



**COALTECH 2020**

## **Task 6.8.2**

# **The collection, treatment and utilization of water accumulated in the coal mines located in the Upper Olifants River catchment**

by

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## EXECUTIVE SUMMARY

### ABSTRACT

Mine water in the Upper Olifants River Catchment in Mpumalanga (upstream of Loskop Dam) is at times discharged into local streams, resulting in local acidification and regional salination of surface water resources. Pollution of surface water can be prevented by collecting and treating mine water to a quality where it could be re-used without restriction (Cleanwater 2020 Initiative). Mine water in the Olifants River Catchment currently amounts to only 4,6% of the total water usage, but contributes 78,4% of the sulphate load.

Limestone and lime treatment is the most cost-effective technology for neutralisation and partial sulphate removal of acidic/sulphate-rich water to sulphate levels of less than 1500 mg/l due to precipitation of magnesium and removal of the associated sulphate fraction (through gypsum crystallisation). Neutralised mine water of this quality may be suitable for irrigation. A number of alternative desalination treatment technologies were investigated (subsequent to gypsum crystallisation pre-treatment) where treated mine water must meet more stringent quality requirements (e.g. less than 200 mg/P SO<sub>4</sub>). The capital cost of these processes varied between R4 million/(Ml/d) and R10 million/(Ml/d) and the running cost between R2/m<sup>3</sup> and R5/m<sup>3</sup>.

Water usage in the Upper Olifants River Catchment currently amounts to 947 Ml/d (including the power stations), and will increase to an estimated 1385 Ml/d by 2020. The additional water demand by 2020 (438 Ml/d) will have to be supplied by importation from neighbouring catchments, and more efficient utilisation of the local water resources, including excess mine water. Various levels of treatment are required to make mine water suitable for the following potential applications (acceptable treated water sulphate concentration shown in brackets): irrigation (2000 mg/l), coal processing plant (1000 mg/l), general industrial use (500 mg/l), discharge to public streams (500 mg/l), potable use (200 mg/l) and cooling water in power stations (20 to 40 mg/l). The following two options, or a combination of thereof, can be considered for management of excess mine water in the Upper Olifants River Catchment:

1. Collection and treatment of excess mine water to a quality suitable for selected urban and industrial applications (Option A).
2. Collection and treatment of mine water to a quality suitable for irrigation (Option B).

The estimated capital and running cost for Option A amounts to R528.5 million and R55.7 million/year, respectively, compared with R68,2 million and R11,9 million/year for Option B. It is recommended that Option B be investigated for implementation in the short to medium-term. Option B was selected due to cost benefits and the initial favourable results obtained by a joint Water Research Commission and Coal Industry initiative where mine water is used for irrigation. Option A may become feasible in the long-term to ensure maximum environmental protection and reduced treatment cost as a result of anticipated technological improvements over the next 5 to 10 years.

### 1. BACKGROUND

The South African coal industry initiated a research initiative in 1998 (COALTECH 2020) with the vision to promote collaboration between the industry, researchers, the state and labour and to promote research initiatives that would benefit them and other stakeholders. Another initiative came about almost at the same time when the Olifants River Forum formulated the Cleanwater 2020 project. The project aims: *“To establish a profitable public-private partnership that will collect and treat water arising from mining, industrial and other economic activities in the Witbank-Highveld coalfield (100 km east of Johannesburg) and make it available to users in the area”*. Funds were obtained from COALTECH 2020 in 1999 to finance this study conceived by the Cleanwater 2020 initiative.

The Witbank-Highveld coalfield is located 100 km east of Johannesburg. The region is a summer rainfall area and receives 750 mm on average annually. Day temperatures varies between 15 and 30°C.

Mine water in the Upper Olifants River Catchment in Mpumalanga Province (upstream of Loskop Dam) is at times discharged into local streams, resulting in local acidification and regional salination of surface water resources. The natural ground water resources are also impacted by dewatering around mining operations and migration of polluted subsurface plumes from mine workings. So, for instance, 120-160 mg/l sulphate is routinely measured in the Witbank Dam and Middelburg Dam mainly as a result of coal mining and related activities. It is estimated that, in the absence of any coal mining and related activities, the sulphate concentration would have been as low as 20-40 mg/l. High salinity in surface water limits the use of water, and introduces indirect costs in the use of the water further downstream. Pollution of surface water can be prevented by collecting and treating excess mine water to a quality where it could be re-used without restriction (Cleanwater 2020 Initiative).

Successful implementation of the Cleanwater 2020 Initiative will offer the following benefits:

- Convert a pollution threat to the water resources into an augmentation of the local water resources.
- Preserve the local water resources and increase the reliable yield.
- Reduce the need for importation of fresh water to the Olifants River Catchment from neighbouring catchments.
- Assist in the creation of job opportunities through the construction, operation and maintenance of water-related projects.
- Enhance best utilisation of local water resources, both of natural and mining origin.

The aims of this project were to:

- Determine the location, quantity and quality of excess mine water.
- Identify a promising regional collection and treatment scheme.
- Identify potential users for treated mine water.
- Recommend promising mine water management options for the short term and the long term.
- Provide a cost estimate of various management options to guide future decision making.

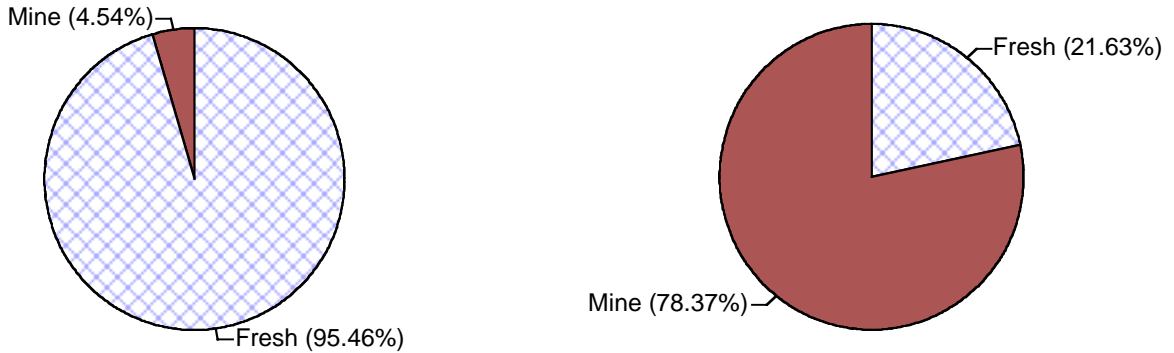
The interests of the following stakeholders were valued as important due to their direct interests:

- Coal mining industry, who has to carry the cost of treating excess mine water
- Downstream water users, who have to carry the costs associated with poor quality raw water.
- Authorities, who are responsible for the supply of potable water and control of pollution through legislation and law enforcement.
- Technology suppliers, who have made investments in technology development that could be used for treatment of excess mine water.

