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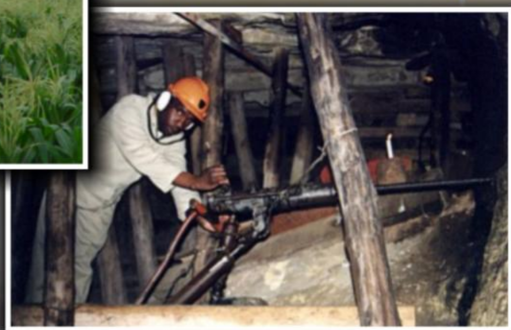
Vaal River System: Large Bulk Water Supply Reconciliation Strategy

RE-USE OPTIONS



DECEMBER 2006

PREPARED BY:

DMM

Golder Associates

SRK Consulting
Engineers and Scientists

wrp
A Miya Group Company

ZITHOLELE CONSULTING

WRP_FC1196.CDR

DEPARTMENT OF WATER AFFAIRS AND FORESTRY

DIRECTORATE: NATIONAL WATER RESOURCE PLANNING

VAAL RIVER SYSTEM: LARGE BULK WATER SUPPLY RECONCILIATION STRATEGY

RE-USE OPTIONS

December 2006

VAAL RIVER SYSTEM: LARGE BULK WATER SUPPLY RECONCILIATION STRATEGY

LIST OF REPORTS

Report No:	Title
P RSA C000/00/4406/01	Urban water requirements and return flows
P RSA C000/00/4406/02	Potential savings through WC/WDM in the Upper and Middle Vaal water management areas
P RSA C000/00/4406/03	Re-use options
P RSA C000/00/4406/04	Irrigation water use and return flows
P RSA C000/00/4406/05	Water resource analysis
P RSA C000/00/4406/06	Groundwater Assessment: Dolomite Aquifers
P RSA C000/00/4406/07	First stage reconciliation strategy

Above list of reports effective as at December 2006

VAAL RIVER SYSTEM: LARGE BULK WATER SUPPLY RECONCILIATION STRATEGY

RE-USE OPTIONS

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DMM Development Consultants, Golder Associates Africa, SRK, WRP Consulting Engineers and Zitholele Consulting.

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Consultants: DMM / Golder Associates Africa / SRK / WRP and Zitholele

Approved for the Consultants by:

....

PG van Rooyen

Study Leader

DEPARTMENT OF WATER AFFAIRS & FORESTRY

Directorate National Water Resource Planning

Approved for DWAF by:

....

JI Rademeyer

Study Manager

....

JA van Rooyen

Director (D: NWRP)

Vaal River System: Large Bulk Water Supply Reconciliation Strategy

RE-USE OPTIONS

TABLE OF CONTENTS

List of Tables

List of Figures

Vaal River System: Large Bulk Water Supply Reconciliation Strategy

Re-use Options

1 INTRODUCTION

1.1 BACKGROUND

The Department of Water Affairs and Forestry (DWAF) has, as part of the development of the Internal Strategic Perspectives (ISPs) for the Vaal River Water Management areas (WMAs), identified and prioritised several studies that are necessary to further support Integrated Water Resource Management in the Vaal River System. Although previous water balance assessments indicated that augmentation of the Vaal River System is only required by the year 2025 **(DWAF, 2004a to d),** several factors were identified that could influence this date and require further investigations.

Firstly, it was acknowledged that the water requirement projection scenarios used in the ISP study did not explicitly include the effect of water conservation and water demand management initiatives **(DWAF, 2004d)** and as a result the Directorate Water Use Efficiency commissioned the Water Conservation and Water Demand Management study with particular focus on the Upper and Middle Vaal River WMAs.

Secondly, it was recognised that the time it takes to implement a large water resource augmentation scheme could be as long as fifteen years and coupled with the fact that the future water requirement scenarios exhibit low growth rates makes the timing of any future intervention critical.

Thirdly, a comprehensive Reserve Determination has not been undertaken for the Vaal River System and will have to be incorporated into the development of reconciliation strategies.

In view of the above considerations as well as other uncertainties identified in the assumptions used in the ISP study **(see DWAF, 2004d for details)**, the Directorate: National Water Resource Planning (D:NWRP) has commissioned the reconciliation study of the large bulk water supply system of the Vaal River.

The ISPs for the Vaal River WMAs further identified the need for integrated water quality management of the Vaal River and its major tributaries. Although there are several individual Catchment Management Strategies already completed, these strategies and their objectives need to be integrated in a system context. To this end, the D:NWRP has commissioned a study to develop an Integrated Water Quality Management Plan for the Vaal River System, which is running concurrently with the Reconciliation and Water Conservation and Water Demand Management studies **(DWAF, 2005)**.

During the inception phases of these studies it was identified by the respective management teams that the integration of strategies and co-ordination of study activities would be essential to development coherent water resource management measures for the Vaal River System. The management of the studies was therefore coordinated by combining the project management of the Water Conservation and Reconciliation studies and have cross representation of study managers on the Water Quality Study.

In each of the tree abovementioned studies the importance of stakeholder involvement in the development of the strategies was emphasised and an integrated stakeholder engagement process was designed. This resulted in combining the stakeholder meetings for all three the studies, combining the Steering Committee Meetings of the Water Conservation and Reconciliation studies and having shared representation on the Water Quality Study.

1.2 PURPOSE OF THE STUDY

The Large Bulk Water Supply Reconciliation Strategy for the Vaal River System Study has the objective to develop management measures for meeting the growing water requirements of the industrial and urban sectors that are served by the Integrated Vaal River System. The development of these strategies requires reliable information of the water requirements and the water resources for the current situation as well as likely future scenarios for a planning horizon of twenty to thirty years.

The key objectives of the study are to:

- Update the current and future urban and agricultural water requirements.
- Assess the water resources and existing infrastructure.
- Take into account the Reserve requirements for alternative classifications.
- Formulate reconciliation interventions, both structural and administrative/regulatory.
- Conduct stakeholder consultation in the development of the strategy.

In order to achieve these objectives the study was undertaken through a series of tasks which culminated into a set of study reports that are listed on the back of the cover page of the report. The information form the task reports were combined to formulate the reconciliation strategy, the main deliverable from the study, which are presented in the report with the title Reconciliation Strategy for the Vaal River System (2006).

1.3 SCOPE OF THIS REPORT

The objectives of this study were to:

- Review of water re-use options in South African literature and selected international literature
- Identify and assess the potential water re-use options in the Upper and Middle Vaal River systems.
- Investigate the feasibility of the re-use options for the study area.
- Make recommendations for further investigation of the most feasible option(s).

Methodology used in the project included:

- An assessment of international literature and local investigations and planning information to establish a baseline for the identification of suitable water re-use options in the upper and middle Vaal River System.
- Development and distribution of a questionnaire to identified stakeholders in conjunction with the Water Quality task to gather information on current water use, discharges, water quality and future planning information.
- Collation of information received from the questionnaire, follow-up site visits, telephonic enquiries and DWAF regional offices into a database.
- Presentation of the information at a workshop with DWAF to qualitatively identify the water re-use options most likely to be feasible.
- Ranking of the qualitatively identified options to quantify those most suitable for further investigation (quality is only qualitatively considered as it is quantitatively assessed in the Water Quality task).
- Preliminary costing of the quantitatively identified options and recommendations for further investigation.

1.4 STUDY AREA

The study area encompassed the most populated and industrialised parts of the Vaal Catchment. The study area for this task is shown in **Figure 6.2**.

Organisations that used and generated large volumes of water were identified during the stakeholder engagement process (Stakeholder Engagement Process task), which included stakeholder meetings and ongoing communication. The stakeholder list obtained from Task 2: Stakeholder Engagement Process was further refined based on the knowledge the respective consultants have of the project area. Due to budget limitations, the stakeholder list was then reduced to the main water users in the major demand centres of the Upper and Middle Vaal River System, which were identified as:

- West Rand.
- Klerksdorp, Orkney, Stilfontein, Hartebeesfontein1 (KOSH).
- Emfuleni: Vanderbijl/Vereeniging.
- Ekurhuleni: the area falling within the Blesbokspruit catchment.

[1] Hartebeesfontein is now part of Buffelsfontein

2 LITERATURE REVIEW

2.1 OVERVEIW

This section includes a review of literature on international water re-use options. Some examples of water re-use option from South Africa in general and specifically for the Vaal River System are also included. The potential of these re-use options for the study area is discussed under Sections 7.2 and 8.

2.2 INTERNATIONAL LITERATURE

There has been greater use and acceptance of reclaimed wastewater effluents as an alternative source of water for a wide variety of re-use options as discharge limits have become more restrictive and sources of water supplies have become limited (USEPA, 2004). Practices of wastewater re-use vary among countries, as re-use targets and technology options differ significantly depending on socio-economic circumstances, industrial structure, climate, culture, religious preference, as well as policy readiness (UNEP, 2006):

- Tunisia is one of the very few countries that have elaborated and implemented a national policy for wastewater re-use (UNEP, 2006).
- In 1992 the state of Washington passed the Reclaimed Water Act to manage the use and quality of reclaimed water in order to protect environmental and human health (REF: Washington website).
- To ensure sustainable and successful wastewater re-use, the following requirements must be fulfilled (UNEP, 2006):
    - The potential public health risk associated with wastewater re-use are evaluated and minimized.
    - The specific water re-use option meets the water quality objectives.

The rationale for and benefits of re-use are presented in **Table 4.1**. Re-use options currently being practised internationally, and in South Africa are listed in **Table 4.2**. Selected re-use options are described in more detail in **Table 4.3**.

Table 4.1: Wastewater re-use: rationale, potential benefits, and factors driving its further use (UNEP, 2006)

Rationale for wastewater re-use
• Water is a limited resource. Increasingly, society no longer has the luxury of using water only once. • Wastewater re-use more appropriately matches water use application with water resource quality resulting in more effective and efficient use of water. • The goal of water resource sustainability is more attainable when wastewater re-use option is implemented.
Potential benefits of wastewater re-use
Wastewater re-use conserves freshwater supplies: • Wastewater re-use increases the total available water supply. High-quality water supplies, such as for drinking water, can be conserved by substituting reclaimed water where appropriate.
Wastewater re-use is environmentally responsible: • Wastewater re-use can preserve the health of watercourses, wetlands, flora and fauna. It can reduce the level of nutrients and other pollutants entering watercourses and sensitive marine environments by reducing wastewater discharges.
Wastewater re-use makes economic sense: • Reclaimed water is available near urban development where water supply reliability is most crucial and water is priced the highest.
Wastewater re-use can save resources: • Reclaimed water originating from municipal wastewater contains nutrients; if this water is used to irrigate agricultural land, less fertilizer is required for crop growth. By reducing nutrient (and resulting pollution) flows into watercourses, tourism and fishing industries are also helped.
Factors driving further implementation of wastewater re-use
• Proximity: Reclaimed water is readily available in the vicinity of the urban environment, where water resources are most needed and are highly priced.
• Dependability: Reclaimed water provides a reliable water source, even in drought years, as production of urban wastewater has low seasonal variability • Versatility: Technically and economically proven wastewater treatment processes are available now that can provide water for non-potable and potable re-use. • Safety: Non-potable water re-use systems have been in operation for over four decades with no documented adverse public health impacts in developed countries. • Competing demands for water resources: Increasing pressure on existing water resources due to population growth and increased agricultural demand. • Fiscal responsibility: Growing recognition among water and wastewater managers of the economic and environmental benefits of using reclaimed water. • Public interest: Increasing awareness of the environmental impacts associated with overuse of water supplies, and community enthusiasm for the concept of wastewater re-use. • Environmental and economic impacts of traditional water resources approaches: Greater recognition of the environmental and economic costs of water storage facilities such as dams and reservoirs. • Proven track record: The growing number of successful wastewater re-use projects all over the world.

Factors driving further implementation of wastewater re-use (continued)

- Implementation of a cost recovery approach to water pricing: The introduction of new water charging arrangements (such as full cost pricing) that more accurately reflect the full cost of delivering water to consumers, and the growing use of these charging arrangements.
- More stringent water quality standards: Increased costs associated with upgrading wastewater treatment facilities to meet higher water quality requirements for effluent disposal.
- Necessity and opportunity: Motivating factors for development of wastewater re-use projects such as droughts, water shortages, prevention of sea water intrusion and restrictions on wastewater effluent discharges, plus economic, political, and technical conditions favourable to wastewater re-use.

Table 4.2: Categories of wastewater re-use (UNEP, 2006)

Category of re-use	Description of category
Urban use	
Unrestricted irrigation	Landscape irrigation of parks, playgrounds, school yards, golf courses, cemeteries, residential, green belts.
Restricted irrigation	Irrigation of areas with infrequent and controlled access.
Other uses	Fire protection, disaster preparedness, and construction.
Agricultural	
Food crops	Irrigation for crops grown for human consumption.
Non-food crops and crops consumed after processing	Irrigation for fodder, fibre, flowers, seed crops, pastures, commercial nurseries, and instant lawn.
Recreational use	
Unrestricted body contact	No limitation on body contact: lakes and ponds used for swimming.
Restricted body contact	Fishing, boating, and other non-contact recreational activities.
Other	
Environmental enhancement	Artificial wetlands creation, natural wetland enhancement, stream flow.
Groundwater recharge	Groundwater replenishment for potable water, salt water intrusion control, subsidence control.
Industrial re-use	Cooling system water, process water, boiler feed water, toilets, laundry, construction wash-down water, air conditioning.
Residential use	Cleaning, laundry, toilet, air conditioning.
Potable re-use	Blending with municipal water supply, pipe to pipe supply.

Table 4.3: Details of selected re-use options

Description	Examples/application	Benefits	Issues/constraints	Ref	Potential for Study Area
Wastewater reclamation					
Reclamation consists of treating sewage after a secondary biological treatment with various technologies such as coagulation and flocculation, dissolved air flotation clarifier, sand filtration, ozonation, activated carbon treatment and chlorine disinfection to potable water quality.	Reclamation began in 1968 in **Windhoek**, Namibia to augment ground and surface water supply. Windhoek, the only city in the world directly reclaiming treated wastewater effluent for re-use as potable water, treats up to 21 Ml/d in two plants - one for potable use and one for irrigation of parks and sports fields.	• An additional water source • Prevention of pollution through reduced discharge of nutrients to water resources and subsequent limiting of eutrophication (phosphate is not a problem in most re-use situations and neither is nitrogen).	• Since the treatment cost for reclamation is higher than that of the existing water supply system, the reclamation plant has been operated on an intermittent basis to supplement the main supplies. • It is recommended to use an indirect reclamation scheme, such as storage in an aquifer, if geographical circumstances allow it. • Policies and regulations on a national and local level are needed for proper support to ensure long-term safety and sustainability.	Van Leeuwen, 1996 Menge, 2006 UNEP, 2006	No, public perception is an obstacle
	Since 2004, about 57,000m^3/day of wastewater has been processed in two factories in **Singapore**: about 7,000m^3/day are pumped into freshwater reservoirs for indirect potable usage, constituting less than 1% of total water consumption. The	• An additional water source • Prevention of pollution through reduced discharge of nutrients to water resources and subsequent limiting of eutrophication (phosphate is not a problem in most re-use situations and neither is nitrogen).	• Public resistance has been addressed by the Public Utility Board (PUB) of Singapore, which opened a public education centre in early 2003 to enhance the public understanding of reclaimed water, called 'NEWater', and other water-related topics.	UNEP, 2006 Water Proofing Adelaide, 2004?	No, public perception is an obstacle

Description	Examples/application	Benefits	Issues/constraints	Ref	Potential for Study Area
	plan is to increase this to 2.5% by 2011.		• Increased levels of wastewater treatment required for some schemes may significantly increase greenhouse impacts due to the higher power requirements unless more sustainable sources of energy can be made available.		
Groundwater recharge					
Groundwater recharge with reclaimed water for water storage and water transmission.	None given	• Reduces the constant • and continuing depletion of • ground water	• There is a high risk of polluting the aquifer if the quality of the recharge is not adequately managed. • There are potential health concerns when water is used for irrigation or other purposes. • As the performance of soil aquifer treatment is uneven depending on hydraulic loading, each project should be carefully designed and adequate attention paid to reducing pathogens.	UNEP, 2006; Papaiacovou, 2001	No, Risk of pollution
Soil aquifer treatment (SAT)					
Partially treated sewage effluent is allowed to infiltrate into the soil and move down to the groundwater for re-use in irrigation or for recreational purposes.	Areas where soil and groundwater conditions are favourable for artificial recharge of groundwater through infiltration basins. This has been trialled in Phoenix, Arizona since 1967 and studies have shown it to be effective (Pescod 1992)	• Groundwater recharge has been used to prevent the decline in groundwater level and to preserve the groundwater resource for future use. • Compared to conventional surface water storage, aquifer recharge has many advantages, such as negligible evaporation, little secondary contamination by animals, and no algal blooming. It is also less costly because no pipeline construction is	• The main constituents that must be removed from sewage effluent before it can be used for unrestricted irrigation are pathogenic organisms. • Nitrogen concentration might also have to be reduced and suspended solids and biodegradable material should perhaps be removed to protect the irrigation system or for aesthetic	Van Leeuwen, 1996 Pescod 1992	N, Risk of pollution

Description	Examples/application	Benefits	Issues/constraints	Ref	Potential for Study Area
		required. • It protects groundwater from saltwater intrusion by barrier formation in coastal regions, and controls or prevents land subsidence.	reasons. • For recreational lakes or discharge into surface water, phosphorus should also be removed to prevent algal grown in the receiving water.		
Mine water re-use for irrigation					
Irrigating with gypsiferous mine water in suitable soils on a commercial basis (Most mining operations re-use water to the extent possible, within constraints imposed by quality requirements, water availability, and discharge considerations).	In a field trial in South Africa (exact location not given) during 1997-2000, three centre pivots were set up for irrigation with coal mine wastewater—one in virgin soil (unmined) and two in mine-rehabilitated land.	• Offers a solution to the twin problems of wastewater disposal and shortage of irrigation water. • Excellent yields were obtained for wheat on both virgin and rehabilitated land, and also short-season maize grown on virgin land.	• How big the opportunity is depends on the availability of suitable soils nearby, the resultant soil water and salt balance, the different cropping systems, the choice of irrigation management strategies, and the impact of the irrigation drainage on local and regional water resources. • Research is continuing, using catchment-scale computer modelling to assess the impact of scaling-up on the volume and quality of surface water and groundwater.	USEPA, 2006	Yes, mine water re-use for irrigation considered but not specifically gypsiferous water – report did not go to this level of detail

Description	Examples/application	Benefits	Issues/constraints	Ref	Potential for Study Area
Wastewater re-use for urban activities					

A large percentage of water used for urban activities does not need quality as high as that of drinking water. Dual distribution systems (one for drinking water and the other for reclaimed water) have been utilized widely.	Various countries, especially in highly concentrated cities of the developed countries. In **Tokyo** treated wastewater has been supplied since 1984 up to a maximum 8,000 m^3/day.
	
