Earth canals return flows were estimated at 30% of the losses, or 20% of the total supply.

Demand and supply figures were calculated for all the land use data from 1920 to 1995 and are average annual totals.

Irrigation demand can be estimated with the following formula :

$$Id = Area * [f*Eo - r*Ro] /1000$$

With :

Id irrigation demand (million m3)
Area total irrigation area of a given year (km2)
f crop factor, weighed if more than one type of crop is irrigated in each month
Eo mean monthly A-pan evaporation for specific month (mm)
r effective rainfall factor for a specific month
Ro monthly rainfall (mm)

Crop factors for the quaternary sub-catchments are included in Annexure . The effective rainfall factor was agreed upon as 0,7.

For calibration purposes, a historical growth pattern for irrigated areas had to be calculated.

Catchment	**Area (km2)**				
	1960	**1970**	**1980**	**1990**	**1995**
B41B	1,01	1,41	12,48	6,83	4
B41C	0,96	1,33	3,84	7,5	7,4
B41G	9,35	19,69	20,32	22,82	26,39
B41H	5,24	10,34	13,72	11,98	11,98
B41J	4,93	7,61	20,06	11,27	11,27
B41K	12,83	19,82	26,33	29,35	29,35
B42F	10,04	15,93	19,32	20,05	20,05
B42G	11,05	17,54	21,28	22,07	22,07
B42H	20,62	32,73	39,71	44,70	53,47
B42E	32,15	35,73	39,87	41,89	45,04
Total	**108,18**	**162,13**	**216,93**	**218,46**	**231,02**

Catchment	Catchment name	Irrigation board	Abstraction point	Irrigation Area * 2,5 (km2)	Gross demand	shortages	Gross supply	Field edge demand	Field edge supply	60% losses	20% return flows
B41B	Stoffberg-Dullstroom	Laersdrift	Weir in Witpoortje	4	1,29	0,13	1,16	0,516	0,464 (1,16-0,696)	0,696	0,232
B41C	Roossenekal	Mapochsgronde	Tondeldoos dam	4,81	1,59	0,41	1,18	0,636	0,472	0,708	0,236
			Vlugkraal dam	2,59	0,86	0,21	0,65	0,344	0,26	0,39	0,13
B41G	Dwars river	Small Dwars	Jounie dam		1,6	0	1,6	0,64	0,64	0,96	0,32
			Der Brochen dam	16,04	5,86	0,11	5,75	2,344	2,3	3,45	1,15
			ROR Dwars	1,25	0,53	0,22	0,31	0,212	0,124	0,186	0,062
			ROR DWARS	5,35	1,95	0,49	1,46	0,78	0,584	0,876	0,292
B41H	Middle Steelpoort	Great Dwars	ROR Steelpoort	9,17	5,56	0,07	5,49	2,224	2,196	3,294	1,098
			Small dams	2,82	1,71	0,02	1,69	0,684	0,676	1,014	0,338
B41J	Steelpoort	Central Steelpoort	ROR Steelpoort	1,69	1,19	0,01	1,18	0,476	0,472	0,708	0,236
			ROR Steelpoort	6,76	4,74	0,67	4,07	1,896	1,628	2,442	0,814
			ROR Steelpoort	2,82	1,98	0,32	1,66	0,792	0,664	0,996	0,332
B41K	Lower Steelpoort	Tswelopele	Small dams	25,35	5,94	0,59	5,35	2,376	2,14	3,21	1,07
			ROR Steelpoort	4	0,94	0,08	0,86	0,376	0,344	0,516	0,172
Total B41				**90,4**	**3,574**	**3,33**	**32,41**	**14,29**	**12,96**	**19,45**	**6,48**