## **2. QUANTITY AND QUALITY OF MINE WATER**

Mine water discharged in the Upper Olifants River Catchment currently amounts to approximately 44 Ml/d (Table I) during an average hydrological year and is expected to increase to an estimated 131 Ml/d by 2020. The quality of mine water is generally poor with a sulphate concentration between 800 and 3000 mg/l. It is not acceptable to discharge such poor quality mine water into high quality

surface water. The current background sulphate load of water in the Upper Olifants River Catchment is estimated at 28,4 t/d (as SO<sub>4</sub>) (947 MI/d @ 30 mg/l SO<sub>4</sub>), which is small compared to the estimated 102,9 t/d sulphate load associated with excess mine water (2337 mg/l SO<sub>4</sub> @ 44 MI/d). The above-mentioned figures show that a relatively small volume of excess mine water is responsible for a major contribution of salinity. Excess mine water in the Olifants River Catchment currently amounts, volume wise, to only 4,6% of the total water usage, but contributes 78,4% of the sulphate load (Table II and Figure 1).



1.1 Volume (%)

1.2 Sulphate load (%)

**Figure 1. Comparison of water volumes and sulphate load of fresh water usage and mine water in the Upper Olifants River Catchment**

**Table I. Estimated volumes of mine water in the Upper Olifants River Catchment (based on an average hydrological year).**

Power station/Colliery	Volume (MI/d)	Quality		
		pH	Sulphate (mg/l) 95%	Magnesium (mg/l) 95%
<b>Middelburg Dam catchment</b>	14,55		1524	88
1. Arnot	4,4	8,5	2832	77
2. Eikeboom	0,46	8,6	75	41
3. Woestalleen	0,19	8,1	2069	280
4. Optimum	9,5	7,8	977	91
<b>Witbank Dam catchment</b>	10,74		2498	287
5. Douglas	0,66	7,8	1645	250
6. Goedehoop	0,56		2500	250

7. Greenside	0,65	8,7	3050	292
8. Kleinkopje and Landau	4,08	8,9	2604	304
9. Kroonfontein	0,09	8,5	1361	99
10. Middelburg South	0,02	7,6	2018	303
11. Middelburg North	0,58	3,8	2805	308
12. Rietspruit	1,41	8,5	2626	380
13. Tavistock	0,49	7,1	1520	148
14. Khutala	2,2		2500	250
<b><u>Kriel/Matla complex</u></b>	9,12		563	47
15. Kriel	1,99	8,4	729	99
16. Malta	5,67	8,9	485	32
17. Syferfontein	1,46	8,8	637	37

Table I : (continued)

Power station/Colliery	Volume (Ml/d)	Quality		
		pH	Sulphate (mg/l) 95%	Magnesium (mg/l) 95%
<b><u>Klipspruit catchment</u></b>	9,62		5071	217
18. South Witbank	2,47	2,8	4986	160
19. Middelburg Stream	0,61		2600	50
20. Old Tavistock	0,08		2600	50
21. Brugspruit High TDS	2,7	4,0	8203	435
22. Brugspruit Low TDS	2,5	3,3	3701	170
Total	44,03			

\* Note: The sulphate concentration has a confidence level of 95 % to be lower than the given value (i.e. 95 percent of the periodic samples taken has sulphate concentrations lower than the given value).

**Table II : Comparison between water volumes and sulphate load of fresh water usage and excess mine water discharges in the Upper Olifants River Catchment.**

Parameter	Fresh water	Mine water	Total	Fresh water	Mine water
	MP/d	MP/d	MP/d	%	%
Volume (MI/d)	947	44,0	991	95,6	4,4
Sulphate concentration (mg/l)	30	2337			
Sulphate load (t/d)	28,4	102,9	131,3	21,6	78,4

### 3. COST ASSOCIATED WITH TREATMENT, COLLECTION AND DISTRIBUTION

Limestone treatment is the most cost-effective technology for neutralisation of acid water and partial sulphate removal to levels of approximately 2000 mg/l SO<sub>4</sub> (Table III). With high lime treatment to pH >11, sulphate can be further reduced to 1400 mg/l due to precipitation of magnesium and removal of the sulphate fraction (through gypsum crystallisation) associated with magnesium. Neutralised mine water of this quality may be suitable for irrigation.

A number of alternative desalination treatment technologies were considered (subsequent to gypsum crystallisation pre-treatment) when treated mine water must meet more stringent quality requirements for industrial reuse, discharge to a public stream, drinking or power station cooling water, including Aqua K, Barium, Biological sulphate removal, EDR, Electrolytic, GYPCIX, RO or Savmin. The cost of such technologies is expected to decrease over the next 10 years through further technological progress.

Table III shows the capital and running cost associated with the treatment of mine water with various treatment processes. For mine water to be reused for any application, except for irrigation (which could be utilised at the source), a collection system will have to be installed for transportation of the untreated mine water to a central treatment plant, as well as a distribution system for transportation of the treated water to the users. The cost of collection systems for the catchment is estimated at R192,9 million (Table IV) and that of a distribution system at R65,1 million (Table V). The annual running cost for the collection and distribution systems is estimated at R3,1 million and R2,2 million respectively (Tables IV and V).

**Table III : Capital and running cost of various treatment processes (treatment module of 15 MI/d).**

Treatment process	SO <sub>4</sub> level in treated water	Capital cost (R million / (MI/d))	Running cost (R/m <sub>-</sub> )
Limestone neutralisation (incl. iron(II) oxidation)	2500	0,50	0,59
Lime neutralisation (pH 8)	1500	0,53	1,36
Limestone/lime treatment (pH 11) & gypsum crystallisation	1100	0,88	1,02
Lime treatment (pH 11.5) & gypsum crystallisation	1100	0,57	1,61
Advanced sulphate removal (including neutralization pre-treatment)	200	4,0 to 10,0	2,0 to 5,0

**Table IV : Cost of collection systems.**

Sub-catchment	Capital cost (R)	Running cost (R/year)
Middelburg Dam	32 000 000	410 000
Witbank Dam	52 400 000	745 000
Matla/Kriel/Syferfontein	90 900 000	1 525 000
Brugspruit	17 600 000	400 000
Total	192 900 000	3 080 000

**Table V : Cost of distribution systems.**

Sub-catchment	Capital cost (R)	Running cost (R/year)
Middelburg Dam	30 134 974	691 236
Witbank Dam	17 442 583	627 774
Matla/Kriel/Syferfontein	5 239 648	236 232
Brugspruit	12 258 531	601 989
Total	65 075 736	2 156 231

#### 4. RE-USE OPTIONS FOR TREATED MINE WATER

Water usage in the Upper Olifants River Catchment currently amounts to 947 MI/d (including the power stations), and will increase to an estimated 1385 MI/d by 2020 (Table VI). The additional water demand by 2020 (438 MI/d) will have to be supplied by water importation from neighbouring catchments, and more efficient utilisation of the local water resources, including water stored or discharged by mines.