	Indirect re-use in Tshwane metropolitan areas from Roodeplaat dam
		• Decreased pollution of water resources into which treated WWTW effluent would otherwise be discharged.
		• Decreased consumption of potable water.
			• One of the key concerns for wastewater re-use in urban applications is the protection of public health, as urban re-use has the potential to expose a large number of people to disease-causing microorganisms. Care should be taken to avoid contamination of drinking water by misconnection (cross connection) between potable water pipes and reclaimed water pipes (the international standard is purple pipes), and also to disinfect reclaimed wastewater properly.
			• Costs for dual reticulation systems in new developments are higher than traditional schemes; however some consumers may recognise the benefits and be prepared to pay the higher land prices or other charges that may apply. Updating water supply systems in established areas with dual reticulation is very expensive and the benefits are unlikely to warrant the cost.
			• The following problems have also been identified in wastewater re-use for toilet flushing:
			  • Biofilm (slime) formation in reservoir tank due to reduction of residual chlorine in reclaimed water (Fukuoka Municipal Government, 1999).
			  • Corrosion of pipes;
				UNEP, 2006
				
				Water Proofing Adelaide, 2004
					Yes, but ruled out – see section 5.2.2

Description	Examples/application	Benefits	Issues/constraints	Ref	Potential for Study Area
			• Blockage of pipe and strainer;		
Wastewater re-use for industrial applications*					
Treatment of final effluent to near potable standards for re-use in industry	**Durban South WWTW**	• Decreased pollution of water resources into which treated WWTW effluent would otherwise be discharged. • Decreased consumption of potable water.	• Water quality requirements for industry re-use differ according to application types. Potential concerns for industrial water re-use include scaling, corrosion, biological growth, and fouling, which may impact industrial process integrity and efficacy, as well as product quality. • Obtaining the necessary quality may require secondary treatment, tertiary treatment, or specific methods to meet individual needs. • Where the water is used for industrial purposes, the wastewater would recycle back to the wastewater treatment plant with a marginal increase in salinity in each cycle. Advanced treatment technologies to desalinate the water are available but are expensive and have high energy requirements. • Cleaner production (CP) assessment is an analytical method of particular relevance for evaluating options for industrial water re-use.	Offringa, 2006 Water Proofing Adelaide, 2004?	Yes, already occurring. No further promising instances where this could be used were found. See section 5

Description	Examples/application	Benefits	Issues/constraints	Ref	Potential for Study Area
	Since 2004, **Singapore** has re-used about 50,000m^3/day of treated water for non-potable usage by industrial and commercial institutions, including wafer fabrication parks.	• Industrial water re-use has the following specific benefits, in addition to the general environmental benefits discussed in earlier sections: • Potential reduction in production costs from the recovery of raw materials in the wastewater and reduced water usage; • Heat recovery; • Potential reduction in costs associated with wastewater treatment and discharge.	• None given	UNEP, 2006	Yes, already occurring. No further promising instances where this could be used were found. See section 5
Industrial wastewater re-use for irrigation					
Wastewater originating from food production are applied in agriculture with as little additional effort as possible.	**Chile**	• Substances that would be removed at the WWTW, such as those that are readily biodegradable or originate from agricultural production, are now directly applied in agriculture. Hence, the water itself is put to use without having to be treated, while the contaminating components in the wastewater are put to use productively and do not need to be disposed of.	• The main threat evoked by this approach is that various forms of wastewater contamination are spread in the environment without control through a central body rather than being removed from the wastewater in a controlled surrounding, such as a WWTW.	Etschmann, 2000	Yes but no suitable effluents were found

Description	Examples/application	Benefits	Issues/constraints	Ref	Potential for Study Area
Wastewater re-use for irrigation					
Re-use of sewage water has been practiced for a long time in various parts of the world. .	Raw wastewater re-use is an important practice in several countries, especially for agriculture, with about 20% of the world population's food being produced through this practice. Currently almost 20% of Adelaide's (Australia) treated wastewater is re-used for vegetables and other crops, including vines. Parts of the Mezquital Valley in Mexico have been irrigated with sewage water since 1886 while land disposal of wastewater has been practiced in India for up to 160 years [Rowe, 1995]. In recent years many more projects that apply treated wastewater for various needs have been implemented.	• Wastewater flows are fairly constant all year round, and the water quality after treatment is consistent making it more attractive in some respects than some less reliable alternatives. • Recycled wastewater generally has higher levels of nutrients than other water sources and therefore when used for irrigation can reduce the need for additional fertilisation. • Soil conservation through humus build-up and prevention of land erosion. • Contribution to better nutrition and food security for many households.	• Conventionally treated wastewater is suitable for non-drinking purposes such as irrigation and some industrial and domestic purposes. The extent to which wastewater will be used as a resource depends on: potential customers, quality and treatment e.g. excess nitrogen may cause overgrowth, delayed maturity, and poor quality of crops; excess boron, sodium and chloride becomes toxic; • For demands such as irrigation, which are predominantly during summer, appropriately sized storage would be needed if wastewater re-use were to be maximised. Storage options include Aquifer Storage and Recovery (ASR). • Surface storage requires large areas of land and the need for connecting pipe work when the storage is located away from the water source. • Evaporation from storage facilities leads to increased salinity levels so design to minimise evaporation is important.	Water Proofing Adelaide, 2004? Rowe, 1995 UNEP, 2006	Yes, see section 5

Description	Examples/application	Benefits	Issues/constraints	Ref	Potential for Study Area
	In **Africa and Asia**, an estimated 85 to 90% of all the freshwater use is for agriculture. In **Tunisia** the volume of reclaimed wastewater produced increased to 156 million m^3 in 2001 and will expand to 200 million m^3 by 2006 (UNEP, 2006)	• Use of moderately saline water, much of which was previously thought to be unusable, due to an 8-10 fold range in the salt tolerance of agricultural crops. This range in tolerance greatly expands the acceptable range of water salinity (ECw) considered suitable for irrigation.	• Farm practices, such as the type of crop to be grown, irrigation method, and agronomic practices, will determine to a great extent the quality suitability of irrigation water. • Application of a non-saline wastewater, such as one containing 200 to 500 mg/l, when applied at a rate of 20,000 m^3 per hectare, a fairly typical irrigation rate, will add between 2 and 5 tonnes of salt annually to the soil. If this is not flushed out of the root zone by leaching and removed from the soil by affective drainage, salinity problems can build up rapidly. Leaching and drainage are thus two important water management practices to avoid salinization of soils. • The potential health hazards associated with effluent irrigation can make this a very sensitive issue and public concern will only be mollified by the application of strict control measure. The ideal objective in site selection is to find a suitable area where long-term application of treated effluent will be feasible without adverse environmental or public health impacts.	Pescod, 1992	Yes, see section 5

Description	Examples/application	Benefits	Issues/constraints	Ref	Potential for Study Area
	Limassol, Cyprus re-uses 3.5 million m³/annum treated effluent via groundwater recharge for restricted irrigation such as public amenity areas, golf courses, etc., but excluding vegetable and similar irrigation.	• The marginal cost for tertiary treatment is much less than the cost paid for dam water or desalination water (it is estimated that the marginal cost of the tertiary treatment effluent is currently about 9 US cent/m³. • The treated effluent is used mainly for agriculture and therefore fresh water of the best quality can be saved for domestic uses. • If used properly it resolves environmental problems caused by untreated wastewater on the one hand and on the other it decreases consumption of potable water	• If a combination of natural fresh water, treated effluent and desalinated water is used, then a most efficient and cost effective use of the natural resources will be achieved with the average cost of water in the national economy substantially reduced.	Papaiacovou, 2001	Yes, see section 5
	In **Sydney** costs (in Australian $) vary from less than 80¢/Kl for effluent pumped direct from the WWTW to typical nearby customers to over $2/Kl for dual reticulation with an average of $1/Kl.	• The optimum mix of water use efficiency (water conservation and demand management) and re-use has been achieved through least cost planning.	• Climate may constrain re-use during the wet season resulting in the need storage facilities.	White, 1998	Yes, see section 5
Treated WWTW effluent for mining					
Use of treated wastewater from the municipal WWTW	25 Ml/d is planned for re-use by mines in the Rustenburg area.	• Decreased pollution of water resources into which treated WWTW effluent would otherwise be discharged. . Decreased consumption of potable water.	• None noted	Hayes, 2006	Yes, already occurring – see Section 5

Description	Examples/application	Benefits	Issues/constraints	Ref	Potential for Study Area
Re-use of stormwater for irrigation					
Stormwater re-use as a management option	Case studies in **United States of America, Central Asia, Egypt, India and Pakistan**.	• Protection of the quality of receiving waters for downstream uses benefits the regional environment and ecology.	• The factors affecting drainage water management include geomorphology, hydrology, climate conditions and the socio-economic and institutional environment.	Pescod, 1992	No, occurs already on small scale and as effective re-use because stormwater systems discharge to watercourses.
Alternate application					
Use of treated wastewater (dirty) alternating with surface or groundwater (clean).	None given	• Protection of the quality of receiving waters for downstream uses benefits the regional environment and ecology.	• An alternative application strategy will require duel conveyance systems and availability of the effluent dictated by the alternate schedule of application.	Pescod, 1992	Yes, use of treated wastewater considered – details of blending etc are beyond scope of report
Blending					
Blending of treated sewage with conventional sources of water, canal water or ground water, if multiple sources are available.	None given	• Blending saline irrigation water with non-saline treated wastewater could produce water of acceptable salinity level. The microbial quality of the resulting mixture could be superior to that of the unblended wastewater.	• None given	Pescod, 1992	Yes, use of treated wastewater considered – details of blending etc are beyond scope of report

Description	Examples/application	Benefits	Issues/constraints	Ref	Potential for Study Area
Environmental enhancement					
Includes augmentation of natural/artificial streams, fountains, and ponds.	None given	• None given but would include maintenance of biodiversity and suitable habitat.	• Public health concerns must be adequately addressed for environmental enhancement applications in order to avoid negative human health impacts.	UNEP, 2006	

2.3 PREVIOUS STUDIES ON RE-USE OPTIONS IN THE VAAL RIVER SYSTEM

Information in this section was obtained from the DWAF Literature Review Report for the Vaal River System (DWAF, 2005). Only the findings related to the water re-use options that are pertinent to this study are included in this section.

The water re-use options identified, based on the projections above, are summarized in **Table 4.4**, which includes related options in terms of the international experiences described in **Section 2.2**.

Table 4.4: Identified re-use options in the Vaal River System from previous studies

Re-use option (DWAF, 2005)	Study date	Related international experiences (refer to Section 2.2)
Recycling of treated sewage effluent for domestic use, via the Vaal Dam: the most cost effective option was identified as the commissioning of a pipeline to convey Johannesburg Northern WWTW effluent to a tributary of the Klip River, followed by a second pipeline transferring Kempton Park WWTW effluent to the Blesbokspruit. The study (DWA 1985) noted that farmers in the same catchment as the WWTW may object to losing the water that currently flows downstream to them. This option was never implemented.	1985	WWTW effluent has been extensively used for irrigation on a world wide basis (UNEP, 2006). Blending of WWTW effluent with other water resources has been done to augment supplies with the potential spin-off of improved water quality following blending (Pescod, 1992).
Artificial recharge of the aquifer in the Tarlton area by surface water, in years of above average run-off.	1988	Reclaimed sewage water (further treated final sewage effluent) has been used for groundwater recharge (UNEP, 2006).
Use of the dolomitic aquifers as storage facilities, which can be artificially recharged when the Vaal and Bloemhof dams overflow: there is the possibility of utilizing the total subsurface storage of a few selected compartments for artificial recharge instead of artificially recharging all of the exploitable compartments in Gauteng.	1989	
Blending of water from the Vaal Dam and Vaal Barrage in order to prevent the total dissolved solids (TDS) concentration of water supplied to consumers from rising above a set standard (proposed at 300mg/l): this recommendation has been implemented.	1996	Blending of WWTW effluent with other water resources has been done to augment supplies with the potential spin-off of improved water quality following blending (Pescod, 1992).
A 1985 study considered the likely impact of the above blending option on irrigation agriculture and a 1999 study recommended optimising water use and irrigation, and adjusting to less sensitive crops.	1985, 1999	The identified 8-10 fold range in the salt tolerance of agricultural crops greatly expands the acceptable range of water salinity (ECw) considered suitable for irrigation (Pescod, 1992).

3 REVIEW OF FUTURE PLANNED DEVELOPMENT

Planning information from local and regional departments was reviewed under the Urban Water Conservation and Demand Management task of the study and hence is not described in detail in this section.

Municipal demand is anticipated to grow in all the regions except the West Rand (See **Figure 6.2**). Growth in the West Rand is largely dependent on whether mines in the region remain open.

Although the KOSH area is also economically dependant on mining, the Klerksdorp city council is projecting continuing growth (City Council of Klerksdorp 2005). Information related to future water use projections for the municipal, mining and industrial sectors are included in Section 9 of this report. Selected national and provincial plans and programs that have relevance to water re-use options for irrigation (refer to Section 2) are presented below.

The Department of Agriculture, Conservation and Environment (DACE) has agricultural growth as one of its objectives and hence aims to move food security beyond subsistence level and promote access to markets worldwide, while meeting the high product standards of the international arena (DACE, 2003).

The focus of agricultural growth in DACE's Strategic Plans for 2004-2009 (Gauteng) and 2003/4 – 2005/6 (Mpumalanga) is on poverty alleviation and includes agricultural development projects and repair of irrigation systems while simultaneously protecting the environment and assuring the safety of food. Agricultural development is considered for rural as well as urban areas. Urban agriculture has emerged as a key livelihood and coping strategy for urban residents and as an essential land use, changing the way people in cities feed themselves, and making a significant contribution to urban food security (DACE, 2004).

Re-use of wastewater is applicable in terms of the 2003/4 – 2005/6 Strategic Plan's Agricultural Development Program under the following objectives (DACE, 2003):

- Catchment plans.
- Construction of soil and water conservation structures.
- Scheduling of farm irrigation (water use efficiency).

and the Farmers' Support and Training Program (DACE, 2003):

- Establishment of food gardens.
- Encouraging production of alternative crops.

Although re-use of wastewater is in line with DACE's strategic plans, it is not specifically mentioned as a source of irrigation water, hence it is recommended that DWAF engage with DACE in this regard, possibly through the Water Allocation Reform (WAR) program.

The WAR program is a proactive intervention to address imbalances in the water sector and focuses primarily on the redistribution of water with the ultimate aim of greater socio-political and socio-economic stability for the country (Seetal, 2006). Re-use of treated wastewater effluent in irrigation thus has direct links to the WAR program.

4 MAJOR WATER USERS/GENERATORS IN FOCUS AREAS

Large potential water users/generators were identified in four key focus areas. The key focus areas, West Rand, KOSH, Ekurhuleni and Emfuleni, were selected because they contained large industries along with high populations. The locality of potential water users/generators is presented in **Figure 6.2** and those considered in the identification of re-use options are listed in **Table 6.1**.

Attempts were made to collect data from all major potential water users and generators. Involvement of these organisation was achieved through the distribution of an introductory letter that accompanied the questionnaire. The letter explained the project and requested participation in the completion and submission of the questionnaire to the project team. To encourage and promote participation, contact was maintained with the identified organisations via frequent telephone and e-mail contact. The results of the data collection exercise are presented in **Figure 6.1**. This data is presented in **Sections 4** and **5**.

The identified stakeholders fall into the following water user sectors:

- Municipalities.
- Water service providers (eg Rand Water and Midvaal).
- Wastewater treatment works.
- Mining.
- Industry.
- Irrigation.