Catchment	Catchment name	Irrigation board	Abstraction point	Irrigation Area * 2,5 (km2)	Gross demand	shortages	Gross supply	Field edge demand	Field edge supply	60% losses	20% return flows
B42E	Middle Spekboom	Spekboom	ROR Spekboom	28,4	13,45	0,97	12,48	5,38	4,992	7,488	2,496
		Lower Spekboom		16,6	7,86	1,62	6,24	3,144	2,496	3,744	1,248
B42F	Upper Watervals	Watervals river ward 2	ROR Watervals	20,05	10,61	0,83	9,78	4,244	3,912	5,868	1,956
			Buffelskloof dam (B42G)	19,87	10,78	2,38	8,4	4,312	3,36	5,04	1,68
			Buffelskloof dam (B42H)	13,24	6,09	1,33	4,76	2,436	1,904	2,856	0,952
B42G	Lower Watervals	Watervals river ward 1	ROR Watervals	2,21	1,27	0,05	1,22	0,508	0,488	0,732	0,244
B42H	Lower Spekboom	Lower Spekboom	ROR Watervals	18,82	10,04	2,79	7,25	4,016	2,9	4,35	1,45
		Watervals river ward 1	ROR Spekboom	21,4	11,42	4,47	6,95	4,568	2,78	4,17	1,39
Total B42				**140,59**	**71,52**	**14,44**	**57,08**	**28,61**	**22,83**	**34,25**	**11,42**
Total B4				**230,98**	**107,26**	**17,77**	**89,49**	**42,9**	**35,79**	**53,7**	**17,9**

Table 6 : Water use by irrigation in the Steelpoort catchment averaged over 1920 to 1995, (million m3/a)(DWAF, 01/99)

ROR : Run-off river

Water usage by afforestation

Forests impact negatively on the hydrology of the catchment due to interception and evapotranspiration.

Afforestation is located in the 5 upper quaternary subcatchments. Commercial forestry areas mainly developed between 1970s and 1990s.

	Growth in afforestation areas (km2)									
	1920	1930	1940	1950	1960	1970	1980	1990	1993	1997
B41A	2,52	3,48	3,55	3,52	7,52	25,89	31,79	41,81	41,05	41,05
B41B	0	0	0	0	0	0,09	0,25	0,27	0,27	0,27
B42A	0	0	0	0	0	0,93	2,48	3,64	2,62	2,62
B42B	0	0	0	0	0	11,82	31,45	33,51	33,25	33,25
B42C	0	0	0	0	0	0,19	0,52	0,56	0,56	0,56
Total	**2,52**	**3,48**	**3,55**	**3,52**	**7,52**	**38,94**	**66,51**	**78,80**	**77,76**	**77,76**

Table : Growth pattern and current afforestation data (DWAF, 01/1999b)

Subcatchment	**Area (km2)**	**Afforestation demand (million m3/a)**
B41A	41,05	2,12
B41B	0,27	0,03
B42A	2,63	0,27
B42B	33,26	4,11
B42C	0,56	0,05
Total	**77,77**	**6,58**

Table 7 : Water usage by afforestation (DWAF, 01/1999b)

Mining and domestic water demands

Catchment		Mine	Demand	Total mine demand	Domestic abstraction	Domestic demand	Total
B41A	Belfast	Transvaal Alloys	0,165		Belfast dam		
		Cam Alloys *	0,73			0,84	1.005
B41C	Roossenekal	Mapochs mine	0,55	0,55	Mapochs mine borehole	0,06	0,61
B41H	Middle Steelpoort	Vansa Vanadium	0,4				
		Tweefontein chrome mine	0,064	0,464			0,464
B41J	Steelpoort	Winterveld chrome mine	4,896	4,896			4,896
B42B	Sterkspruit				PTC Du Plessis	3,285	3,285
B42C	Rest of Dorps river	CMI *	1,642				
B42D	Upper Spekboom	Rooival Gold mine	0,006				
		P&G development	0,006	0,012			0,012
B42E	Middle SPekboom	Cullinan Holdings	0,6	0,6			0,6
Total				**6,687**		**4,125**	**10,812**

** included in domestic demands*

Table 8 : Mining and domestic water demand by subcatchment (DWAF 01/1999b)

One of the objectives of the simulation was to compare natural run-off values with the present day conditions values, and simulated natural stream flows were used to represent natural hydrology.