**Table VI : Current and projected water usage in the Upper Olifants River Catchment.**

User	Water demand/supply (MI/d)		
	Current	2020	Change
<b>Demand</b>			
Irrigation	211	211	0
Stock watering	16	19	3
Urban and industrial	173	504	331
Mining	68	27	-41
Power stations*	479	625	146
Total (excluding power stations)	468	761	237

Total (including power stations)	947	1 385	483
<b>Supply</b>			
Mine water decant	44	131	87

\* Supplied from water sources outside the Upper Olifants River Catchment.

Different levels of treatment are required to make excess mine water suitable for the following potential applications (acceptable sulphate concentration of treated water shown in brackets):

- \* irrigation (2000 mg/l)
- \* coal processing plant (1000 mg/l)
- \* general industrial use (500 mg/l)
- \* discharge to public streams (500 mg/l)
- \* potable use (200 mg/l)
- \* cooling water in power stations (20 to 40 mg/l)

#### 4.1 Irrigation

Mine water which is partially treated for removal of free acidity, metals, magnesium and sulphate (to less than 2000 mg/l) can be used for irrigation. This option is currently being investigated and would appear to be attractive. The further investigation addresses the following aspects:

- Cost effectiveness. Should irrigation be applied near the source of partially treated mine water, the costs would be relatively low as no collection and distribution system, other than that needed for irrigation, will be required. Such costs could be carried from income generated by the irrigation scheme.
- Long term effects on soil and ground water. It is known that sodium-rich water is not suitable for long term irrigation purposes due to soil degradation effects. The mine water in the Upper Olifants Catchment is low in sodium and thus the only question that remains is whether gypsum-rich water is suitable for irrigation in the long term. No negative effects were observed from irrigation with gypsum-rich water in the following cases: a three year WRC demonstration project (Annandale, 2000), Israeli experience (Tanner, 1999) and even from 100 year modelling (Annandale, 2000).
- Water availability. Due to limited water resources, the current policy of the Department of Water Affairs and Forestry requires that water can only be allocated for new applications (e.g. new irrigation schemes) should water of sufficient quantities be available. Currently, 211 Ml/d of fresh water is used for irrigation of 9097 ha in the Upper Olifants River Catchment. If mine water (current volume is estimated at 44 Ml/d and it is estimated to increase to 131 Ml/d in 2020) is used to replace fresh water in existing irrigation schemes, it will fall within the current policy. Although existing irrigation schemes are not situated in the vicinity of excess mine water, the likelihood of finding suitable sites are quite high. (Figure 2).

#### 4.2 Other uses

Treated mine water to a sulphate level in the range of 50 to 500 mg/l can also be used for other uses such as stockwatering, urban and industrial and potentially power stations (Table VI). The following aspects must however be addressed to allow the concept of regional collection and treatment of excess mine water for use by selected users:

- Legal aspects associated with the collection and re-use of treated mine water (e.g. water transfer policy, water price policy, licence system).
- Institutional aspects related to the type and form of organization needed for the implementation of the project.

- LEGEND :**
- 1 Kromdraai Colliery
  - 2 Schoongezicht / Navigation Colliery
  - 3 Landau Colliery
  - 4 Greenside Colliery
  - 5 Kleinkopje Colliery
  - 6 Witbank Consolidated
  - 7 Arthur Taylor Colliery
  - 8 Phoenix Colliery
  - 9 SWCM
  - 10 Tavistock Colliery
  - 11 Atcom Colliery
  - 12 Rietspruit Colliery
  - 13 Matla Colliery
  - 14 Kriel Pits (Eskom)
  - 15 Kriel Colliery
  - 16 Syferfontein Colliery
  - 17 Eikeboom Colliery
  - 18 Optimum Colliery
  - 19 Arnot Colliery
  - 20 Arnot Colliery
  - 21 Bank Colliery
  - 22 Koorfontein Colliery
  - 23 Middelburg Mine Services
  - 24 Douglas Colliery
  - 25 Goedehoop Colliery
  - 26 Khutala Colliery
  - 27 South Witbank Colliery
  - 28 Middelburg Steam
  - 29 Old Tavistock Colliery
  - 30 Brugspruit
- Proposed sites for treatment plants  
 ■ Irrigation areas



**Figure 2 : Map of existing irrigation areas and existing mining operations**

## 5. MANAGEMENT OPTIONS

The following two options, or a combination thereof, can be considered to assist in the management of mine water in the Upper Olifants River Catchment:

- Collection and treatment of excess mine water to a quality suitable for selected urban and industrial applications (Option A). The benefit of this Option is that mine water (4.5 % by volume) will be treated to a quality comparable with that of unpolluted surface water.
- Collection and treatment of mine water to a quality suitable for irrigation (Option B). The benefit of this Option is that the large volume of good quality surface water (95.5 %) will not be effected through mixing with a small volume (4.5 %) of saline mine water.

The estimated capital and running cost for the total Upper Olifants River Catchment for Option A amounts to R528.5 million and R55.7 million/year, respectively, compared with R68,2 million and R11,9 million/year for Option B (Table VII). These cost figures are based on a cost of R75 million for a 15 Ml/d sulphate removal plant (including brine/sludge disposal cost), to a sulphate level of 200 mg/l, and R8.55 million for a 15 Ml/d pre-treatment plant. It is recommended that Option B (pre-treatment/irrigation combination) be investigated for implementation in the short to medium-term for the following reasons:

- Prevent pollution of surface water by not discharging potentially acidic and saline mine water to public streams.
- Treatment cost for irrigation application of the excess mine water is more affordable, as the Capital Expenditure is only 13% compared with Option A, and the running cost only 21% compared with Option A.
- The land required for irrigation of excess mine water (1891 ha in 2000) amounts to only 21% of what is already used for irrigation (9097 ha in 2000). Research indications are that gypsum-rich water can be used for irrigation, without affecting the long-term suitability of soil for irrigation.
- The potential exist to more than double the income generated from irrigation compared to dry land farming. In addition, two crops instead of one can be produced annually.
- Irrigation could create job opportunities and stimulate the regional economy.

The long-term environmental impacts of the irrigation use of sulphate-rich mine water should be investigated and resolved to the satisfaction of all stakeholders, before proceeding with the catchment wide implementation of the scheme.