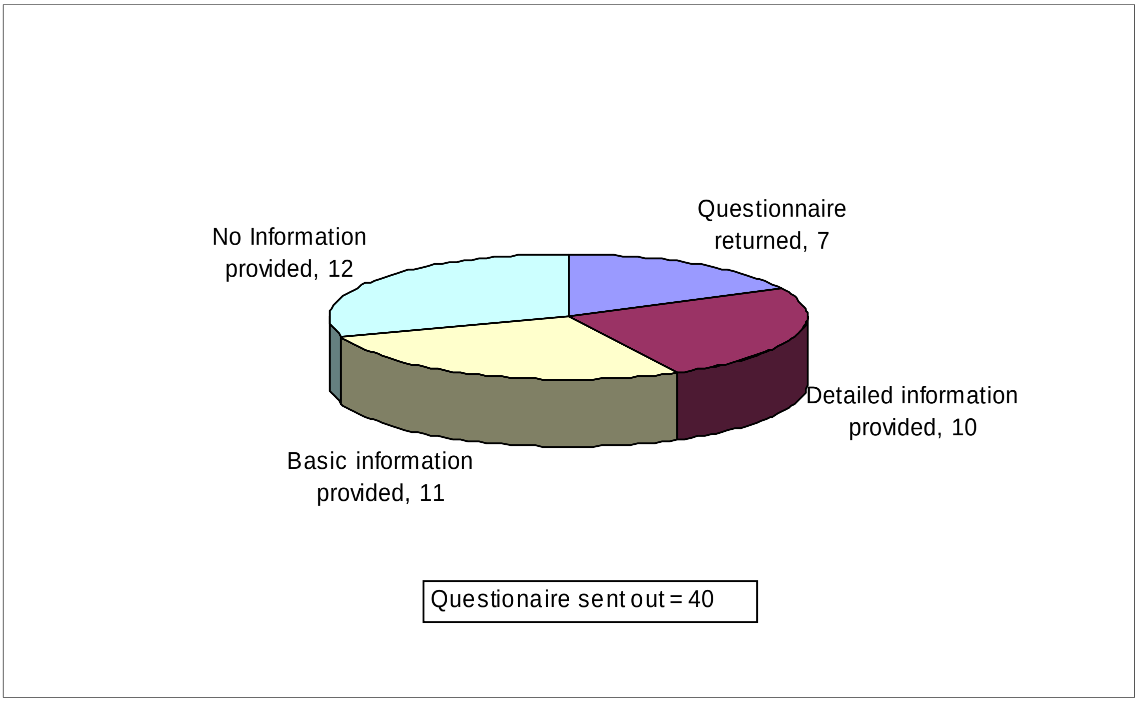

Figure 6.1: Summary of information received

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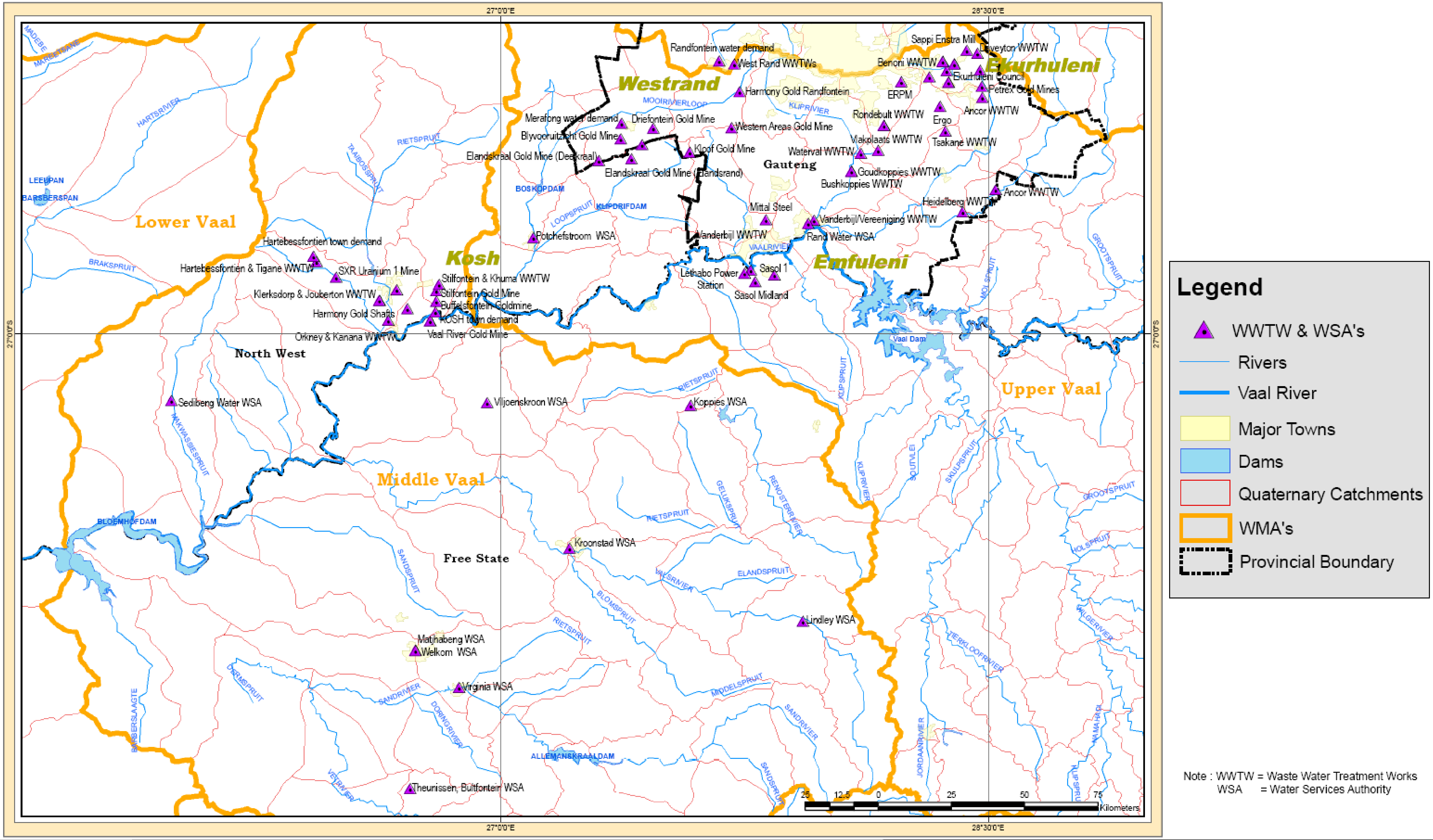

Note : WWTW = Waste Water Treatment Works
WSA = Water Services Authority

PROJECT NO.	COORDINATE SYTEM			DATE	SCALE
335412	Decimal Degrees		Locality Plan of Water Users and Generators	29/11/2006	1: 200 000
	SPHEROID: WGS84	CENTRAL MERIDIAN: LO 27		COMPILED BY: RVL Setiko	FIG NO. 6.2

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Table 6.1: Water users and/or generators considered in the identification of re-use options

Stakeholder	Location		Main business
Ekurhuleni	**Lat**	**Long**	
Sappi Enstra Mill	-26.12603	28.43189	Paper
Petrex Gold Mines	-26.23806	28.47917	Goldmine
Ergo	-26.30000	28.35000	Gold extraction
Ekurhuleni Council	-26.19000	28.37000	Water Service Authority
Ancor WWTW	-26.27135	28.47953	Water Service Authority
Benoni WWTW	-26.20910	28.31713	Water Service Authority
Daveyton WWTW	-26.13605	28.46480	Water Service Authority
Jan Smuts WWTW	-26.22473	28.37525	Water Service Authority
JP Marais WWTW	-26.16863	28.39311	Water Service Authority
Welgedacht WWTW	-26.18891	28.47330	Water Service Authority
Rynfield WWTW	-26.16073	28.35793	Water Service Authority
West Rand			
Harmony Gold Randfontein	-26.25444	27.73333	Goldmine
Western Areas Gold Mine	-26.36472	27.70806	Goldmine
Kloof Gold Mine	-26.44056	27.57889	Goldmine
Driefontein Gold Mine	-26.36667	27.46667	Goldmine
Blyvooruitzicht Gold Mine	-26.40000	27.36667	Goldmine
West Wits Gold Mine	-26.41667	27.43333	Goldmine
Westrand Consolidated Goldmines	-26.25444	27.73333	Goldmine (closed)
Elandskraal Gold Mine (Deelkraal)	-26.46667	27.30000	Goldmine (closed)
Elandskraal Gold Mine (Elandsrand)	-26.46167	27.39944	Goldmine
West Rand WWTWs	-26.16851*	27.71660*	Water Service Authority
Merafong water demand	-26.32000	27.32000	Water Service Authority
Randfontein water demand	-26.16000	27.67000	Water Service Authority
Emfuleni			
Sasol 1	-26.80399	27.76759	Petro-chemical
Lethabo Power Station	-26.81308	27.74868	Power Station
Mittal Steel	-26.64899	27.81439	Steel works
Sasol Midland	-26.83936	27.78092	Petro-chemical
Sasolburg WWTW	-26.81924*	27.84062*	Waste Water Treatment Works
Vanderbijl/Vereeniging WWTW	-26.65053*	27.96167*	Waste Water Treatment Works
KOSH			
Harmony Gold Orkney Shafts	-26.96060	26.78070	Goldmine
Stilfontein Gold Mine	-26.86670	26.80000	Goldmine
Buffelsfontein Goldmine SXR Uranium 1 Mine	-26.90000 -26.82544	26.80000 26.49048	Goldmine Goldmine
Vaal River Gold Mine	-26.96060	26.78070	Goldmine
Klerksdorp & Jouberton WWTW	-26.89710	26.62457	Waste Water Treatment Works
Orkney & Kanana WWTW	-26.95927	26.65214	Waste Water Treatment Works
Stilfontein & Khuma WWTW	-26.84828	26.80759	Waste Water Treatment Works
Hartbeesfontein & Tigane WWTW	-26.77795	26.43145	Waste Water Treatment Works
KOSH town demand	-26.93287	26.79895	Waste Water Treatment Works
Hartebessfontien town demand	-26.76077	26.42178	Waste Water Treatment Works

Stakeholder	Location		Main business
Other			
Sebokeng WWTW	-26.61642	27.74291	Waste Water Treatment Works
Vanderbijl WWTW	-26.69089*	27.82645*	Waste Water Treatment Works
Bushkoppies WWTW	-26.49916	28.07731	Waste Water Treatment Works
Goudkoppies WWTW	-26.49916	28.07731	Waste Water Treatment Works
Meyerton WWTW	-26.60399	28.01407	Waste Water Treatment Works
Olifantsvlei WWTW	-26.49916	28.07731	Waste Water Treatment Works
Waterval WWTW	-26.44403	28.10644	Waste Water Treatment Works
Vlakplaats WWTW	-26.43546	28.15918	Waste Water Treatment Works
Rondebult WWTW	-26.35841*	28.17648*	Waste Water Treatment Works
Dekema WWTW	-26.35841	28.17648	Waste Water Treatment Works
Heidelberg WWTW	-26.62473	28.41988	Waste Water Treatment Works
Bickley WWTW	-26.59303	28.49518	Waste Water Treatment Works
Tsakane WWTW	-26.37598	28.36593	Waste Water Treatment Works
Rand Water WSA	-26.65972	27.94389	Water Service Authority
Midvaal Water Company WSA	-26.93248	26.79658	Water Service Authority
Sedibeng Water WSA	-27.20590*	25.98340*	Water Service Authority
Virginia WSA	-28.08990	26.86988	Water Service Authority
Potchefstroom WSA	-26.70361*	27.09801*	Water Service Authority
Kroonstad WSA	-27.65995*	27.20999*	Water Service Authority
Lindley WSA	-27.88495	27.92766	Water Service Authority
Koppies WSA	-27.22092	27.58287	Water Service Authority
Viljoenskroon WSA	-27.21214*	26.95556*	Water Service Authority
Theunissen, Bultfontein WSA	-28.40135*	26.71829*	Water Service Authority
Matjhabeng WSA	-27.97445*	26.73477*	Water Service Authority
Welkom WSA	-27.97607	26.73447	Water Service Authority
Esther Park WSA	-26.10015	28.18363	Water Service Authority
Olifantsfontein WSA	-25.94330	28.21421	Water Service Authority
Ratanda WSA	-26.58208	28.30355	Water Service Authority
Rynfield WSA	-26.16073	28.35793	Water Service Authority
Herbert Bickley WSA	-26.44568	28.44780	Water Service Authority
Carl Grundling WSA	-26.38421	28.46965	Water Service Authority

*These coordinates have not yet been validated

5 IDENTIFICATION OF POSSIBLE RE-USE OPTIONS

This section collates all the abstractions and discharge information received from stakeholders and qualitatively identifies possible re-use options. The data are presented per focus area and discharge and abstraction data on each stakeholder is given in **Appendix 1**. An overview of the data is presented in **Figure 7.1**.

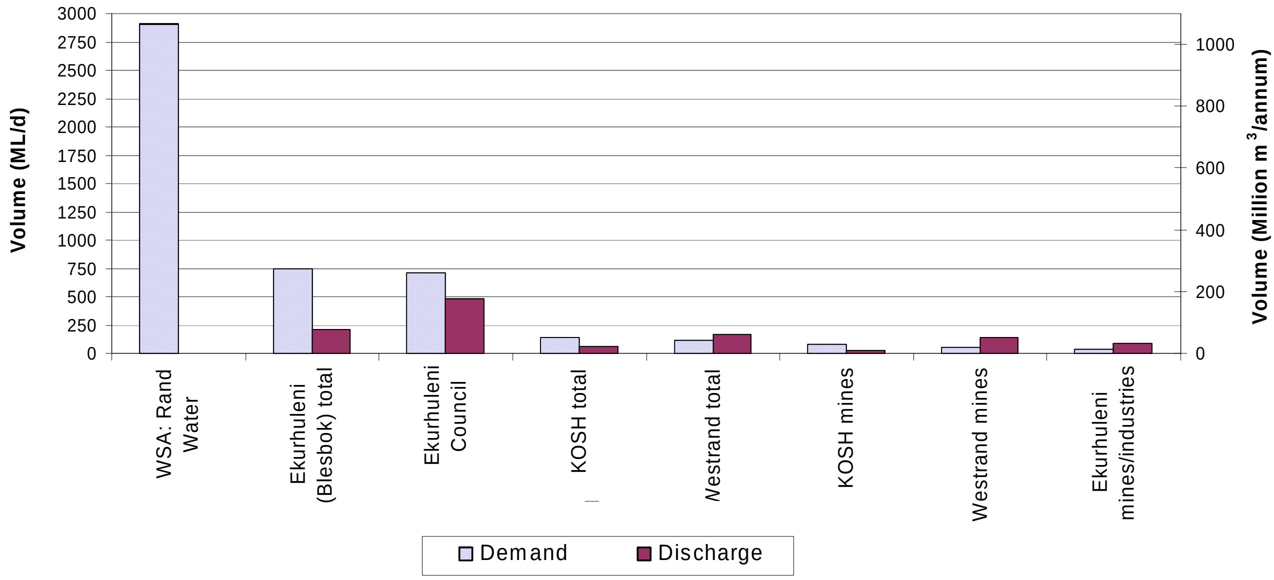

Figure 7.1: Overview of water demand and discharges

The Rand Water demand is the total demand for its area of supply, which includes areas outside of the study area. Rand Water's abstraction is included in the graph for comparative purposes. In a typical municipal scenario discharges may only be 50% of demand but in areas where mines have significant dewatering volumes, discharges exceed demand.

Demands include supply from water boards or direct abstractions from surface or groundwater. Discharges are limited to point source discharges of treated sewage effluent from WWTW, mine dewatering and industrial water. Inclusion of storm water discharges and non-point source discharges, for example, seepage water from mines was beyond the scope of work of this study but may need to be considered in future studies.

5.1 ANALYSIS OF RE-USE OPTIONS IN FOCUS AREAS

5.1.1 EKURHULENI FOCUS AREA

The Ekurhuleni region was identified as a focus area due to its large urban population and significant industrial and mining operations. The demands and discharges of the main stakeholders in the area are presented in **Figure 7.2** and **Figure 7.3**.

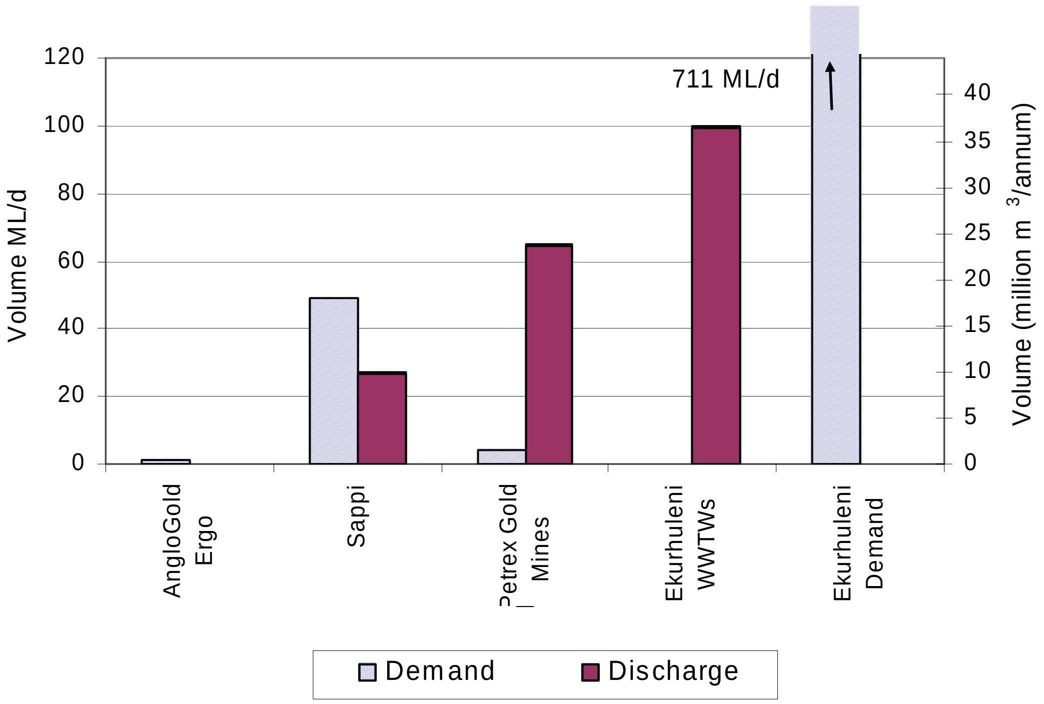

Figure 7.2 : Current water demand and discharges in the Ekurhuleni area

The main industry in the Ekurhuleni region is Sappi, which currently uses more water than it discharges i.e. it has a net water demand. The demand is currently met by a combination of potable water from Rand Water and treated municipal sewage effluent. There are plans to significantly reduce Sappi's water demand by the year 2010 to approximately 10 500 m^3/d through internal re-use. Discharge will also decrease to about 10.5m^3/d and treated municipal sewage effluent will no longer be used in their processes.