The results, presented in the following table, indicate that the Steelpoort subcatchment (B41) has approximately 10% reduction in runoff as a result of development, while the Spekboom subcatchment (B42) experiences a difference in run-off between natural and present day conditions in the order of 30%.

Annex 4 : Weighed crop factors for irrigation areas

Source : (DWAF, 01/1999b)

BK41B		**Monthly crop factors**											
	Area factor	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Maize	0,50	0,51	0,91	1,10	0,97	1,09	0,95	0,25	0,00	0,00	0,00	0,00	0,00
Beans	0,30	0,65	0,47	0,00	0,17	0,50	0,70	0,70	0,00	0,00	0,00	0,00	0,35
Peas	0,20	0,30	0,00	0,00	0,00	0,00	0,00	0,00	0,16	0,30	0,45	0,66	0,67
Weighed crop factors		0,51	0,60	0,55	0,54	0,70	0,69	0,15	0,03	0,06	0,09	0,13	0,24

BK41C		**Monthly crop factors**											
	Area factor	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Maize	0,50	0,51	0,91	1,10	0,97	1,09	0,95	0,25	0,00	0,00	0,00	0,00	0,00
Beans	0,30	0,65	0,47	0,00	0,17	0,50	0,70	0,70	0,00	0,00	0,00	0,00	0,35
Peas	0,20	0,30	0,00	0,00	0,00	0,00	0,00	0,00	0,16	0,30	0,45	0,66	0,67
Weighed crop factors		0,51	0,60	0,55	0,54	0,70	0,69	0,15	0,03	0,06	0,09	0,13	0,24

BK41G		Monthly crop factors											
	Area factor	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Wheat	0,25	0,38	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,30	0,57	0,97	0,97
Sweat potatoes	0,07	0,00	0,00	0,00	0,00	0,00	0,29	0,70	0,99	1,20	0,30	0,00	0,00
Tomatoes	0,04	0,39	0,67	0,70	0,56	0,53	0,70	0,70	0,52	0,00	0,00	0,00	0,30
Maize	0,18	0,51	0,91	1, 10	0,97	1,09	0,95	0,25	0,00	0,00	0,00	0,00	0,00
Soya beans	0,06	0,00	0,00	0,35	0,75	0,94	0,95	0,43	0,00	0,00	0,00	0,00	0,00
Sugar beans	0,06	0,65	0,47	0,00	0,17	0,50	0,70	0,09	0,00	0,00	0,00	0,00	0,35
Lucern	0,35	0,70	0,80	0,80	0,80	0,80	0,80	0,70	0,60	0,50	0,50	0,50	0,60
Weighed crop factors		0,48	0,50	0,52	0,53	0,58	0,59	0,39	0,30	0,33	0,34	0,41	0,48

BK41H		Monthly crop factors											
	Area factor	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Wheat	0,25	0,38	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,30	0,57	0,97	0,97
Sweat potatoes	0,06	0,00	0,00	0,00	0,00	0,00	0,29	0,70	0,99	1,20	0,30	0,00	0,00
Tomatoes	0,03	0,39	0,67	0,70	0,56	0,53	0,70	0,70	0,52	0,00	0,00	0,00	0,30
Cotton	0,04	0,01	0,30	0,48	0,79	0,82	0,60	0,28	0,00	0,00	0,00	0,00	0,00
Beans	0,04	0,65	0,47	0,00	0,17	0,50	0,70	0,09	0,00	0,00	0,00	0,00	0,35
Lucern	0,55	0,70	0,80	0,80	0,80	0,80	0,80	0,70	0,60	0,50	0,50	0,50	0,60
Citrus	0,03	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67
Weighed crop factors		0,54	0,51	0,50	0,52	0,53	0,55	0,48	0,42	0,44	0,46	0,54	0,61