Option A, however, also holds merit, and should be reconsidered over the medium to long-term, along with the following developments:

- Reduction in the cost of advanced sulphate removal technologies. It is foreseen that, due to technological improvements to some of the technologies, cost could be reduced to levels near to that of lime treatment within the next 5 - 10 years.
- Increased cost of imported fresh water. The cost of fresh water in the Upper Olifants River Catchment will increase over the next decade. This is due to the fact that the future increased demand for water in the catchment will have to be imported from neighbouring catchments at substantial cost.
- The cost of mine water collection may in future be substantially reduced, by utilisation of the natural underground drainage paths set up in the underground mine workings.

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## CHAPTER 1

### 1. BACKGROUND

Polluted mine water is regularly discharged at an average rate of 44 MI/d in the Upper Olifants River Catchment to public streams. It is expected that this volume will increase to 131 MI/d by 2020. The excess mine water is acidic in certain locations, and generally contains high sulphate concentrations (greater than 1 500 mg/l). Should this water be collected and treated to a quality where it can be reused, it will offer the following benefits:

- Large volumes of surface water will not be polluted by small volumes of excess mine water. The mean annual runoff in the Upper Olifants River Catchment to Loskop Dam amounts to 386 million m<sup>3</sup>/a (1057 MI/d).
- Less high quality water will need to be imported if a local water resource in the form of stored water in mine workings is reclaimed for reuse. The amount of mine water that is currently stored in mine workings is estimated at 1 200 million m<sup>3</sup>. This is significantly more than the approximately 590 million m<sup>3</sup> storage capacity of the three major surface water impoundments (Witbank Dam, Middelburg Dam and Loskop Dam).
- The total current water usage of the Upper Olifants Catchment is estimated at 947 MI/d, including the power stations.

The objectives of the project are:

- Identify and quantify the source, potential volume (flow) and quality of surplus mine water generated in the Upper Olifants River Catchment, down to Loskop Dam.
- Develop alternative options for the collection and treatment of mine water. The most attractive mine water treatment options in terms of proven technology, waste generation, saleable by-products and reliable high quality product water, must be formulated and analysed.
- Identify the cost-effective combination of mine water collection and treatment schemes
- Consider options for the recycling and reuse of treated mine water to the major urban and industrial demand centres.

The overall aim of this investigation is to estimate the cost of various collection and treatment options, and reuse of treated water for various applications (e.g. irrigation, urban, industrial or discharge to public streams).

The interests of all stakeholders were recognised as important. Special consideration was given to:

- Coal mining industry who have to carry the cost of treating excess mine water.
- End-users who have to carry the cost associated with poor quality water.
- Authorities, who are responsible for water supply and control of effluent discharges through legislation and law enforcement.
- Technology suppliers, who have made investments in technology development that could be used for treatment of excess mine water.

## CHAPTER 2

### MINE WATER FLOW AND QUALITY

#### 2.1 INTRODUCTION

Excess polluted mine water decanted or seeping into the Upper Olifants River Basin poses a major threat to the environment and clear water dam in the catchment. The Department of Water Affairs and Forestry has therefore initiated the development and implementation of a Water Quality Management Plan for the Upper Olifants River Basin in the early 1990's. Development of the plan led to the division of the catchment into management units (MU's), in order to facilitate the efficient monitoring and management of the catchment (**Figure 2.1**).

It is estimated that polluted mine water enters the Upper Olifants River catchment at a rate of 18.25 million m<sup>3</sup>/year (50 MI/day).

It has been proposed that the excess mine water be collected, treated and then redistributed to the local industries and town councils. The aim of this project is to identify a cost effective way of collecting and treating the excess polluted mine water.

For the purposes of the proposed Mine Water Collection System, the study catchment has been divided into three sub-catchments, viz. :

- the Witbank Dam catchment,
- the Middelburg Dam catchment,
- and the Klipspruit catchment.

It has been found that the mine water volumes and qualities varies for each of the three catchment, as will be seen in this report. It has therefore been suggested that three treatment plants be built to cater for the varying mine water qualities. There will be one plant in each of the three catchments (refer to **Figure 2.1**).

The scope of work for the project is as follows :

- determining the volume of excess mine,
- determining the quality of the excess mine water,
- design of a collection system to transport the water to the treatment works,
- capital, operating and maintenance costing of the collection system,
- design of the treatment works,
- capital, operating and maintenance costing of the treatment works,
- investigation into re-use options,
- and the capital, operating and maintenance costing of the re-use options.

This report aims to address the first two aspects of the scope of work viz. the determination of the volume and quality of the excess mine water.