No additional potential industrial re-use options in the Ekurhuleni area have been identified over and above Sappi's existing re-use plans.

The main mines in the area are Petrex (previously Grootvlei), ERPM and ERGO. Petrex has an anticipated remaining life of about 10 years and ERGO has closed. ERPMs current life of mine is estimated at another 8 years. By 1991 dewatering of the East Rand Basin was largely managed from the Grootvlei and Sallies Mines, and the Central Rand from ERPM and Durban Roodepoort Deep Mines due to closure and abandonment of many mines on the East and Central Rand (Rose et al, 2004). ERPM is now the only mine pumping out of the central basin (although not solely ERPM's water) and this water continues to contribute to the Vaal River System. Approximately 25Ml/d of decant water from ERPM is treated in an HDS (High Density Separation) plant and then discharged to a pan from where it is re-used, evaporated or discharged. The final discharge volume from the pan could not be confirmed by the mine.

Petrex currently discharges (dewaters) 75 Ml/day with an average/mean electrical conductivity

(EC) of 305mS/m. Due to the poor quality of the water, Petrex would prefer to continue dewatering even after closure to avoid contamination of the overlying dolomite aquifer. A case study desalination project was conducted at Petrex in 1999 as part of the development of the Rhodes Biosure Process (Rose et al, 2004). The pilot plant demonstrated an 80 -85% sulfate removal at a flow rate of 16.2 Ml/day. An HDS (High Density Separation) plant is currently operating at Petrex and a Rhodes Biosure Process plant that will handle 10 Ml/day is being installed.

At closure Petrex plans to continue pumping water in order to avoid contamination of the overlying dolomite aquifer. The pumping rate required to ensure this is unknown but the plan is for at least 40Ml/d to be discharged, desalinated and used for municipal supply in the area. 40Ml/d approximately equals the predicted shortfall in water supply in the Springs area by 2015 and Rand Water has already expressed interest in using the Petrex water to meet this demand. Rand Water is further in favour of this option because it would mean the development of infrastructure on the East Rand. More than 40ML/d may need to be pumped at Petrex to maintain sufficiently low water levels. Any excess pumping water will be discharged through the Biosure plant to the Blesbokspruit. Petrex has considered a number of other options for closure such as supplying the agricultural sector or pumping more water at a different location.

A joint venture between Petrex and other catchment stakeholders for desalination of water for re-use was identified as a promising re-use option. Such re-use would remove salt load from the Vaal, supplement demand in the Upper Vaal Catchment and protect the dolomite aquifer. The desalination technology proposed by Petrex should achieve 95% recovery for the Petrex water. The remaining brine will pose an environmental risk which needs to be carefully considered. Research for re-use of the brine is underway (Golders, pers. comm., 2006) and research on the possibility of regional brine disposal centres in also underway. Petrex has undertaken an investigation of this option and a discussion between the primary stakeholders, namely Petrex, Rand Water, the water services authority (Ekurhuleni) and DWAF was held in June 2006. Funding of desalination should be negotiated between all the parties contributing to the slat loads in the water resource.

A further option is to supply emerging small scale farmers or resource poor agriculture with treated wastewater from the Ekurhuleni focus area. The area is expected to grow and will thus provide a reliable and consistent supply of wastewater into the future. This would be a new use of water in the Vaal and would not decrease demand. It might improve river quality by removing the salt load from the wastewater treatment works. However, depending on the manner in which irrigation is carried out this salt may find its way back to the river or to groundwater/soil. The option was identified as a promising option at the re-use workshop since it aids in poverty alleviation. Irrigation with wastewater also aligns with **DACE's Strategic Plans** (refer to Section 6 of this report).

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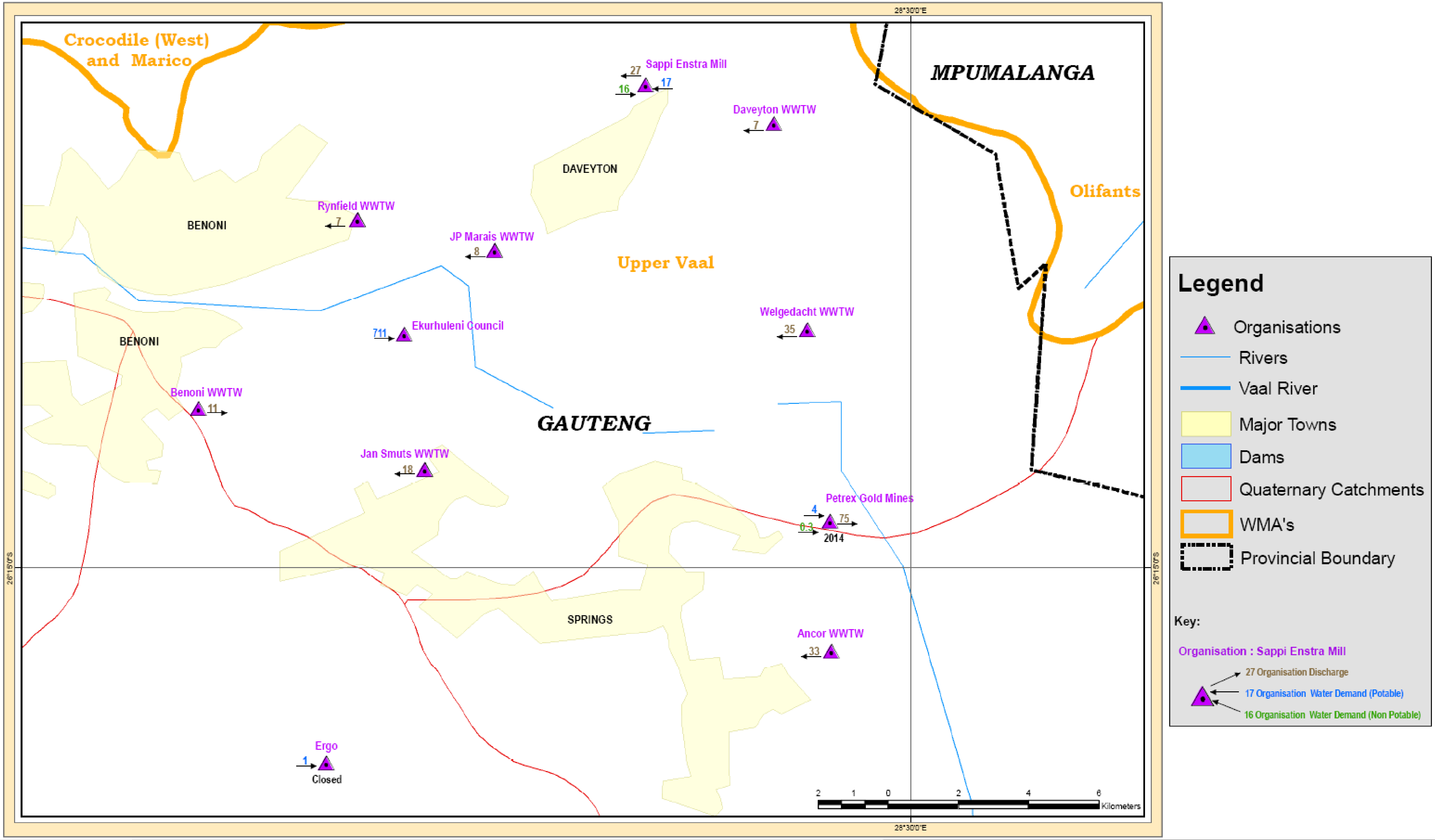

PROJECT NO.	COORDINATE SYTEM		Locality Plan of Water Demand and Discharges in the Ekurhuleni Region	DATE	SCALE
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	WGS84	LO 27		RVL Setiko	7.3

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5.1.2 WEST RAND FOCUS AREA

The West Rand region was identified as a focus area due to its significant mining operations. Closure dates of the mines depend on the gold price and if the price should drop many of these may close. Many of the mines have very high discharge rates in comparison to their demands – this is because they are continually dewatering significant compartments within the dolomitic groundwater system. Other of the mines have very little groundwater and thus have high demands but no discharges. The demands and discharges of the main stakeholders in the area are presented in **Figure 7.4** and **Figure 7.5.**

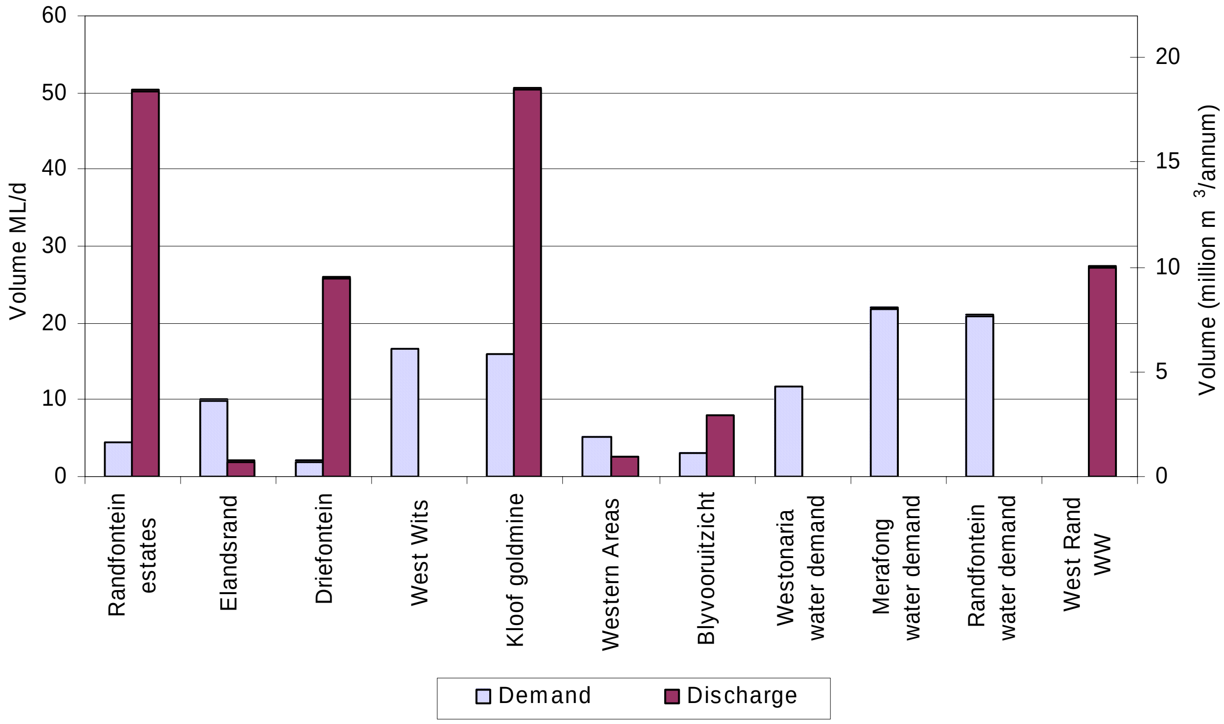

Figure 7.4: Current water demand and discharges in the West Rand area

The main mines in the area are Randfontein Estates, Kloof, Driefontein and Blyvooruitzicht, which have positive water balances, and West Wits, Elandskraal (Elandsrand) and Western Areas Gold Mine, which have negative water balances. West Rand Cons and Elandskraal (Deelkraal) mines are closed. Limited information was obtained from Blyvooruitzicht and Western Areas Goldmine.

There are a few plans for future re-use in the West Rand area although Randfontein estates has a plan for treatment of its poor quality decant water (discharge) for mine water supply. There are also conceptual plans to replace process water with fissure water at Kloof and Blyvooruitzicht.

Theoretically, further re-use is possible if the mines in this area with positive water balances supply those with negative water balances. However, such options were ruled out during the water re-use workshop. This is because the mines discharging to the Wonderfonteinspruit effectively supply Potchefstroom and the irrigation schemes downstream via Boskop dam. Hence this water is not available as such. On the other side of the divide, Randfontein Estates discharges to the Klipspruit. This water is reportedly of good quality hence it improves the quality of the river and thus its removal is not advised.

The role of water boards in the supply chain i.e. mine to water board to mine supply, needs to be investigated as does ownership and management of infrastructure, such as treatment plants and pipelines, especially after mine closure. Water demand will decrease as closure approaches but due to the fluctuating gold price, closure dates are uncertain.

The re-use of water from wastewater treatment plants is not considered viable in the West Rand area as the discharge volumes are expected to be unreliable due to the uncertainty that exists regarding life of mines in the area. As the West Rand area is characterized by mining, no industrial water re-use options were identified for this area.

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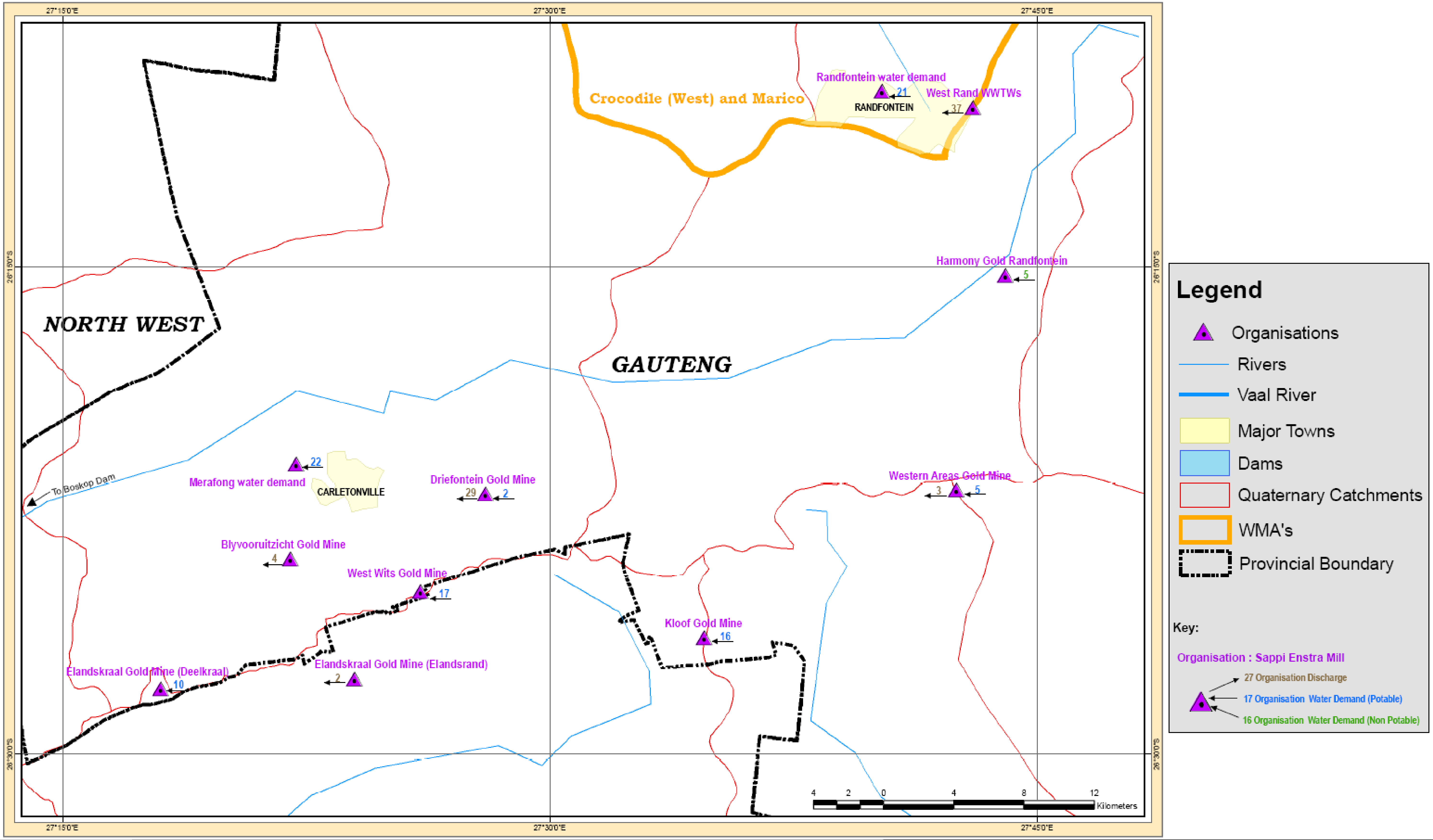

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	SPHEROID: WGS84	CENTRAL MERIDIAN: LO 27		COMPILED BY: RVL Setiko	FIG NO. 7.5

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5.1.3 EMFULENI FOCUS AREA

The Emfuleni region was identified as a focus area due to its significant industrial operations and urban population. The demands and discharges of the main stakeholders in the area are presented in **Figure 7.6** and **Figure 7.7**.