BK41J		Monthly crop factors											
	Area factor	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Wheat	0,09	0,38	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,30	0,57	0,97	0,97
Cotton	0,09	0,01	0,30	0,48	0,79	0,82	0,60	0,28	0,00	0,00	0,00	0,00	0,00
Beans	0,09	0,65	0,47	0,00	0,17	0,50	0,70	0,09	0,00	0,00	0,00	0,00	0,35
Lucern	0,63	0,70	0,80	0,80	0,80	0,80	0,80	0,70	0,60	0,50	0,50	0,50	0,60
Citrus	0,07	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67
Weighed crop factors		0,58	0,62	0,59	0,64	0,67	0,67	0,52	0,42	0,39	0,41	0,45	0,54

BK41K		Monthly crop factors											
	Area factor	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Wheat	0,20	0,38	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,30	0,57	0,97	0,97
Cotton	0,79	0,01	0,30	0,48	0,79	0,82	0,60	0,28	0,00	0,00	0,00	0,00	0,00
Lucern	0,01	0,70	0,80	0,80	0,80	0,80	0,80	0,70	0,60	0,50	0,50	0,50	0,60
Weighed crop factors		0,09	0,25	0,39	0,63	0,66	0,48	0,23	0,01	0,06	0,12	0,20	0,20

BK42E		Monthly crop factors											
	Area factor	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Wheat	0,21	0,38	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,30	0,57	0,97	0,97
Maize	0,15	0,51	0,91	1,10	0,97	1,09	0,95	0,25	0,00	0,00	0,00	0,00	0,00
Vegetables	0,03	0,00	0,00	0,00	0,00	0,00	0,29	0,70	0,99	1,20	0,30	0,00	0,00
Cotton	0,18	0,01	0,30	0,48	0,79	0,82	0,60	0,28	0,00	0,00	0,00	0,00	0,00
Dry beans	0,03	0,65	0,47	0,00	0,17	0,50	0,70	0,09	0,00	0,00	0,00	0,00	0,35
Lucern	0,20	0,70	0,80	0,80	0,80	0,80	0,80	0,70	0,60	0,50	0,50	0,50	0,60
Citrus	0,20	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67
Weighed crop factors		0,45	0,50	0,55	0,59	0,62	0,57	0,39	0,28	0,33	0,36	0,44	0,47

BK42F		Monthly crop factors											
	Area factor	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Wheat	0,21	0,38	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,30	0,57	0,97	0,97
Maize	0,13	0,51	0,91	1,10	0,97	1,09	0,95	0,25	0,00	0,00	0,00	0,00	0,00
Cotton	0,04	0,01	0,30	0,48	0,79	0,82	0,60	0,28	0,00	0,00	0,00	0,00	0,00
Vegetables	0,03	0,00	0,00	0,00	0,00	0,00	0,29	0,70	0,99	1,20	0,30	0,00	0,00
Other	0,01	0,39	0,67	0,70	0,56	0,53	0,70	0,70	0,52	0,00	0,00	0,00	0,30
Lucern	0,06	0,70	0,80	0,80	0,80	0,80	0,80	0,70	0,60	0,50	0,50	0,50	0,60
Citrus	0,52	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67
Weighed crop factors		0,54	0,53	0,56	0,56	0,57	0,56	0,46	0,42	0,48	0,51	0,58	0,59

BK42G		Monthly crop factors											
	Area factor	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Wheat	0,21	0,38	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,30	0,57	0,97	0,97
Maize	0,13	0,51	0,91	1,10	0,97	1,09	0,95	0,25	0,00	0,00	0,00	0,00	0,00
Cotton	0,04	0,01	0,30	0,48	0,79	0,82	0,60	0,28	0,00	0,00	0,00	0,00	0,00
Vegetables	0,03	0,00	0,00	0,00	0,00	0,00	0,29	0,70	0,99	1,20	0,30	0,00	0,00
Other	0,01	0,39	0,67	0,70	0,56	0,53	0,70	0,70	0,52	0,00	0,00	0,00	0,30
Lucern	0,52	0,70	0,80	0,80	0,80	0,80	0,80	0,70	0,60	0,50	0,50	0,50	0,60
Citrus	0,06	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67
Weighed crop factors		0,55	0,59	0,62	0,62	0,63	0,62	0,48	0,39	0,40	0,43	0,50	0,56