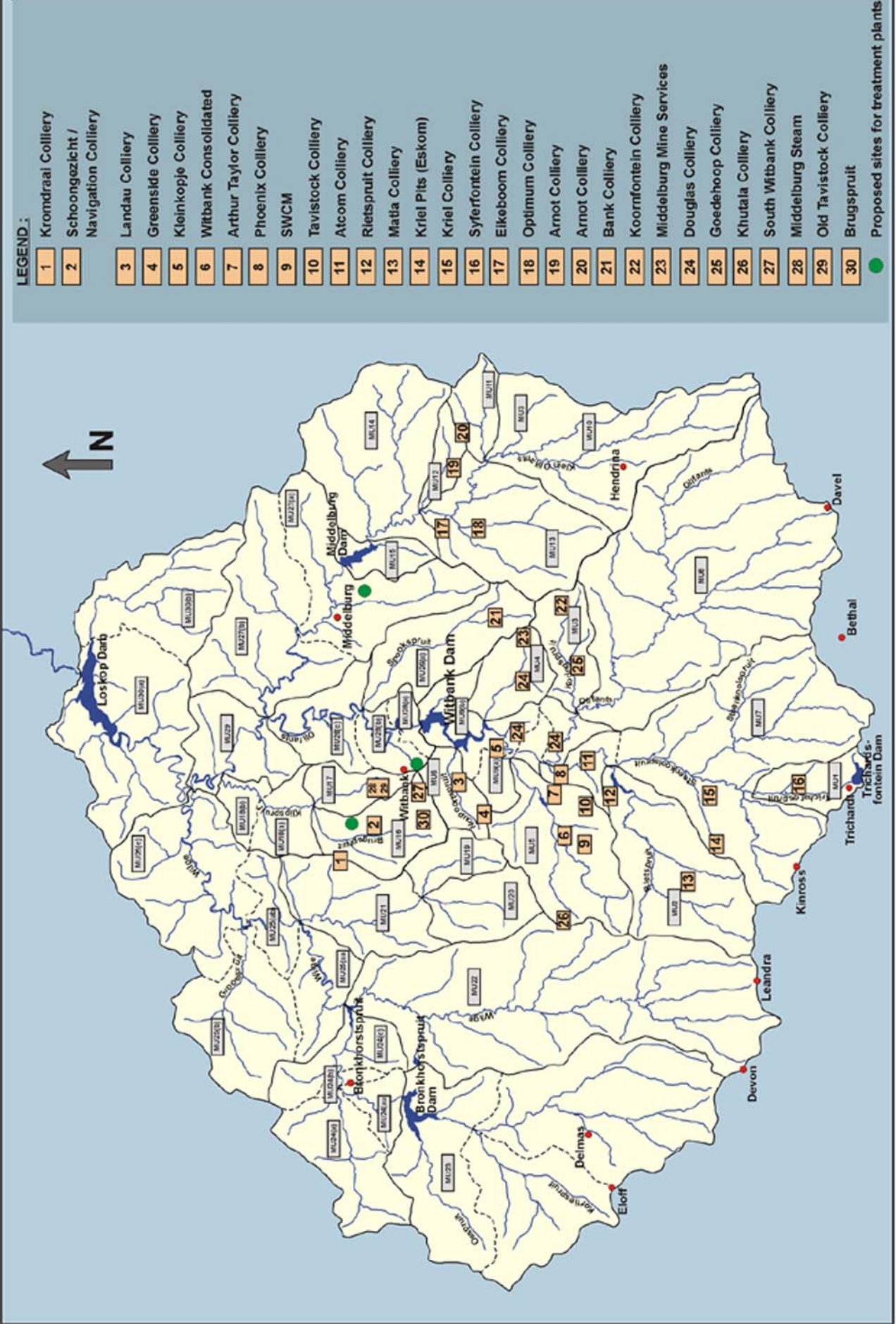


Figure 2.1 : Proposed sites for Treatment Plants

## 2.2 DESCRIPTION OF CATCHMENTS

For the purpose of the proposed Mine Water Collection System the study area has been divided into three catchments (**Figure 2.2**). They can be categorised as follows :

- Witbank Dam Catchment;
- Middelburg Dam Catchment;
- Klipspruit Catchment.

### 2.2.1 Witbank Dam Catchment

The Witbank Dam catchment is located at the headwaters of the Olifants river. Land use practices in the catchment are varied and include agriculture, power generation, coal mining as well as urban development.

The Eastern Transvaal Highveld (ETH) is one of the most fertile agricultural regions in the country. A variety of crops are irrigated on an estimated 2 040 ha (0.59 % of the catchment area).

Power generation by coal-fired power stations is the largest industrial activity in the catchment. A total four ESKOM power stations, including Duhva, Kriel, Matla and Komati are located in the catchment. The Department of Water Affairs and Forestry and ESKOM monitor this potential source of pollution to the surface water and groundwater resources.

Extensive underground and opencast coal mining for the domestic and foreign markets as well as for coal-fired powered stations are taking place in the catchment. A total of 16 major collieries and a number of smaller operations are active in the catchment. Two different coal fields are mined in the catchment. The Highveld Coalfields are located in the southern portion of the catchment and the Witbank-Springs Coalfields are located in the northern part of the catchment. The active and closed coal mines located within the Witbank Dam catchment which were considered for the Mine Water Collection System are as follows :

- Douglas Colliery
- Goedehoop Colliery
- Greenside
- Kleinkoje & Landau
- Koorfontein
- Kriel
- Matla Mine
- Middelburg Mine – South
- Rietspruit Mine Services
- Syferfontein Colliery
- Tavistock Colliery
- Tweefontein Colliery
- Khutala

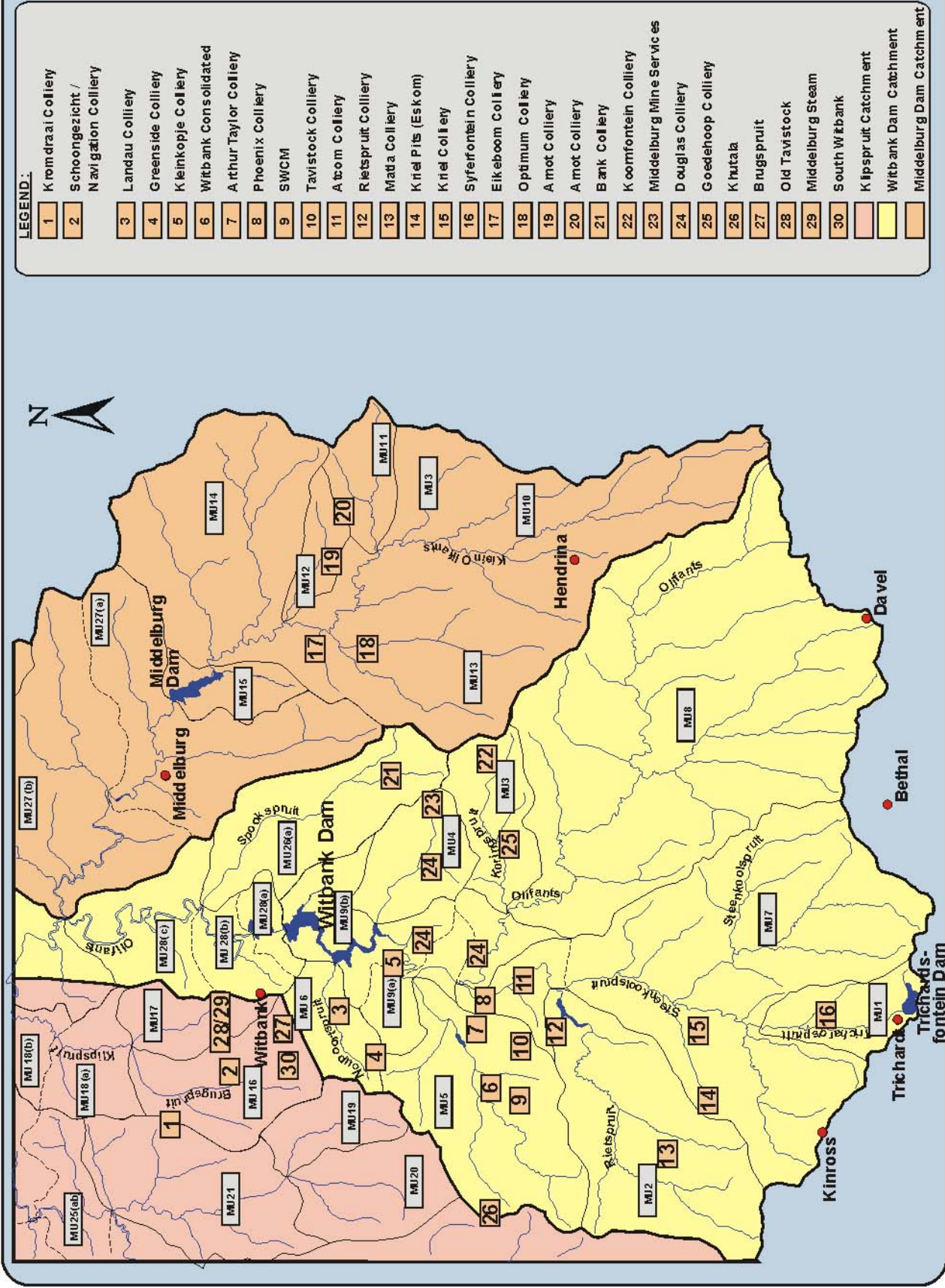


Figure 2.2 : Location of coal mines in the Klipspruit, Witbank Dam & Middelburg Dam Catchments



Urban development in the catchment is limited to a number of smaller towns on the Highveld ridge including Kinross, Trichardt and Bethal. Kriel town is located on the Steenkoolspruit, while Witbank straddles the watershed between the Olifants river and the Klipspruit.