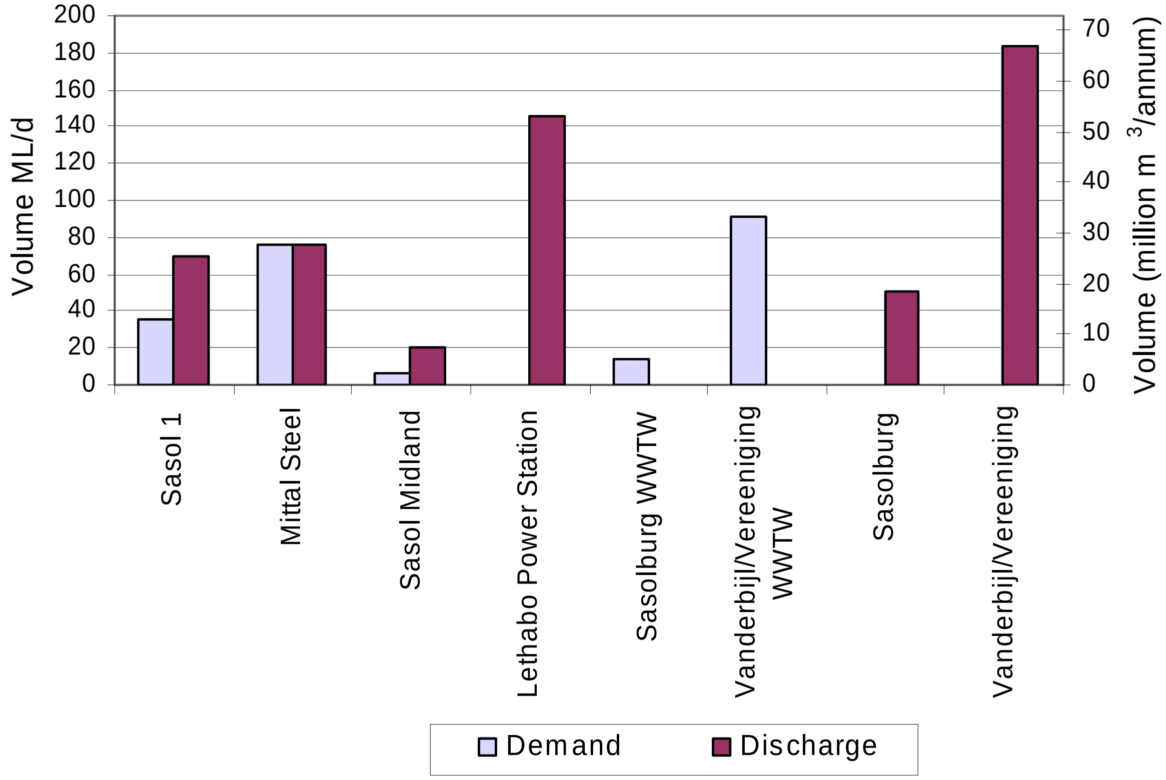

Figure 7.6: Current water demand and discharges in the Emfuleni area

The main water users in the area are Sasol One, Sasol Midlands, Lethabo Power Station and Mittal Steel. Information for the Sasol sites was obtained from a report drafted in answer to the questionnaire and that from the Mittal Steel site was obtained from its Water conservation and Demand Management Strategy.

Sasol

Sasol derives its water from raw water abstraction from the Suikerbosch abstraction line (conductivity of 20ms/m) and, to a minor extent, potable water from Rand Water. The original extraction point was the Vaal Barrage (conductivity of 80ms/m), which was considered too saline: the poorer the quality of the water, the higher the abstraction rate required to meet the water demand on site after treatment.

During the past few years the total water abstraction volume for the Sasol One and Midlands sites has been reduced due to the implementation of various projects; in addition significant improvements in the wastewater quality were also experienced:

- Raw water use reduction from average of 70 Ml/day to 52 Ml/day due to Natural gas implementation.
- The displacement of potable water as cooling water make-up on the Midland site with filtered flocculated water supplied from the Sasol One site.
- The closure of Steam Station 3 on the Midland site.
- The conversion from coal to a natural gas feedstock.

A Sasol Sasolburg Water Abstraction and Discharge model has been developed to assist in determining how current and future operations would influence the water abstraction requirements and discharge at both Sasol sites. The current Sasol water strategy is based on the principles of reduction at source followed by re-cycle and re-use and lastly treatment. A continuous 2% growth rate in water demand per year for current plants compounded over 10 years, with a 0% growth for discharge, has been modelled.

Sasol One and Sasol Midlands have the potential to supply Lethabo although treatment of the water will be required. Sasol could also re-use more water internally but the feasibility of this would need to be investigated carefully.

Mittal Steel

Mittal Steel abstracts water directly from the Vaal River and Vaal Dam. Approximately 50% of input water is evaporated due to the nature of the process in the manufacture of steel (high temperatures). Mittal Steel implemented a zero effluent discharge policy at the end of 2005 due to regulatory pressure, including the impending waste discharge charge system. The project team recommended that the precedent of zero effluent discharge be applied to other industries in the area, for example Sasol.

Due to the zero discharge, no water re-use options are available from Mittal Steel. No re-use options were identified to supply Mittal Steel since, compared to demand, discharge in the catchment is low and discharges that were available were not nearby.

Lethabo Power Station

Data for Lethabo was limited. Supply to Lethabo could be provided from Sasol or alternatively, Lethabo and the Vereeniging industrial area could also be supplied with treated sewage effluent from the region’s WWTW.

Re-use of water in the Emfuleni area is a quality rather than a quantity issue and will be assessed further in the Water Quality Task.

Vereeniging Industrial Area

Vereeniging has a large industrial area. Potentially this could be supplied with treated wastewater from the region. This would require a secondary reticulation network and would require further investigation.

Further options considered in the Emfuleni Area

A further option is to supply emerging small-scale farmers or resource poor agriculture with treated wastewater from the Emfuleni focus area. The area is expected to grow and will thus provide a reliable and consistent supply of wastewater into the future. This would be a new use of water in the Vaal and would not decrease demand. It might improve river quality by removing the salt load from the wastewater treatment works. However, depending on the irrigation method salt may find its way back to the river or into the soil or groundwater. The option could merely change the salt load from a point source to a diffuse source. The option was identified as a promising option at the re-use workshop since it aids in poverty alleviation.

Mining in the Emfuleni area is limited to coal mines in the Sasolburg area, which are essentially small scale (1.8Mt coal per annum) following the plant conversion to natural gas. No re-use options were therefore considered for the mining sector in this focus area.

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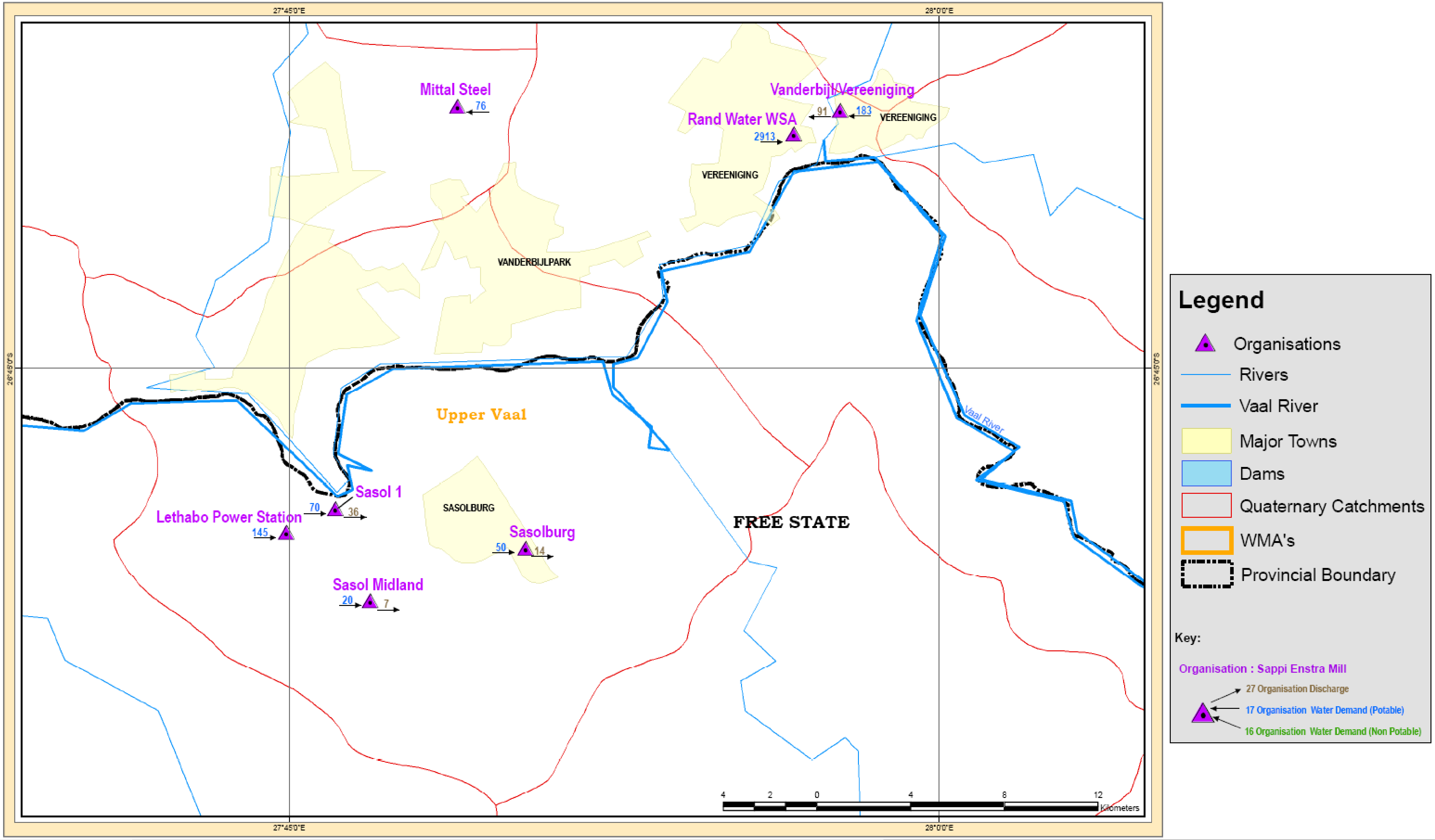

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	WGS84	LO 27		RVL Setiko	7.7

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5.1.4 KOSH FOCUS AREA

The KOSH region was identified as a focus area due to its significant mining operations. The demands and discharges of the main stakeholders in the area are presented in **Figure 7.8** and **Figure 7.9**.

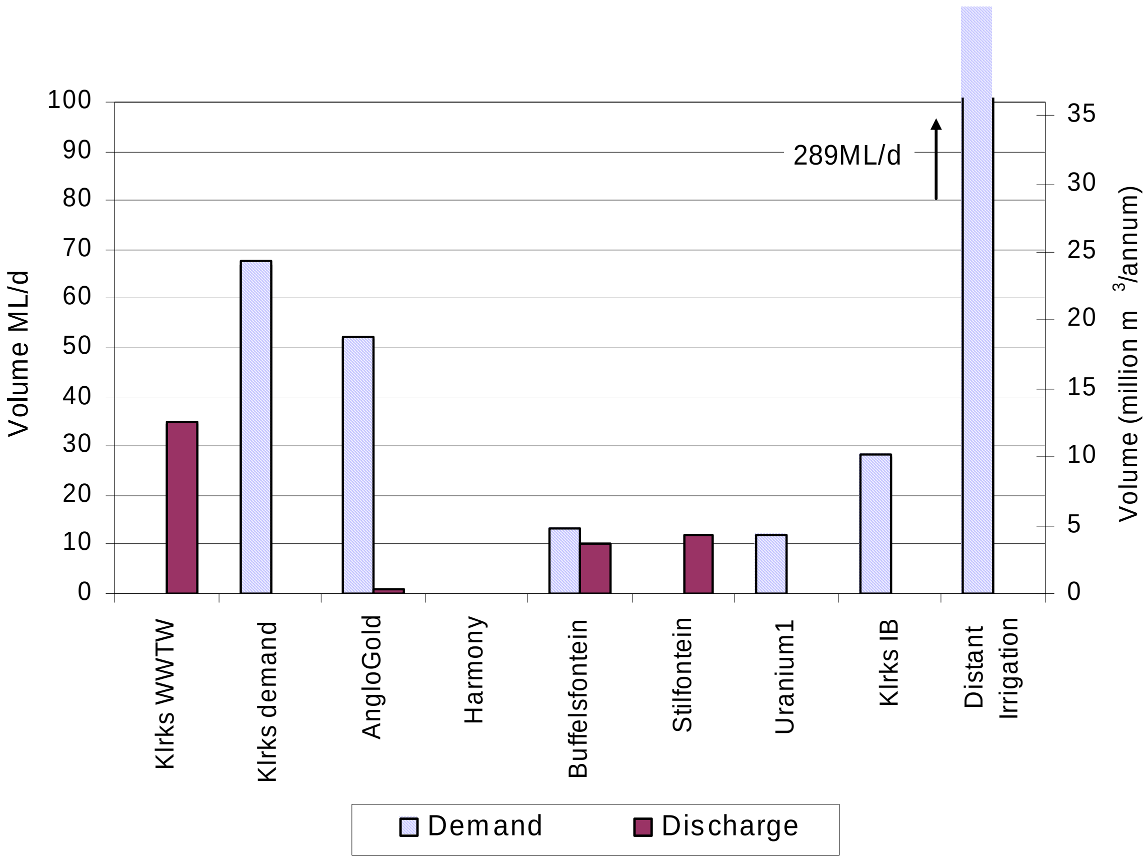

Figure 7.8: Current water demand and discharges in the KOSH area

The KOSH area is characterized by mining and hence no industrial water re-use options were identified for this area.

The main mines in the KOSH area are Stilfontein Gold Mine, Harmony Gold Orkney Shafts, AngloGold Ashanti Vaal River, Buffelsfontein Gold Mine and SXR Uranium 1 Mine. The KOSH area has ample infrastructure in terms of pipelines for re-use options.

Stilfontein Gold Mine is already closed but unless pumping continues at Stilfontein, the other mines in the catchment will be flooded. Hence pumping must continue until the last mine in the area closes, which will be around 2025. Stilfontein Gold Mine is currently in negotiations with Midvaal to supply Midvaal with its excess water. This water will require treatment prior to supplying Midvaal, which, at this stage, may make it too expensive for Midvaal to buy (pers comm. Marina Kruger). Currently all water in Stilfontein mine is pumped from underground. Another option, which has not been investigated, is to remove some of this water via boreholes before it enters the mine workings. This water is likely to be cleaner dolomitic water and this could then be supplied to Midvaal without the problem of pre-treatment. However, this option is not a re-use of water but rather a direct abstraction. As stated previously, the option of removal by boreholes has not been investigated in any detail and, at this stage, no parties in the region are willing to fund such an investigation. It would be in the best interests of the region for this to be investigated but DWAF or another outside party would need to facilitate this. Midvaal wants to increase its customer base, hence re-use will probably not be acceptable to Midvaal unless distribution of the re-used water is via Midvaal.

Buffelsfontein discharges some underground water, which could supply AngloGold Ashanti Vaal River with its non-potable water requirements. However, AngloGold fears that accepting this water will indicate implicit acceptance of responsibility for the water. AngloGold particularly fears the financial responsibility after Buffelsfontein closes if it is seen as responsible for the water. Once again, DWAF would need to step in to facilitate such a re-use option. In other respects the options is very feasible and will remove contaminated water from the system. Hence it was identified as a promising possible re-use option.

Uranium 1 will, by the end of this year, be supplied with 10ml/d of its total water requirement of 12 Ml/d from the Klerksdorp WWTW. The mine has a zero discharge.

Re-use of water in the area is a quality rather than a quantity issue and will be assessed further in the Water Quality Task of the study. A water quality model for the optimum mine water re-use scenario for Stilfontein-Buffeslfontein-Anglo gold-Midvaal has been run and is discussed in the: task of the Water Quality study.

The re-use of water from wastewater treatment plants was not considered in the KOSH area. The supply of such water is dependant on the urban population, which is in turn dependant on the mines. The mines could close at some time in the future and as such re-use of wastewater was not considered viable as dependency on an unreliable source may be created.