BK42H		Monthly crop factors											
	Area factor	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Wheat	0,21	0,38	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,30	0,57	0,97	0,97
Maize	0,14	0,51	0,91	1,10	0,97	1,09	0,95	0,25	0,00	0,00	0,00	0,00	0,00
Cotton	0,14	0,01	0,30	0,48	0,79	0,82	0,60	0,28	0,00	0,00	0,00	0,00	0,00
Vegetables	0,03	0,00	0,00	0,00	0,00	0,00	0,29	0,70	0,99	1,20	0,30	0,00	0,00
Dry beans	0,02	0,65	0,47	0,00	0,17	0,50	0,70	0,09	0,00	0,00	0,00	0,00	0,35
Lucern	0,16	0,70	0,80	0,80	0,80	0,80	0,80	0,70	0,60	0,50	0,50	0,50	0,60
Citrus	0,29	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67
Weighed crop factors		0,47	0,51	0,55	0,58	0,61	0,57	0,41	0,32	0,37	0,40	0,48	0,50

Annex 5 : Balancing water demand and supply for one subcatchment (B41J)

Irrigation demand can be estimated with the following formula (DWAF, 01/1999b):

Id = Area * [f*Eo – r*Ro] /1000

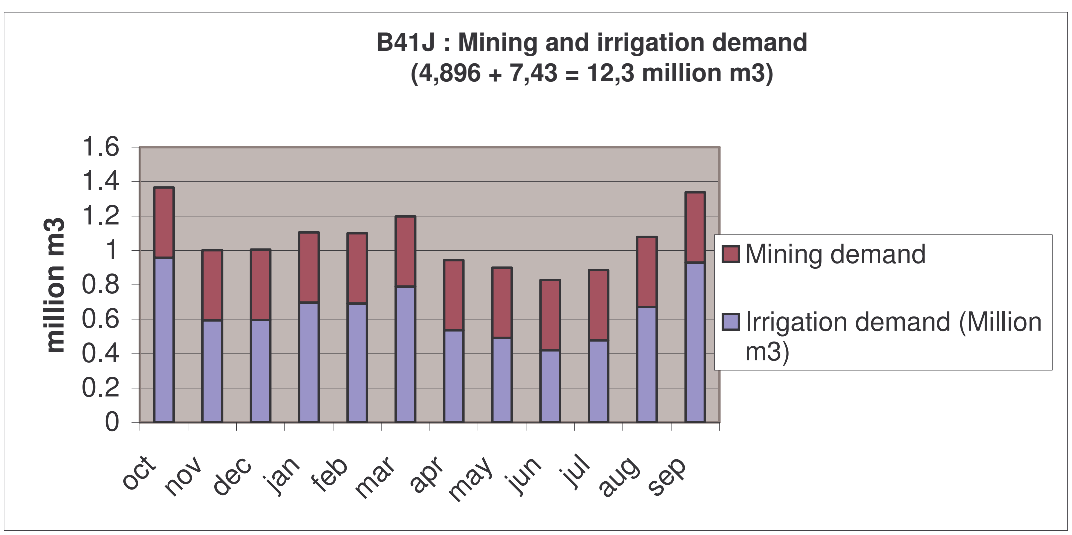
With :

Id irrigation demand (million m3)
Area total irrigation area of a given year (km2)
f crop factor, weighed if more than one type of crop is irrigated in each month
Eo mean monthly A-pan evaporation for specific month (mm)
r effective rainfall factor for a specific month
Ro monthly rainfall (mm)