### **2.2.2 Middelburg Dam Catchment**

The Middelburg Dam is located in the headwaters of the Klein Olifants river. It is an important catchment, not only in context of water supply to the greater Middelburg area, but also in terms of the flow and pollution load contributions to the Loskop Dam. The catchment is impacted by various land uses including towns and related settlements, coal mining, power generation, agriculture, cattle feed lots and industry.

The Middelburg Dam catchment covers an area of 1576 km<sup>2</sup>, but a significant portion of it drains to pans. These pans act as small isolated catchments and reduce the effective total catchment area draining to the Middelburg Dam to 1401 km<sup>2</sup>. The Klein Olifants River is the major stream in the catchment. Most of the other streams are tributaries of the Klein Olifants River.

The Middelburg Dam catchment is extensively utilised for agriculture. Approximately 23 % of the catchment is cultivated, while most of the remaining land, not impacted by industrial and mining operations, is under pasture. Livestock farming activities in the catchment consist of cattle, sheep and pig farming. Maize is the dominant dry-land crop in the region.

There are number of power generation operations in the Middelburg Dam catchment. Hendrina Power Station and Arnot Power Station, two of Eskom's eight coal-fired power stations, are situated within the catchment. Coal to fuel the power stations is supplied by the adjacent collieries. Extensive coal mining for the foreign and domestic market is taking place in this catchment. Approximately 9 % of South Africa's annual coal production originates from this catchment. The active and closed coal mines located within the Middelburg Dam catchment which were considered for the Mine Water Collection System include :

- Arnot Colliery
- Eikeboom
- Woestalleen Colliery
- Optimum Colliery

Urban development in the Middelburg Dam catchment is limited to rural settlements and residential villages at power stations and collieries. There are two independent local authorities, namely Hendrina and Kwazamokuhle.

### **2.2.3 Klipspruit Catchment**

The Klipspruit catchment has two significant tributaries, the Brugspruit and the Blesbokspruit. The Brugspruit rises to the south-west of Witbank and flows in a northerly direction to the Klipspruit confluence. The Blesbokspruit rises from the

north-west of Witbank and flows into the Klipspruit approximately 10 km downstream of the Brugspruit/Klipspruit confluence.

Land use in the catchment is mainly dominated by mining, industrial and residential developments. Agriculture, mainly crop cultivation and livestock farming, is concentrated in the northern part of the catchment. Currently mining in this catchment is not as concentrated as is in the Witbank Dam and Middelburg Dam catchments.

The active and closed coal mines located within the Klipspruit catchment which were considered for the Mine Water Collection System include :

- Kromdraai
- South Witbank
- Middleburg Stream
- Old Travistock

A number of large industries are located in the Klipspruit Catchment. Highveld Steel and Vanadium Corporation Ltd is located on the watershed between the Klipspruit catchment and the Wilge River Catchment. Other major industries in the area are Trans Alloys, Ferro Metals and Vantra.

## **2.3 EXCESS MINE WATER PRODUCTION**

It should be noted that all volumes of excess mine water reflected in this report represents the historical and present situations only. The modelling of mine water production, to determine future flows is currently being undertaken by Sunderland and Associates and will only be available towards the end of 1999. All information, with regard to the volume of excess mine water for each of the mines was obtained from the Water Resource Model of the Upper Olifants River Catchment report which was compiled by BKS, Jakoet and Associates and Wates Meiring and Barnard.

The volume of water to be released into the proposed Mine Water Collection System is based on historical and current decanting and seepage rates only. No consideration was given to effluent generated from wastewater treatment works on the mines or polluted mine water that is being stored on the mines.

This section along with **Section 2.4** of this report aims to determine the possible volume of polluted water that each mine would release into the collection system and the location of their decanting points.

### **2.3.1 Arnot Colliery**

Arnot Colliery is situated in the Mpumalanga Province about 40 km south east of Middelburg. The colliery is in the Middelburg Dam catchment in Management Units no. 11 and 12. The first mining activities at Arnot started in 1973 and are scheduled to end in 2015. Refer to **Figure 2.3.1** for a layout of the Arnot Colliery.

The mining operations at Arnot consists of the following elements:

- Opencast pits viz Mini Pit (Pit B West), Pit 1, Pit 2 West and Pit 2 East at which mining has ceased. Future pits which include New Pit 2 East and New Pit 2 West which will be restarted at the original Pit 2 West and East. On completion Pit 3 West, Pit B West and Pit G South will be mined.
- Underground workings at U2 and U3 of which only U3 is still operational.

Pit 2 East and West are opencast pits which are presently decanting. The decant water is collected in trenches and pumped either to the T6 Ramp or to the evaporation ponds. Polluted water runoff from the crusher plant areas and workshop is collected in pollution control dams which are connected to Magazine Pan via a transfer tank.

Runoff from the unrehabilitated spoils at the Mini pit is channeled towards the final void from where it seeps to the Rietkuilspruit. In 1996 the mine obtained a permit to discharge a maximum of 1 Ml/day from the C1 underground dam in the U3 workings to the Rietkuilspruit.

Since Pit 1, Pit 2 West, Pit 2 East and Mini Pit have been mined out, they are either decanting or seeping. Pit 2 West has filled up in 1996 and Pit 2 East in 1994. Mini Pit is presently decanting at a rate of 1917 m<sup>3</sup>/month (0.06 Ml/day). At present no management method has been identified to deal with seepage or decant. The storage volume of the pits together with the decant depths of storage are reflected in **Table 2.3.1(a)**.

**Table 2.3.1(a) : Storage volumes and surface areas of various pits**

Pit Name	Storage Volume (million m <sup>3</sup> )
Pit 1	152.9
Pit 2 West	48.7
Pit 2 East	23.8
Pit B	12.7
Pit G South	5.2
New Pit 2 West	9.7
New Pit 2 East	4.4
Pit 3 West	15.5
Pit B West	12.8

The annual average combined seepage and decanting rate from the Arnot Colliery is estimated to be about 1,615,644 m<sup>3</sup>/year (4.43 Ml/day).