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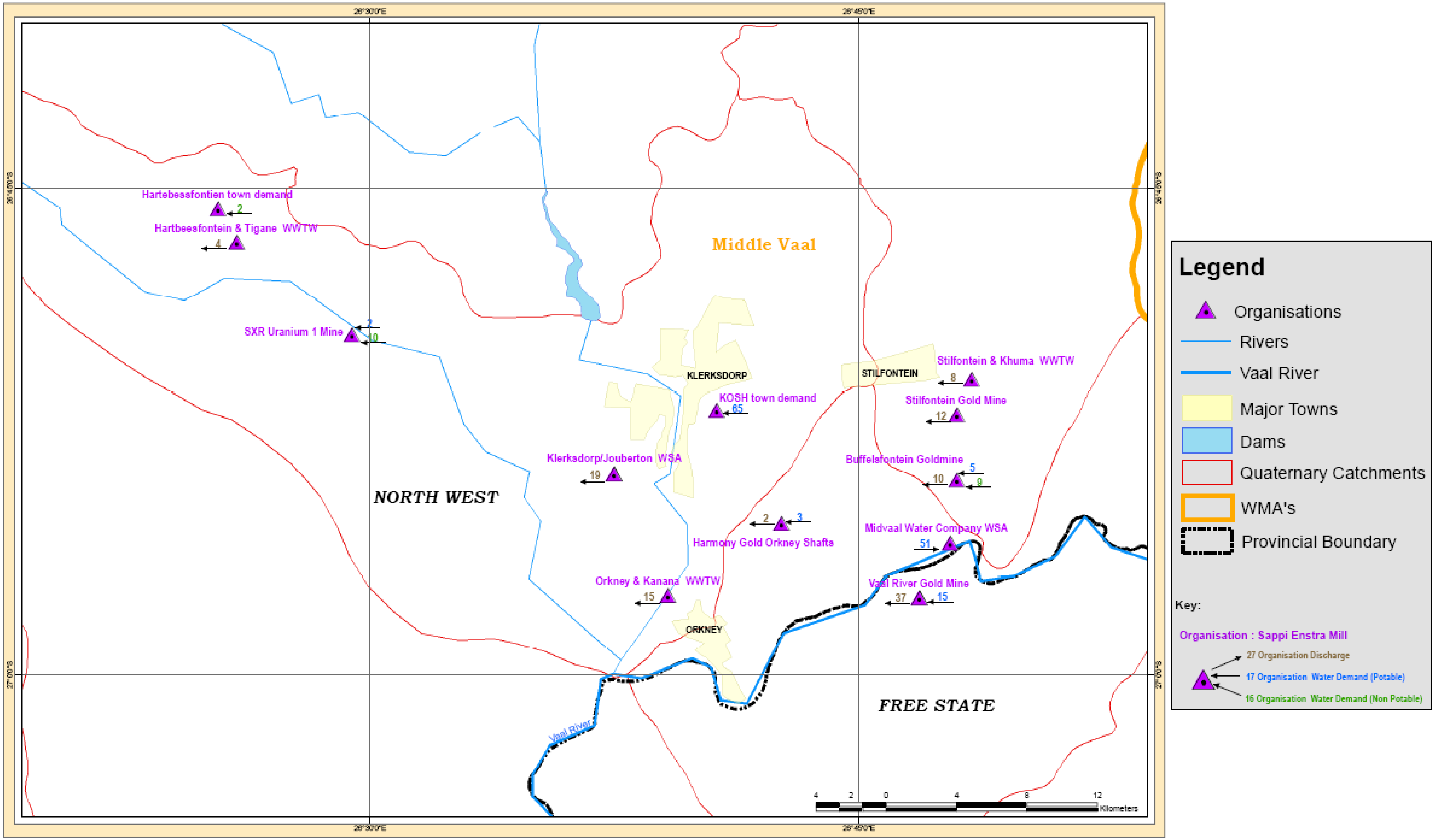

PROJECT NO.	COORDINATE SYTEM			DATE	SCALE
335412	Decimal Degrees		**Locality Plan of Water Demand and Discharges in the Kosh Region**	29/11/2006	1: 200 000
	SPHEROID: WGS84	CENTRAL MERIDIAN: LO 27		COMPILED BY: RVL Setiko	FIG NO.: 7.9

Path: J:\Proj\335412\GIS\MXD\Kosh Region_270606.mxd

5.2 GENERAL RE-USE OPTIONS APPLICABLE TO ALL FOCUS AREAS

Several re-use options were identified that are applicable to all focus areas.

5.2.1 TREATED WASTED WATER RE-USED DOMESTICALLY

Most towns in the study area have an approximate return flow of 55% which could supplement the existing potable water supply for water uses that do not required potable water quality, such as flushing of toilets, cleaning etc (refer to **Table 4.2**). This re-use option could be implemented on a small scale as a case study to test its viability prior to full-scale implementation in an applicable urban area.

Full-scale potable supply from treated sewage effluent has both quality and social issues (negative public perception) and is currently not considered viable by the project team.

5.2.2 PARK, GARDENS AND SPORTS FACILITIES

Irrigation of sports facilities, golf courses and other grounds requires high volumes of less than potable quality water, which can be supplied by treated sewage effluent. Certain towns have designed their systems to make the re-use of treated sewage effluent on parks and gardens possible. For example, Klerksdorp irrigates parks and gardens in close proximity to its WWTW with treated wastewater. Irrigation of these parks and gardens has been occurring for the last for 30 years. Currently about 150 Ml/annum (0.41Ml/d) is used. Klerksdorp City Council considers further extension of this re-use option as logistically unviable due to the cost involved in extending the pipeline infrastructure to all parks and gardens spread across the city. This constraint will be similar in all cities.

This option may be viable for other towns where the proximity of the treated sewage effluent and topography of the terrain render this option cost effective. This will need to be assessed on a case-by-case basis. However, the amount of water that could be used in this way would be very small in the context of the whole Vaal System and is thus beyond the scope of this study. The logistics of supplying all parks and gardens in towns and cities with treated sewage effluent was not considered viable. A secondary network of pipes would be required and would be costly. Further, it would be difficult to stop the public from accessing this water and using it for drinking resulting in a public health risk.

5.2.3 AGRICULTURAL USE – EXISTING IRRIGATION AND LIVESTOCK WATERING

Wastewater, Industrial discharges or mine discharges from all the regions in the study area could be re-used in existing irrigation schemes. Currently some agricultural irrigation with treated wastewater does exist. For example, in Klerksdorp, 206Ml/annum (0.56ML/annum) of water from the WWTW goes to a cattle farm (pers comm. Jan Harold). However, this represents a very small volume of water and was not considered further as part of this study.

The supply of large irrigation schemes already in place, with discharge water was also initially considered. In such a case a bigger volume can be used and, except for transporting water to the intake, the reticulation is already in place. However, this option already effectively occurs in many cases since wastewater treatment works, mines and industries discharge to rivers, which are then used for irrigation. Hence, this option was ruled out at the water re-use workshop and not considered further as part of this study.

5.2.4 LARGE SCALE SCHEMES FOR RE-USE OF WASTEWATER IDENTIFEID

Augmentation of the Vaal River System from Joburg's Northern WWTW which presently discharges to Hartebeespoort Dam was described in **Table 4.4**. Another option under consideration is supply of Tshwane Metro (Crocodile-Marico catchment) from ERWAT in Ekurhuleni. The Crocodile Reconciliation Study is dealing with these options.

6 LIST OF POTENTIAL RE-USE OPTIONS

The re-use options identified in the preceding sections that are to be assessed further are listed below. These options were identified by a desktop study and then further streamlined via a re-use workshop involving DWAF and several consultants.

- Ekurhuleni:
  - Petrex to supply Rand Water for municipal supply.
  - Community irrigation with treated wastewater effluent.
- West Rand:
  - None
- Emfuleni:
  - Internal re-use of water by Sasol and/or re-use of Sasol discharge by Lethabo.
  - Dual water supply system for industry, considering the four largest industries in the area;
  - Community irrigation with treated wastewater effluent.
- KOSH:
  - Stilfontein Mine to supply Midvaal.
  - Buffeslfontein Mine to supply Anglo gold Mine.

During the re-use workshop fatally flawed and non-viable options were identified as re-use of water from Kloof Mine and Randfontein Estates, respectively.

7 SCREENING OF RE-USE OPTIONS

The objective of the screening of the re-use options listed in **Section 8** of this report is to quantitatively identify the most feasible option(s) for further investigation. Feasibility ultimately depends on the long term sustainability of the option.

Each option has been screened according to the criteria in **Table 9.2**, which includes the three pillars of sustainable development, namely financial, environmental and social. The financial pillar (technical issues and financial considerations) has been given the greatest weighting as viability of the selected re-use option is ultimately dependent on the costs associated with construction, operation and maintenance. The social pillar is given a lower weighting than the environmental pillar (environmental and ecological considerations) as negative impacts on society can be more readily mitigated than those on the environment, for example, it is often far easier to source an alternative water supply for a community than to clean up the degraded resource, which will continue to negatively impact on the environment.

The results of the screening are summarised in **Table 9.1** and detailed in **Tables 9.3 – 9.8**. The higher the total score, the more sustainable the option based on the ranking in **Table 9.2**. The screening identified the Petrex option and the two KOSH options as the most promising although all options were found to be highly sustainable.

Table 9.1: Summary of screening and suitability of re-use options

Preliminary ranking								Suitability			
Option	Technical feasibility	Financial considerations	Ecological considerations	Environmental considerations	Social considerations	Total score	Relevant Table	Sustainability potential based on total score	Adequate information is available for this option to be considered further	Re-use applicable to limited areas only	Option to be investigated further in this study
Petrex	58.5	24	27	18	20.5	148	9.3	High	Yes	Yes	Yes
Sasol	51	18	32	22	19	142	9.4	High	No	Yes	No
Emfuleni	48	18	30	18	17.5	131.5	9.5	High	No	Yes	No
KOSH1	54	21	32	20	17	144	9.6	High	Yes	Yes	Yes
KOSH2	57	24	34	18	19	152	9.7	High	Yes	Yes	Yes
Irrigation	54	18	27	16	17	132	9.8	High	No	No	No

Table 9.2: Screening criteria

Category	Sub-category		Ranking
Technical feasibility	Available quantity to meet demand		5: Highly feasible
	Reliability of supply		4: Feasible
	Concentration of constituents through recycling		3: Moderately feasible
	Distance/topography between supply and demand		2: Unlikely
	Infrastructure requirements		1: Fatally flawed
	WEIGHTING: 3	SCORE	15-75
Financial considerations	Relative capital expenditure required		5: Highly feasible
	Relative operation and maintenance costs		4: Feasible
			3: Moderately feasible
			2: Unlikely
			1: Fatally flawed
	WEIGHTING: 3	SCORE	6-30
Environmental considerations	Change in erosion and scouring potential in the downstream watercourse		5: Significant positive impact
	Altered flow regime		4: Positive impact
	Change in water quality in the downstream watercourse		3: Minimal impact
	Implications for the river classification and reserve determination: changes in quantity and quality could effect both		2: Negative impact
	Change in soil quality		1: Significant negative impact/fatally flawed
	WEIGHTING: 2	SCORE	10-50
Ecological considerations	Change in habitat in the downstream watercourse due to altered flow regime		5: Significant positive impact
	Change in biodiversity in the downstream watercourse due to altered water quality		4: Positive impact
	Reversion to pre-discharge conditions (could be positive if the discharge to be recycled currently has a negative impact on the water course, and negative if the discharge has dilution effects in the watercourse)		3: Minimal impact
			2: Negative impact
			1: Significant negative impact/fatally flawed
	WEIGHTING: 2	SCORE	6-30
Social considerations	Public perception		5: Significant positive impact
	Change in downstream availability due to quality or quantity (re-use may negatively impact downstream users reliant on upstream discharges)		4: Positive impact
	Change in supply to end user – quality and quantity (health implications)		3: Minimal impact
	Change in cost to end user – cost saving versus additional expense		2: Negative impact
	Aesthetic impact: sight, noise, smell and taste		1: Significant negative impact/fatally flawed
	Job creation		
	WEIGHTING: 1	SCORE	6-30

Category	Sub-category	Ranking
Sustainability considering previous criteria	Total score: 175-220	Very high potential to be sustainable
	Total score: 130-175	High potential to be sustainable
	Total score: 95-130	Moderately sustainable
	Total score: 60-95	Low potential to be sustainable
	Total score: <60	Unlikely to be sustainable/fatally flawed

Table 9.3: Petrex water re-use option (Ekurhuleni)

Category	Sub-category	Ranking	Comment
Technical feasibility	Available quantity to meet demand	5	At least 40Ml is available and 40Ml is required by 2015
	Reliability of supply	5	Cost effectiveness and risks to dolomite aquifer should ensure supply
	Concentration of constituents through recycling	2.5	Brine from desalination
	Distance/topography between supply and demand	4	A close distance is planned
	Infrastructure requirements	3	Desalination plant
	WEIGHTING: 3 SCORE	58.5	
Financial considerations	Relative capital expenditure required	3	Petrex is only willing to pay part of the costs of a desalination plant
	Relative operation and maintenance costs	5	End users should be able to absorb the costs
	WEIGHTING: 3 SCORE	24	
Environmental considerations	Change in erosion and scouring potential in the downstream watercourse	3	Potential positive impact in Blesbokspruit but this potential may be transferred elsewhere depending on the WWTW ultimately receiving the re-used water
	Altered flow regime	3	Potential impact in Blesbokspruit but flow may be altered elsewhere depending on the WWTW ultimately receiving the re-used water
	Change in water quality in the downstream watercourse	2	Blesbokspruit quality may decline due to removal of dilution effect of Petrex water but this depends on the WWTW ultimately receiving the water
	Implications for the river classification and reserve determination: changes in quantity and quality could effect both	2.5	Changes in quality and quantity are likely
	Change in soil quality	3	Little change expected
	WEIGHTING: 2 SCORE	27	
Ecological considerations	Change in habitat in the downstream watercourse due to altered flow regime	3	Potential impact in Blesbokspruit but flow may be altered elsewhere depending on the WWTW ultimately receiving the re-used water
	Change in biodiversity in the downstream watercourse due to altered water quality	3	Blesbokspruit quality and hence biodiversity may decline due to removal of dilution effect of Petrex water but this depends on the WWTW ultimately receiving the water
	Reversion to pre-discharge conditions (could be positive if the discharge to be recycled currently has a negative impact on the water course, and negative if the discharge has dilution effects in the watercourse)	3	Unlikely
	WEIGHTING: 2 SCORE	18	
Social considerations	Public perception	2.5	The public tends to perceive mine water as unsafe. Education and communication is required to reverse this perception
	Change in downstream availability due to quality or quantity (re-use may negatively impact downstream users reliant on upstream discharges)	4	Little change is expected
	Change in supply to end user – quality and quantity (health implications)	3	None

Category	Sub-category		Ranking	Comment
	Change in cost to end user – cost saving versus additional expense		4	None - operational cost should be the same as current costs
	Aesthetic impact: sight, noise, smell and taste		3	Possible small impact
	Job creation		4	Some jobs will be retained at the water treatment plant after mine closure
	WEIGHTING: 1	SCORE	20.5	
Other considerations / comments	Petrex requires other stakeholders to participate to make costs effective. Disposal of brine may be a problem			
Sustainability considering previous criteria	**Total score**		148	
	Ranking		High potential to be sustainable	

Table 9.4: Sasol water re-use option (Emfuleni)

Category	Sub-category	Ranking	Comment
Technical feasibility	Available quantity to meet demand	3	36Ml/d is available; demand is 70Ml/d for Sasol and 145Ml/d for Lethabo
	Reliability of supply	4	No closure of Sasol is foreseen
	Concentration of constituents through recycling	3	Possible due to evaporation at Lethabo
	Distance/topography between supply and demand	4	Depends on recipient of the water: both options are < 5km
	Infrastructure requirements	3	Treatment will be required
	WEIGHTING: 3 SCORE	51	
Financial considerations	Relative capital expenditure required	3	Treatment plant
	Relative operation and maintenance costs	3	Ongoing treatment costs
	WEIGHTING: 3 SCORE	18	
Environmental considerations	Change in erosion and scouring potential in the downstream watercourse	3	Reduction in both abstraction and discharge will result in little change
	Altered flow regime	3	Reduction in both abstraction and discharge will result in little change
	Change in water quality in the downstream watercourse	4	Anticipated to improve due to contaminant removal
	Implications for the river classification and reserve determination: changes in quantity and quality could effect both	3	Negligible change in quantity; quality may improve
	Change in soil quality	3	No change expected
	WEIGHTING: 2 SCORE	32	
Ecological considerations	Change in habitat in the downstream watercourse due to altered flow regime	3	Reduction in both abstraction and discharge will result in little change
	Change in biodiversity in the downstream watercourse due to altered water quality	4	Anticipated to improve due to improved water quality
	Reversion to pre-discharge conditions (could be positive if the discharge to be recycled currently has a negative impact on the water course, and negative if the discharge has dilution effects in the watercourse)	4	Anticipated to improve due to improved water quality
	WEIGHTING: 2 SCORE	22	
Social considerations	Public perception	4	Perception related to environmental awareness as this water will not be used for potable purposes
	Change in downstream availability due to quality or quantity (re-use may negatively impact downstream users reliant on upstream discharges)	3	Negligible change in quantity; quality may improve.
	Change in supply to end user – quality and quantity (health implications)	3	No change if treatment adequate
	Change in cost to end user – cost saving versus additional expense	2	Cost implications for Sasol and/or Lethabo
	Aesthetic impact: sight, noise, smell and taste	3	Possible small impact due to treatment plant
	Job creation	4	Possible jobs at treatment plant
	WEIGHTING: 1 SCORE	19	

Category	Sub-category	Ranking	Comment
Other considerations / comments	Sasol and Lethabo's perspective on the idea needs to be considered		
Sustainability considering previous criteria	**Total score**	**142**	
	Ranking	High potential to be sustainable	

Table 9.5: Emfuleni WWTW re-use for industry

Category	Sub-category	Ranking	Comment
Technical feasibility	Available quantity to meet demand	3	Large volume of wastewater available; full demand unknown
	Reliability of supply	4	Reliable in these urban areas with no foreseeable population decline
	Concentration of constituents through recycling	3	Possible
	Distance/topography between supply and demand	3	Specific areas not yet targeted but distance is unlikely to be far
	Infrastructure requirements	3	Additional treatment may be required and separate reticulation will be required
	WEIGHTING: 3 SCORE	48	
Financial considerations	Relative capital expenditure required	2	Separate reticulation and possibly a final treatment step at the WWTW or pre-treatment at the industry
	Relative operation and maintenance costs	3	Depends on treatment required
	WEIGHTING: 3 SCORE	17	
Environmental considerations	Change in erosion and scouring potential in the downstream watercourse	3.5	Discharge likely to decrease
	Altered flow regime	3.5	Discharge likely to decrease
	Change in water quality in the downstream watercourse*	3	Water quality may improve depending on baseline water quality in the resource
	Implications for the river classification and reserve determination: changes in quantity and quality could effect both	3.5	Discharge likely to decrease and quality may improve
	Change in soil quality	3	No change expected
	WEIGHTING: 2 SCORE	31.5	
Ecological considerations	Change in habitat in the downstream watercourse due to altered flow regime	3.5	Discharge likely to decrease
	Change in biodiversity in the downstream watercourse due to altered water quality	3	Quality may improve depending on baseline water quality in the resource
	Reversion to pre-discharge conditions (could be positive if the discharge to be recycled currently has a negative impact on the water course, and negative if the discharge has dilution effects in the watercourse)	3	Quantity likely to decrease and quality may improve
	WEIGHTING: 2 SCORE	18.5	
Social considerations	Public perception	4	Perception related to environmental awareness as this water will not be used for potable purposes
	Change in downstream availability due to quality or quantity (re-use may negatively impact downstream users reliant on upstream discharges)	3	Quantity likely to decrease and quality may improve
	Change in supply to end user – quality and quantity (health implications)	2.5	Quality of effluent may not be adequate for industrial processes and hence the effluent may require pre-treatment
	Change in cost to end user – cost saving versus additional expense	2.5	Added reticulation may increase cost depending on who pays
	Aesthetic impact: sight, noise, smell and taste	2.5	Impact during installation of reticulation
	Job creation	3	Unlikely in the long term
	WEIGHTING: 1 SCORE	17.5	