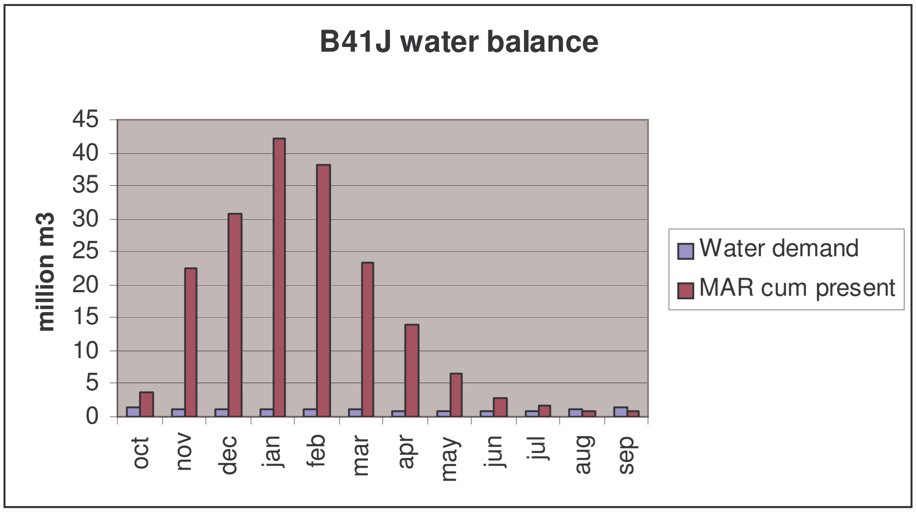
B41J irrigated area : 11,27km2,

Irrigation modules : RR5, RR6, RR7 abstracting in Steelpoort river

BK41J		**Monthly crop factors**											
	Area factor	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Wheat	0,09	0,38	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,30	0,57	0,97	0,97
Cotton	0,09	0,01	0,30	0,48	0,79	0,82	0,60	0,28	0,00	0,00	0,00	0,00	0,00
Beans	0,09	0,65	0,47	0,00	0,17	0,50	0,70	0,09	0,00	0,00	0,00	0,00	0,35
Lucern	0,63	0,70	0,80	0,80	0,80	0,80	0,80	0,70	0,60	0,50	0,50	0,50	0,60
Citrus	0,07	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67
Weighed crop factors		0,58	0,62	0,59	0,64	0,67	0,67	0,52	0,42	0,39	0,41	0,45	0,54



Evaluating water balance by comparing demand with present day MAR for the subcatchment, shortages are estimated to 0,74 million m3, occurring in August and September.



B41J water balance
million m3
45
40
35
30
25
20
15
10
5
0
oct
nov
dec
jan
feb
mar
apr
may
jun
jul
aug
sep
Water demand
MAR cum present

Annex 6: DWAF registration process information

(Source : personal communication with Brian Jackson, DWAF)

The registration process is currently on-going at DWAF, Nelspruit. Data presented here have not been checked yet. The verification process has not begun at the moment, and DWAF is preparing a verification methodology (using satellite images and other tools). Therefore, following data must not be used.

Water User SECTOR	Number_users	TAKING_VOLUME (m3)	STORING_VOLUME (m3)	AFFORESTATION AREA
Mining and industry	57	35 100 294	2 737 539	42
Agriculture	408	98 808 013	8 677 458	244
Forestry	85	1 184 537	1 523 447	7 211
Individual	45	77 800	489 209	0
Schedule 1	130	0	0	0
Recreation	6	0	188 850	0
Tourism	6	1 470	197 044	0
Water Services Provider	3	6 854 863	11 022 701	0
Aquaculture	43	29 723 887	2 076 983	59
Company	18	0	11 501 916	0
Domestic	6	947 850	93 320	1
Sum	**807**	**172 698 714**	**38 508 467**	**7 557**

Volumes indicated here concern both surface and groundwater.

For the agricultural sector, users are either irrigation boards, individual farmers or mining companies when they own the land.

Volumes registered for the irrigation boards:

Irrigation boards	**Volumes (million m3)**	**Volumes BKS (DWAF, 01/1999b)**
Watervals river	17	31,11
Groot Dwars river	7	7,18
Laer Spekboom	13,2	13,49
Central Steelpoort	4,2	6,91
Laersdrift		1,16
Mapochsgronde		1,83
Small Dwars		9,12
Tswelopele		6,21
Spekboom		12,48
Total	**41,4**	**89,49**