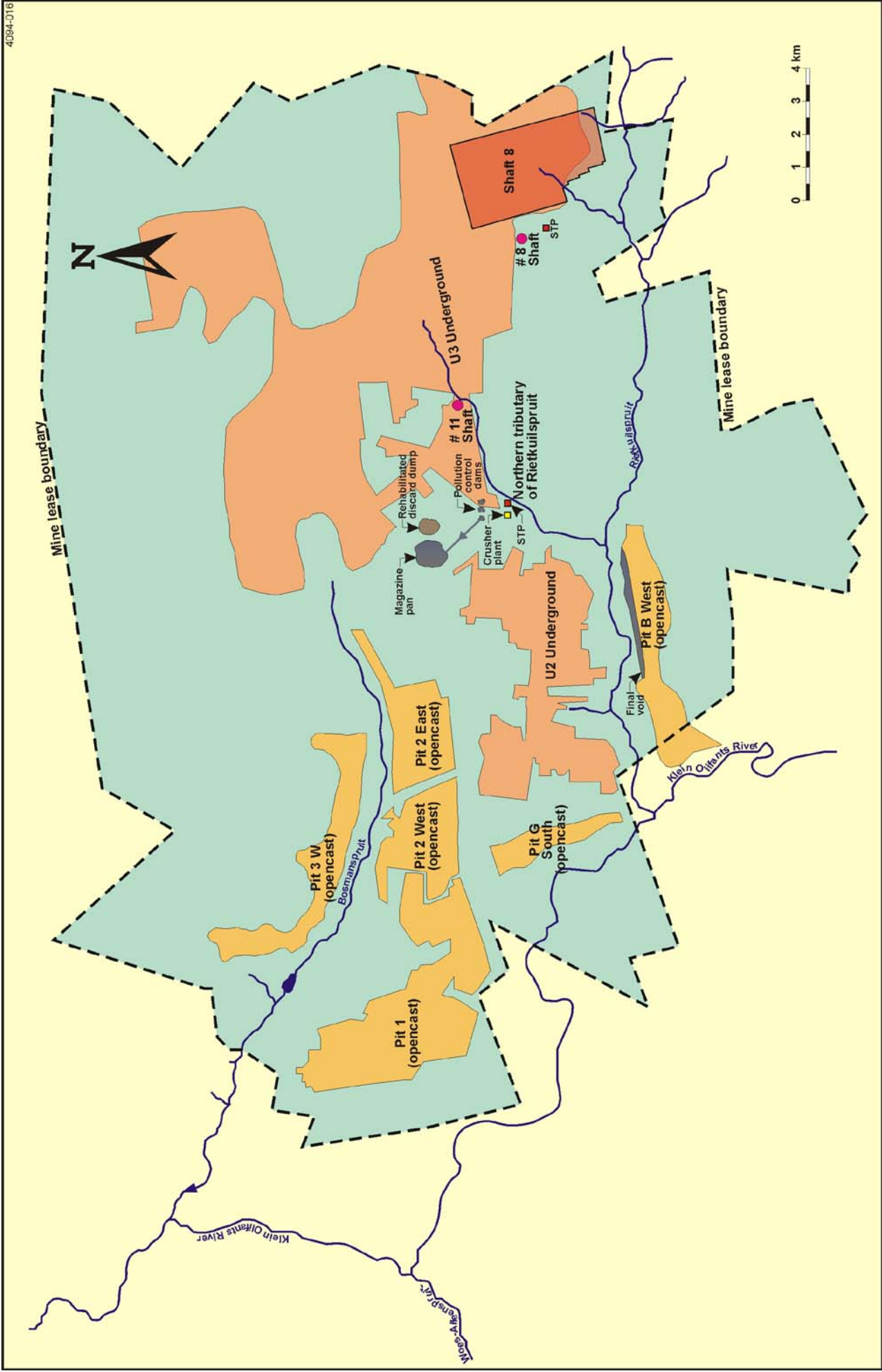


Figure 2.3.1 : Layout of Arnot Colliery

### 2.3.2 Douglas Colliery

Douglas Colliery is run by Ingwe and covers a total lease area of 17 332,26 hectares. Douglas comprises a series of mines with the area having been mined since 1926. At present there are five (5) active areas with the current operations including both opencast and underground mining. Refer to **Figure 2.3.2** for a layout of the Douglas Colliery. The five currently active areas are:




- Albion Section – on the farms Middeldrift 12 I.S. and Rietfontein 43 I.S.
- Douglas Section – on the farms Boschmanskrans 22 I.S. and Vlaklaagte 21 I.S.
- Van Dyksdrift Section – on the farm Vandyksdrift 19 I.S.
- Welverdiend Section – on the farm Welverdiend 23 I.S.
- Wolwekrans Section – on the farm Wolwekrans 17 I.S.

There is presently no information available on the rate at which decanting is currently taking place. The mine wishes to reopen the Douglas Underground section in the year 2000 in order to harvest the rest of the coal. Presently the mine wishes to treat the underground water and then release it during flood conditions. Water inputs to the Vlaklaagte opencast mine include groundwater and rain. Runoff from the undisturbed areas is channelled back into the Olifants River. All runoff from the disturbed areas flows into the pit from where it is pumped to Pit 4A exploration facility. Any overflow from Pit 4A discharges into the Olifants River. Runoff from the rehabilitated section of the Vlaklaagte pit either collects in the pit floor or is discharged directly to the Olifants River. Some of this runoff is collected into a water storage facility.

Seepage from this facility flows back into the opencast pit. Overflow will flow into the Olifants River. There is seepage of mine water continuously from Waterfall. The seepage from Waterfall varies between 0.005 and 0.025 m<sup>3</sup>/s.

Mine water is released from Pit 4A and Oxbow 7. Mine water has been released from Oxbow 7 and Pit 4 A since July 1997 as part of the controlled release scheme which will be discussed in **Section 2.4**.