Category	Sub-category	Ranking	Comment
Other considerations / comments	Screening for this option is generic as specific industries to target for this option are yet to be identified.		
Sustainability considering previous criteria	**Total score**	**132.5**	
	Ranking	**High potential to be sustainable**	

*Ranking may change based on water quality modelling done in Water Quality

Table 9.6: Stilfontein-Midvaal water re-use option (KOSH1)

Category	Sub-category	Ranking	Comment
Technical feasibility	Available quantity to meet demand	3	Available but demand is limited due to quality
	Reliability of supply	5	The mine must keep pumping until all mines affecting dewatering close; demand will then be low due to the closures and consequent job losses
	Concentration of constituents through recycling	3	Midvaal will treat the water
	Distance/topography between supply and demand	4	Midvaal is located downgradient of Stilfontein and is at a distance of <10km away
	Infrastructure requirements	3	Treatment is required but pipes are available
	WEIGHTING: 3 SCORE	54	
Financial considerations	Relative capital expenditure required	4	A treatment plant is costly; the source of funding is a problem
	Relative operation and maintenance costs	3	End users may be able to absorb costs
	WEIGHTING: 3 SCORE	21	
Environmental considerations	Change in erosion and scouring potential in the downstream watercourse	3	Reduction in both abstraction and discharge will result in little change
	Altered flow regime	3	Reduction in both abstraction and discharge will result in little change
	Change in water quality in the downstream watercourse*	4	Quality may improve due to treatment
	Implications for the river classification and reserve determination: changes in quantity and quality could effect both	3	Reduction in both abstraction and discharge will result in little change, however quality may improve due to treatment
	Change in soil quality	3	No change expected
	WEIGHTING: 2 SCORE	32	
Ecological considerations	Change in habitat in the downstream watercourse due to altered flow regime	3	Reduction in both abstraction and discharge will result in little change
	Change in biodiversity in the downstream watercourse due to altered water quality	4	Reduction in both abstraction and discharge will result in little change
	Reversion to pre-discharge conditions (could be positive if the discharge to be recycled currently has a negative impact on the water course, and negative if the discharge has dilution effects in the watercourse)	3	Reduction in both abstraction and discharge will result in little change
	WEIGHTING: 2 SCORE	20	
Social considerations	Public perception	2	Public perceives mine water as unsafe
	Change in downstream availability due to quality or quantity (re-use may negatively impact downstream users reliant on upstream discharges)	3	Reduction in both abstraction and discharge will result in little change
	Change in supply to end user – quality and quantity (health implications)	3	Reduction in both abstraction and discharge will result in little change
	Change in cost to end user – cost saving versus additional expense	3	Public buying from Midvaal may experience increases
	Aesthetic impact: sight, noise, smell and taste	3	Treatment plant will be amongst other facilities and is therefore unlikely to be very noticeable

Category	Sub-category		Ranking	Comment
	Job creation		3	None. Perception of job security at Stilfontein mine may improve due to profitability
	WEIGHTING: 1	SCORE	17	
Other considerations / comments	The cost effectiveness of this option is the biggest obstacle. No one is willing to spend on it but the region will benefit from it			
Sustainability considering previous criteria	**Total score**		**144**	
	Ranking		**High potential to be sustainable**	

*Ranking may change based on water quality modelling done in Water Quality.

Table 9.7: Buffeslfontein-Anglo gold water re-use option (KOSH2)

Category	Sub-category	Ranking	Comment
Technical feasibility	Available quantity to meet demand	3	10Ml/d is available and up to 15Ml/d is required
	Reliability of supply	5	Pumping will have to continue until Anglo Gold Ashanti closes
	Concentration of constituents through recycling	3	Some is possible
	Distance/topography between supply and demand	4	Anglo Gold Ashanti is located downgradient of Buffelsfontein and is at a distance of <10km away
	Infrastructure requirements	4	Pipelines are available but treatment may be required
	WEIGHTING: 3 SCORE	57	
Financial considerations	Relative capital expenditure required	4	It is unlikely that a high level of treatment will be required
	Relative operation and maintenance costs	4	Costs are likely to remain similar to the current costs
	WEIGHTING: 3 SCORE	24	
Environmental considerations	Change in erosion and scouring potential in the downstream watercourse	3	Reduction in both abstraction and discharge will result in little change
	Altered flow regime	3	Reduction in both abstraction and discharge will result in little change
	Change in water quality in the downstream watercourse	4	Quality may improve due to reduced discharge
	Implications for the river classification and reserve determination: changes in quantity and quality could effect both	4	Quality may improve due to reduced discharge; quantity likely to stay the same
	Change in soil quality	3	No change is likely
	WEIGHTING: 2 SCORE	34	
Ecological considerations	Change in habitat in the downstream watercourse due to altered flow regime	3	Reduction in both abstraction and discharge will result in little change
	Change in biodiversity in the downstream watercourse due to altered water quality	3	Quality may improve due to reduced discharge
	Reversion to pre-discharge conditions (could be positive if the discharge to be recycled currently has a negative impact on the water course, and negative if the discharge has dilution effects in the watercourse)	3	Reduction in both abstraction and discharge will result in little change
	WEIGHTING: 2 SCORE	18	
Social considerations	Public perception	4	Not used for potable supply. Perception probably good - environmental awareness
	Change in downstream availability due to quality or quantity (re-use may negatively impact downstream users reliant on upstream discharges)	3	Quality may improve due to reduced discharge. Quantity likely to stay the same
	Change in supply to end user – quality and quantity (health implications)	3	Quality may improve due to reduced discharge. Quantity likely to stay the same
	Change in cost to end user – cost saving versus additional expense	3	No change expected
	Aesthetic impact: sight, noise, smell and taste	3	Treatment plant will be amongst other facilities and is unlikely to be noticeable

Category	Sub-category		Ranking	Comment
	Job creation		3	Unlikely to create any jobs
	WEIGHTING: 1	SCORE	19	
Other considerations / comments	Anglo Gold fears that taking the water will imply responsibility for it, and hence they will be saddled with the pumping costs when Buffelsfontein closes			
Sustainability considering previous criteria	**Total score**		**152**	
	Ranking		**High potential to be sustainable**	

Table 9.8: Community irrigation with treated WWTW effluent

Category	Sub-category	Ranking	Comment
Technical feasibility	Available quantity to meet demand	4	Large volume available; demand uncertain
	Reliability of supply	5	Reliable in these urban areas with no foreseeable population decline
	Concentration of constituents through recycling	3	Concentration likely in soil (refer to environmental considerations)
	Distance/topography between supply and demand	3	Depends on area.
	Infrastructure requirements	3	Additional treatment may be required to limit concentration effects
	WEIGHTING: 3 SCORE	54	
Financial considerations	Relative capital expenditure required	3	Irrigation infrastructure, education and training
	Relative operation and maintenance costs	3	Ongoing reticulation maintenance; monitoring of water and food crops
	WEIGHTING: 3 SCORE	18	
Environmental considerations	Change in erosion and scouring potential in the downstream watercourse	3.5	Reduced discharge
	Altered flow regime	2	Reduced discharge
	Change in water quality in the downstream watercourse	3	Depends on quality of base flow in watercourse i.e. is effluent to be re-used diluting or polluting the resource
	Implications for the river classification and reserve determination: changes in quantity and quality could effect both	3	Changes in quantity and quantity
	Change in soil quality	2	Likely to be negative unless managed
	WEIGHTING: 2 SCORE	27	
Ecological considerations	Change in habitat in the downstream watercourse due to altered flow regime	2	Reduced discharge may affect available habitat if the WWTW effluent maintains a perennial status in the river.
	Change in biodiversity in the downstream watercourse due to altered water quality	3	Depends on quality of base flow in watercourse i.e. is effluent to be re-used diluting or polluting the resource
	Reversion to pre-discharge conditions (could be positive if the discharge to be recycled currently has a negative impact on the water course, and negative if the discharge has dilution effects in the watercourse)	3	Reversion unlikely
	WEIGHTING: 2 SCORE	16	
Social considerations	Public perception	2	Public likely to regard water as unsafe
	Change in downstream availability due to quality or quantity (re-use may negatively impact downstream users reliant on upstream discharges)	2	Less water will be available downstream
	Change in supply to end user – quality and quantity (health implications)	2	Possible health risks for irrigators - planning and management required
	Change in cost to end user – cost saving versus additional expense	4	Waste water irrigation affords potential economic benefits through provision of food and should be available at no cost
	Aesthetic impact: sight, noise, smell and taste	3	Possible impacts - may only be perceived
	Job creation	4	May create economic activity if not formal jobs
	WEIGHTING: 1 SCORE	17	

Category	Sub-category	Ranking	Comment
Other considerations / comments	Further detailed investigation would be required to fully establish health risks versus benefits to emerging farmers		
Sustainability considering previous criteria	**Total score**	**132**	
	Ranking	**High potential to be sustainable**	

8 FURTHER ASSESSMENT OF PROPOSED OPTIONS FOR RE-USE

Based on the screening in Section 7, the following options are proposed depending on the outcomes of further investigation:

- Petrex: supply of water from Petrex to Rand Water to secure future water supply needs.
- KOSH1: supply of Stilfontein Mine water to Midvaal.
- KOSH2: Buffelsfontein-Anglo gold mine to mine water supply.

9 PRELIMINARY COSTING

Preliminary cost of the most feasible proposed options will be carried out for approved options only.

10 FURTHER INVESTIGATIONS REQUIRED

The following will be required to fully assess the feasibility of the proposed options:

- Regulatory aspects of the proposed options need to be considered, for example, the need for a water use licence, restructuring of current tariff structures (WDCS) etc.
- The role of water boards in the supply chain i.e. mine to water board to mine supply, needs to be investigated as does ownership and management of infrastructure, such as treatment plants and pipelines, especially after mine closure.
- The influence that government policy, with regards to regional development, may have on the proposed options.
- Analysis should be undertaken to determine the likely eutrophic and salinity status after implementation of the re-use options (this forms part of the Water Quality task of the study).
- Based on the analysis, treatment and/or management options required for the re-used water

need to be determined.

- Verification of the preliminary cost estimates associated with the re-use option as part of a broader cost-benefit analysis, including cradle to grave evaluation and a cleaner production assessment.

11 RECOMMENDATIONS

It is recommended that the following options be investigated further and appropriate cost estimate be done:

- First priority: Petrex
- Second priority: KOSH1
- Third priority:KOSH2

The Sasol, Emfuleni and irrigation options could be considered in the future.

Uncertainty still exists and thus further investigation is required regarding the recommended options:

- Much of the data is based on estimates.
- Mine closure dates can change based on gold prices.
- Quality may have a large impact and is dealt with separately under the Water Quality task.

A further recommendation is that the role of water boards in the supply chain i.e. mine to water board to mine supply, should be investigated as well as ownership and management of infrastructure, such as treatment plants and pipelines, especially after mine closure.

12 REFERENCES

City Council of Klerksdorp (2005)
City Council of Klerksdorp, South Africa, 2005,
WSDP – Water Services Development Plan
Compiled by Moedi Consulting Engineers (Pty) Ltd, 2005

DACE (2003).
Department of Agriculture, Conservation and Environment, South Africa, 2003,
Strategic Plan of the Department of Agriculture, conservation and Environment 2003/4 – 2005/6.

DWA (1984)
Department of Water Affairs, South Africa, 1984
Report No. PC000/00/0584, **'n Breë Oorsig oor Waterbronontwikkeling vir die Vaalrivierstelsel,** Compiled by the Department of Water Affairs, Directorate of project planning, 1984

DWA (1985)
Department of Water Affairs, South Africa, 1985
Report No. PC 000/00/3185. **Vaal river water quality management study: optimum utilisation of purified effluent in the region north of the Witwatersrand,** Combined by Stewart Sviridov and Oliver Consulting Engineers, On behalf of the Directorate of Planning , 1985

DWAF (2004a)
Department of Water Affairs and Forestry, South Africa, 2004
Report No. P WMA 08/000/00/0304. **Internal Strategic Perspective: Upper Vaal Water Management Area**. Compiled by PDNA, WRP Consulting Engineers (Pty) Ltd, WMB and Kwezi-V3 on behalf of the Directorate: National Water Resource Planning, 2004.

DWAF (2004b)
Department of Water Affairs and Forestry, South Africa, 2004
Report No. P WMA 09/000/00/0304. **Internal Strategic Perspective: Middle Vaal Water Management Area**. Compiled by PDNA, WRP Consulting Engineers (Pty) Ltd, WMB and Kwezi-V3 on behalf of the Directorate: National Water Resource Planning, 2004.

DWAF (2004c)
Department of Water Affairs and Forestry, South Africa, 2004
Report No. P WMA 10/000/00/0304. **Internal Strategic Perspective: Lower Vaal Water Management Area**. Compiled by PDNA, WRP Consulting Engineers (Pty) Ltd, WMB and Kwezi-V3 on behalf of the Directorate: National Water Resource Planning, 2004.

DWAF (2004d)	Department of Water Affairs and Forestry, South Africa, 2004 *Report Number P RSA C/000/00/0103*. **Internal Strategic Perspective: Vaal River System: Overcatching**. Compiled by PDNA, WRP Consulting Engineers (Pty) Ltd, WMB and Kwezi-V3 on behalf of the Directorate: National Water Resource Planning, 2004.
DWAF (2004e)	Department of Water Affairs and Forestry, South Africa, 2004, *Report Number P WMA 03/000/00/1104*. **Crocodile (West) River Return Flow Analysis Study: Relationship Algorithms and Calibration.** Prepared by the Consultants: DMM Development Consultants CC Laubscher Smith Engineers (Pty) Ltd. and WRP Consulting Engineers (Pty) Ltd.
DWAF (2005)	Department of Water Affairs and Forestry, South Africa, 2005, *Report Number P WMA ??/000/00/??05.* **Vaal River System: Development of an Integrated Water Quality Management Plan: Inception Report***.* Prepared by the Consultants: Zitholele Consulting, Golder Associates, DMM Development Consultants CC and WRP Consulting Engineers (Pty) Ltd.
DWAF (2005)	Department of Water Affairs and Forestry, South Africa, 2005, *Report Number ???* . **Vaal River System: large bulk water supply reconciliation strategies: literature review report, Department of Water Affairs and Forestry**
Department of Energy (2003)	Department of Energy, United Sates, 2003, *Report Number* ***???*****. Water Use in Industries of the Future:** Mining Industry. Center for Waste Reduction Technologies for U.S. Department of Energy. Prepared by: Mavis J.
Desalination (2001)	Desalination, Cyprus, 2001, *Journal of desalination 138 (2001), 55-59*. **Case study-wastewater re-use in Limassol as an alternative water source.** Prepared by: Papaiacovou, I.
Desalination (1995)	Desalination, Australia, 1995, *Journal of Desalination 106 (1996),, 233 -240,* **Reclaimed water – an untapped resource.** Prepared by: Van Leeuwen, J. (Hans).
Etschmann (2000)	Etschmann, D. 2000 **Water use and wastewater re-use industry and agriculture in Chile: an analysis concerning the use of partially treated and untreated wastewater from agro industrial production in agriculture**. Technology Resource Management & Development - Scientific Contributions for Sustainable Development, Vol. 2, Chile.

FAO (2003)	Food and Agriculture Organisation of the United Nations, United States, 2003 *Report Number ISSN 0254-5284*. *Irrigation and drainage paper 61.* **Agricultural drainage water management in arid and semi-arid areas.**
Food and agriculture organization of the United Nations (1992)	Food and agriculture organization of the United Nations, Italia, 1992, **Wastewater treatment and use in agriculture - FAO irrigation and drainage paper 47**.Food and agriculture organization of the United Nations. Prepared by: Pescod, M.B.
Government of South Australia (2004)	Government of Southern Australia, Australia, 2004, **Water Proofing Adelaide, information sheet: large-scale wastewater re-use. Government of South Australia.**
Offringa (2006)	Presentation at enviroWater conference, South Africa, 2006, **Water supply in South Africa - formidable challenges and innovative solutions, Water Research Commission. Presentation at enviroWater conference**. Prepared by:, G. Offringa,
Pers comm. Marina Kruger	Personal communication per telephone, Marina Kruger Midvaal Water Company, 18/05/2006
Pers comm. Jan Harold	Personal communication per telephone, Jan Harold, Klerksdorp City Council, 17/05/2006
Pescod (1992)	FAO irrigation and drainage paper 47.Food and agriculture organization of the United Nations, **Wastewater treatment and use in agriculture** (Rome, 1992)
Presentation at enviroWater conference (2003)	Presentation at enviroWater conference, South Africa, 2003 **Treatment of wastewater for re-use in the drinking water system of Windhoek. City of Windhoek. Presentation at enviroWater conference.** Prepared by: Menges, J.
Technology Resource Management & Development (2000)	Scientific Contributions for Sustainable Development, Chile, 2000, *Vol. 2*. **Water use and wastewater re-use industry and agriculture in Chile**: an analysis concerning the use of partially treated and untreated wastewater from agro industrial production in agriculture. Technology Resource Management & Development - Scientific Contributions for Sustainable Development. Prepared by: Etschmann, D.
The World Bank (2006)	The World Bank, United Sates, 2006, *Issue 6 February 2006.* **Conjunctive use of groundwater and surface water. Agricultural and rural development Notes.**
NSW Recycled Water Seminar (1994)	New South Wales Recycled Water Seminar, Australia, 1994, **Water efficiency and re-use: a least cost planning approach. 6th NSW Recycled Water Seminar**. Prepared by: White S.B. and Howe C.
UNEP and GEC (2004)	UNEP and GEC, Japan, 2006, **Water and wastewater re-use: an environmentally sound approach to urban water management.**

USEPA (2004)	USEPA, United States, 2004, *Report Number EPA/625/R-04/108.* **Guidelines for Water Re-use. U.S. Environmental Protection Agency, Municipal Support Division.**
Van Leeuwen (1995)	Journal of desalination, Vol 106 (1996), 233-240 (Australia, 1995) **Reclaimed water – an untapped resource**.
Hayes (2006)	Water, Sewage and Effluent, September 2006 **Back in Control** Compiled by Robin Hayes
WISA (2006)	Water Institute of South Africa, South Africa, 2006, **Why WAR is necessary in South Africa. Department of Water Affairs and Forestry, presentation at WISA 2006 Department of Water Affairs and Forestry, presentation at WISA 2006.** Prepared by: Seetal, A. R.
WRC (2004)	Water Research Commission, South Africa, 2004, *Report number WRC TT195/04*. **The Rhodes Biosure Process, Part 1: Biodesalination of Mine Drainage Wastewaters**. Prepared by: Rose, P.D., Corbett, C.J., Whittington-Jones, K., Hart, and O.O.

Appendix 1: Information for water users and generators

Municipal and water service provider demand and discharges

Municipality/WSA/WWTW	Discharges		Abstraction		Projections			
	Discharges to	Volume (Ml/d)	Abstraction source	Volume	Time frames	Volume projection abstraction (Ml/d)	Volume projection discharge (Ml/d)	Comment
Treated Sewage Effluent Discharges								
Ekurhuleni								
Ancor WWTW	Blesbokspruit (C21E)	32.5	NA	NA	2005 -2025	NA	33.0 - 40.0	
Benoni WWTW	Blesbokspruit (C21D)	11.0	NA	NA	2005 -2010	NA	11.0 - 11.0	
Daveyton WWTW	Blesbokspruit (C21D)	7.2	NA	NA	2005 -2010	NA	7.0 - 8.0	
Jan Smuts WWTW	Blesbokspruit (C21D)	18.0	NA	NA	2005 -2010	NA	18.0 - 19.0	
JP Marais WWTW	Blesbokspruit (C21D)	8.0	NA	NA	2005 -2010	NA	8.0 - 9.0	
Welgedacht WWTW	Not confirmed	35.0	NA	NA	2005 -2010	NA	35.0 - 37.0	
Rynfield WWTW	Blesbokspruit (C21D)	7.0	NA	NA	2005 -2010	NA	7.0 - 7.0	
Westrand								
West Rand WWTWs (estimated as 50% of demand)	Not confirmed	37.4	NA	NA	2005 -2030	NA	37.3 - unknown	
KOSH								
Klerksdorp & Jouberton WWTW	NA	19.0	NA	NA	2005 -2015	NA	19.0 - 24.8	
Orkney & Kanana WWTW	NA	15.0	NA	NA	2005 -2010	NA	15.0 - 16.5	
Stilfontein & Khuma WWTW	NA	7.6	NA	NA	2005 -2010	NA	7.6 - 8.3	
Hartbeesfontein & Tigane WWTW	NA	4.0	NA	NA	2005 -2010	NA	3.9 - 4.2	
Emfuleni								
Sasolburg WWTW	Not confirmed	14.0	NA	NA	2005 -2030	NA	14.0 - unknown	
Vanderbijl/Vereeniging WWTW (estimated as 50% of demand)	Not confirmed	91.0	NA	NA	2005 -2030	NA	91.0 - unknown	
Other								
Bushkoppies WWTW	Klip (C22E)	0.18	NA	NA	2005 -2015	NA	0.18 - 0.19	
Goudkoppies WWTW	Klip (C22E)	0.13	NA	NA	2005 -2010	NA	0.1 - 0.1	
Olifantsvlei WWTW	Klip (C22E)	70.0	NA	NA	2005 -2010	NA	0.2 - 0.1	
Waterval WWTW	Natalspruit (C22C)	102.1	NA	NA	2005 -2025	NA	102.1 - 127.0	
Vlakplaats WWTW	Natalspruit (C22B)	80.0	NA	NA	2005 -2025	NA	80.0 - 99.0	
Dekema WWTW	Natalspruit (C22B)	29.3	NA	NA	2005 -2025	NA	29.3 - 36.0	
Rondebult WWTW	Natalspruit (C22B)	18.0	NA	NA	2005 -2025	NA	18.0 - 22.0	

	Discharges		Abstraction		Projections			
Municipality/WSA/WWTW	**Discharges to**	**Volume (Ml/d)**	**Abstraction source**	**Volume**	**Time frames**	**Volume projection abstraction (Ml/d)**	**Volume projection discharge (Ml/d)**	**Comment**
Heidelberg WWTW	Blesbokspruit (C21F)	5.7	NA	NA	2005 -2010	NA	5.7 - 6.5	
Grundling WWTW	Blesbokspruit (C21E)	3.0	NA	NA	2005 -2025	NA	3.0 - 3.0	
Tsakane WWTW	Blesbokspruit (C21F)	9.0	NA	NA	2005 -2025	NA	9. - 11.0	
Water Supply								
Westrand								
Merafong water demand	NA	NA	Rand Water	22.0	2005 -2030	22.0 - unknown	NA	
Randfontein water demand	NA	NA	Rand Water	21.0	2005 -2030	21.0 - unknown	NA	
Ekurhuleni								
Ekurhuleni Council	NA	NA	Rand Water	711.0	2005 -2030	712.0 - unknown	NA	
Emfuleni								
Sasolburg	NA	NA	Rand Water	50.0	2005 -2030	50.0 - unknown	NA	
Vanderbijl/Vereeniging WWTW	NA	NA	Rand Water	183.0	2005 -2030	183.0 - unknown	NA	
KOSH								
KOSH town demand	NA	NA	Midvaal	65.0	2005 -2030	65.0 - unknown	NA	
Hartebessfontien town demand	NA	NA	Boreholes	1.9	2005 -2030	1.9 - unknown	NA	
Other								
Rand Water WSA	NA	NA	Vaal Dam	2913.4	2005 -2030	2913.4 - unknown	NA	
Midvaal Water Company WSA	NA	NA	Vaal River	141	2005 -2020	140 – 98	NA	
Sedibeng Water WSA	NA	NA	Vaal River	163	2005 -2020	163 - 134	NA	
Virginia WSA	NA	NA	Vaal River	33	2005 -2030	33 - unknown	NA	
Potchefstroom WSA	NA	NA	Boskop Dam	35	2005 -2010	35.0 - 53.0	NA	
Kroonstad WSA	NA	NA	Not confirmed	34	2005 -2030	34 - unknown	NA	
Lindley WSA	NA	NA	Not confirmed	0.6	2005 -2030	1 - unknown	NA	
Koppies WSA	NA	NA	Not confirmed	1.7	2005 -2030	2 - unknown	NA	
Viljoenskroon WSA	NA	NA	Not confirmed	3.5	2005 -2030	4 - unknown	NA	
Theunissen, Bultfontein WSA	NA	NA	Not confirmed	8.9	2005 -2030	9 - unknown	NA	
Klerksdorp/Jouberton WSA	NA	NA	Midvaal	38	2005 -2015	38 – 46	NA	
Matjhabeng WSA	NA	NA	Sedibeng	43	2005 -2030	43 - unknown	NA	
Welkom WSA	NA	NA	Sedibeng	22	2005 -2030	22 - unknown	NA	

* 10ML/d will be supplied to Uranium 1 Mine (2006) and 1 is already supplied to irrigate parks and to a cattle farm.

Industry demand and discharges

	Discharge			Abstraction		Projections			
Industry/system	**Discharges to**	**Volume (Ml/d)**	**Quality**	**Abstraction from**	**Volume (Ml/d)**	**Time frames**	**Volume projection abstraction (Ml/d)**	**Volume projection discharge (Ml/d)**	**Comment**
Ekurhuleni									
Sappi Enstra Mill	Blesbokspruit (C21D)	NA	NA	Rand Water	17.2	2005-2010	17.2 - 10.5	NA	Plans are in place to increase internal re-use and efficiency so that demand and discharge decrease to 10.5ML/d by 2010
Sappi Enstra Mill	Blesbokspruit (C21D)	NA	NA	Treated Sewage	15.7	2005-2010	15.7 - 0	NA	Due to internal re-use treated sewage will no longer be used by 2010
Sappi Enstra Mill	Blesbokspruit (C21D)	27.2	Salinity may be a problem (chloride)	NA	NA	2005-2010	NA	27.2 - 10.5	
Emfuleni									
Sasol 1	Unknown (C22K)	36.0	Not confirmed	Not confirmed	70.0	2005-2030	70.0 - unknown	36.0 - unknown	
Mittal Steel	No Discharge (C22J)	0	NA	Not confirmed	76	2005-2030	76.0 - unknown	0	
Sasol Midland	Unknown (C22K)	6.5	Not confirmed	Not confirmed	20.0	2005-2030	20.0 - unknown	65.0 - unknown	
Lethabo Power Station	No Discharge (C22K)	0	NA	Vaal (treated)	145.0	2005 - 2030	145.0 - unknown	NA	

Mine demand and discharges/dewatering

	Discharges*	Abstraction **	Projections						
Mine	**Discharges to**	**Volume (Ml/d)**	**Quality**	**Abstraction source**	**Volume (Ml/d)**	**Time frames**	**Volume projection abstraction (Ml/d)**	**Volume projection discharge (Ml/d)**	**Comment**
Ekurhuleni									
Petrex Gold Mines	Blesbokspruit (C21D)	65.0	HDS treatment		NA	2005 - 2015	NA	65.0 – 40.0	After closure in about 2015 Petrex plans to continue dewatering – see text
Petrex Gold Mines	Blesbokspruit (C21D)	NA	NA	Rand Water	3.7	2005 - 2030	3.9 – 0	NA	Petrex is closing in about 2015
Petrex Gold Mines	Blesbokspruit (C21D)	NA	NA	Treated Sewage Effluent	0.25	2005 - 2030	0.25 – 0	NA	Petrex is closing in about 2015
Petrex Gold Mines	Blesbokspruit (C21D)	10.0	BioSURE treatment		NA	2005 - 2015	-	10.0 - 10.0	
Ergo	No Discharge (C22C)	0		Rand Water	1.0	2005 - 2030	1- 0	NA	ERGO is currently in closure mode
West Rand									
Harmony Gold Randfontein	Kleinwesrietspruit (which joins the klip) (C23D)	45.0	Good quality dewatering water (to be confirmed)	NA	NA	2005 - 2030	NA	45.0 - unknown	According to the mine, this water cannot be re-used because DWAF has stipulated that it be released to the river
Harmony Gold Randfontein	Wonderfonteinspruit (C23D)	5.5	Process water	NA	NA	2005 - 2030	NA	5.5 - unknown	Conceptual plans to re-use part of this water
Harmony Gold Randfontein	Wonderfonteinspruit/Kleinwesrietspruit (which joins the klip)	Small	Treated Sewage discharge	NA	NA	2005 - 2030	NA	Small - Small	Most of this water is used for instant lawns. The excess is discharged. Hence no exact figure could be obtained.
Harmony Gold Randfontein	Wonderfonteinspruit/Kleinwesrietspruit (which joins the Klip) (C23D)	NA	NA	Rand Water	4.5	2005 - 2030	4.5 – unknown	NA	
Western Areas Gold Mine	unknown (C22J)	2.5	NA	Rand Water (to be confirmed)	5.0	2005 - 2010	5.0 – unknown	2.5 - unknown	
Kloof Gold Mine	Wonderfonteinspruit via the 1m pipeline (C22J)	36.3	Underground water	NA	NA	2005 - 2030	36.3 - 48.0	NA	Conceptual plans to re-use part of this water.
Kloof Gold Mine	Loopspruit (C22J)	12.0	Sewage/Process water		NA	2005 - 2030	NA	12.0 - 12.0	Projections are unknown but estimated to remain the similar until closure in about 2024
Kloof Gold Mine	Loopspruit (C22J)	NA		Rand Water	16.0	2005 - 2030	16.0 – 16.0	NA	Projections are unknown but estimated to remain the similar until closure in about 2024
Kloof Gold Mine	Leeuwspruit (a tributary of the Rietspruit) (C22J)	2.0	Treated sewage		NA	2005 - 2030	NA	2.0 – 2.0	Projections are unknown but estimated to remain the similar until closure in about 2024
Driefontein Gold Mine	Wonderfonteinspruit (C23E)	NA		Rand Water	2.0	2005 - 2030	2.0 - unknown	NA	
Driefontein Gold Mine	Wonderfonteinspruit (C23E)	29.0	Good quality. All process water		NA	2005 - 2030	NA	29.0 - unknown	West Wits takes a small amount of this water (~2ML/mth) occasionally depending on its needs.
Blyvooruitzicht Gold Mine	Tributary of the Mooi (assumed from location) (C23E)	NA		Rand Water	3.0	2005 - 2020	3.0 - 3.0	NA	Projections are unknown but estimated to remain the similar until closure in about 2023
Blyvooruitzicht Gold Mine	Tributary of the Mooi (assumed from location) (C23E)	8.0	Fissure water good quality	NA	NA	2005 - 2020	NA	8.0 - 8.0	Conceptual plans to re-use part of this water.
West Wits Gold Mine	To be confirmed (C23E)	1.9	Treated sewage effluent	NA	NA	2005 - 2020	NA	1.9 - 0	Discharge to decrease until closure in about 2021. Demand satisfied by dewatering

									water.
West Wits Gold Mine	To be confirmed (C23E)	6.9	Process water (to be confirmed)	NA	NA	2005 - 2020	NA	6.9 - 0	Discharge to decrease until closure in about 2021.
Elandskraal Gold Mine (Deelkraal)	Tributary of the Mooi (pers comm) (C23J)	2.0	Treated sewage effluent	NA	NA	2005 - 2030	NA	2.0 - unknown	
Elandskraal Gold Mine (Deelkraal)	Tributary of the Mooi (pers comm) (C23J)	NA	NA	Rand Water	10.0	2005 - 2030	10.0 - unknown	NA	Abstraction is usually only during the dry season

	Discharges*			Abstraction**		Projections			
Mine	**Discharges to**	**Volume (ML/d)**	**Quality**	**Abstraction source**	**Volume (ML/d)**	**Time frames**	**Volume projection abstraction (ML/d)**	**Volume projection discharge (ML/d)**	**Comment**
KOSH									
Vaal River Gold Mine	Vaal River (C24B)	NA	NA	Midvaal Water Company	37.0	2005 - 2030	37 - unknown	NA	To be confirmed
Vaal River Gold Mine	Vaal River (C24B)	NA	NA	Non potable	15.0	2005 - 2030	15.0 - unknown	NA	To be confirmed
Vaal River Gold Mine	Vaal River (C24B)	<1	NA	NA	NA	2005 - 2030	NA	< 1.0 - unknown	
Harmony Gold Orkney Shafts	AngloGold Ashanti Mettalurgicul Operation at Vaal River Gold Mine (C24B)	2.2	NA	NA	2.6	2005 - 2030	2.6 – unknown	2.2 - unknown	
Stilfontein Gold Mine	Third Parties (C24A)	25.0	Underground water	NA	NA	2005 - 2010	NA	25 - 10	
Stilfontein Gold Mine	Koekemoerspruit (C24A)	12.0	Underground water	NA	NA	2005 - 2010	NA	12 - 27	Well developed conceptual plans exist for Midvaal Water Company to re-use this water.
Buffelsfontein Goldmine	Unconfirmed (C24H)	0.2	Treated sewage effluent	NA	NA	2005 - 2015	NA	0.2 - Similar	
Buffelsfontein Goldmine	Unconfirmed (C24H)	NA	NA	Potable	4.6	2005 - 2015	4.6 - Similar	NA	
Buffelsfontein Goldmine	Unconfirmed (C24H)	8.0	Underground water	NA	NA	2005 - 2015	NA	8.0 - Similar	
Buffelsfontein Goldmine	Unconfirmed (C24H)	NA	NA	Non potable	8.7	2005 - 2015	8.7 - Similar	NA	
SXR Uranium 1 Mine	No Discharge (C24H)	NA	NA	Midvaal Water Company	2.0	2005 - 2030	2.0 - similar	0	
SXR Uranium 1 Mine	No Discharge (C24H)	NA	NA	Klerksdorp WWTW	10.0	2005 - 2030	10.0 - similar	0	

* Mine water discharges in the Vaal catchment are mainly due to mine dewatering and to a far lesser extent treated mine WWTW effluent or process water effluent. Mine dewatering comprises either uncontaminated groundwater or contaminated groundwater that has become contaminated with acid mine drainage (AMD) either due to contact with mined surfaces or due to seepage from mine residue deposits. AMD is characterised by low pH and elevated sulfate and iron, and its formation has been well documented (Rose et al, 1994).

** The quantity of dewatering water used in processes is not included in the tables below. Only water originating from outside of the mines or having to be specially pumped for supply (not also for the purpose of dewatering) is included in the abstraction figures.