**LEGEND :**

-  Underground mines
-  Fully and partially rehabilitated open-cast mines
-  Rehabilitated open-cast with either flooded final voids or ponds on surface on rehabilitated areas
-  Slurry deposited in abandoned underground workings
-  Carbonaceous materials disposed on surface comprising discard and slurry. Coal stored on surface at stacker / reclaimers and live coal stockpiles
-  Dams and vlei areas containing contaminated surface water
-  Sewage treatment plant

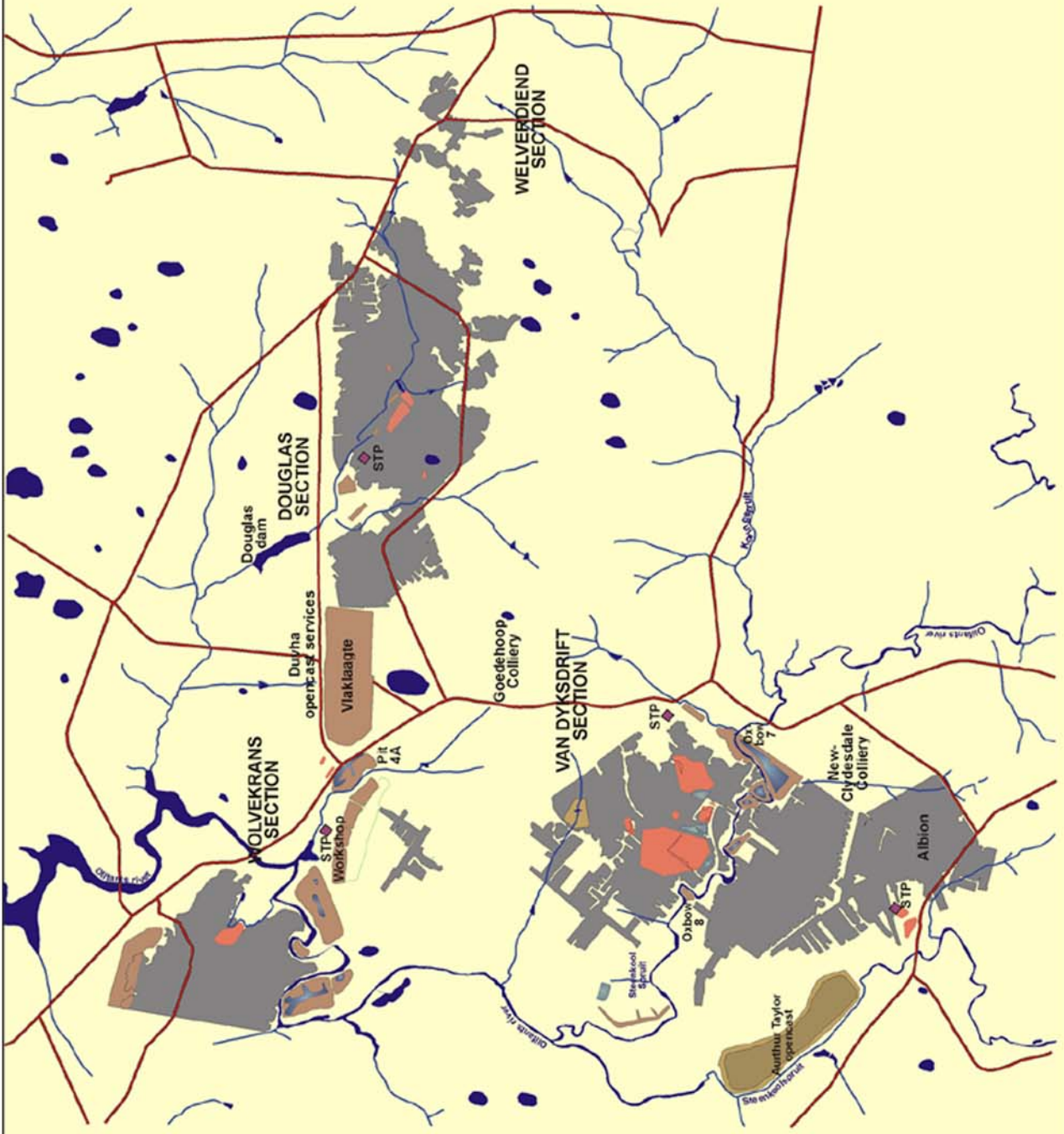


Figure 2.3.2 : Layout of Douglas Colliery

### 2.3.3 Eikeboom Colliery

Eikeboom Colliery is situated in the Mpumalanga Highveld about 30 km south-east of Middelburg and about 20 km northwest of Hendrina. The reserve area covers approximately 4.41 km<sup>2</sup>. The mine is located in the Middelburg Dam catchment in Management Unit no. 13 and Management Unit No 15 which forms part of the Middelburg magisterial district. Refer to **Figure 2.3.3** for a layout of the Eikeboom Colliery.

The mining operations at Eikeboom consists of the following elements:

- Current opencast pits at Klipfontein N2 Block, N1 Block & C1 Block. Future opencast pits include Klipbank, C5 and EP
- Mined out underground workings on the No. 2 seam.

All excess mine water is decanted to the pollution control dam. Runoff and seepage is also channeled to the pollution control dam from where it can either evaporate or spill to the Coetzerspruit. No information pertaining to N1 pit's operational dewatering rates and water quality are available.

C1 opencast is currently decanting at a rate of 10 l/s. This decant flows to the pollution control dam. It has not been determined whether the other pits will decant and what the magnitude of such decant will be.

No operational dewatering of the underground section has been undertaken and the blocks are not expected to decant. The storage capacity for water, however, amounts to 13.0 million m<sup>3</sup>.

The annual average overflow and seepage to the Coetzerspruit is estimated at 168 000 m<sup>3</sup>/year (0.46 Ml/day).

### 2.3.4 Goedehoop Colliery

Goedehoop Colliery is owned and run by Amcoal. Goedehoop colliery is located on the southern bank of the Koringspruit downstream of Blinkpan colliery. The mining operations at Goedehoop Colliery have the following elements: Refer to **Figure 2.3.4** for a layout of the Goedehoop Colliery.

- Underground workings at Springbok, Hope and Vlaklaagte.
- Opencast workings at Vlaklaagte and Haasfontein.

All water decanted in the Springbok section is collected in two pollution control dams. The dams have the option to decant excess water into the Springbokspruit. Currently no excess water is being decanted from the Springbok section. Excess water from water from the Hope section is stored in an Acid Water Dam. No water is allowed to decant from this dam, as any overflow will end up in the Hopespruit, which eventually enters the Koringspruit. Excess water at the Springbok and Hope sections are stored on site and reused or lost through evaporation. A small amount seepage does occur at both the Springbok and Hope sections. Decanting of excess water does at Goedehoop occurs from opencast pits 3 and 13.

The total annual average decanting and seepage from Goedehoop is estimated at about 203 091 m<sup>3</sup>/year (0.56 MI/day).

### 2.3.5 Greenside Colliery

Greenside Colliery is located in the Witbank Magisterial District. Refer to **Figure 2.3.5** for a layout of the Greenside Colliery.

The mining operation at Greenside Colliery has the following elements:

- Underground mine.
- Three (3) opencast pits – pit a, pit c and spencer block.

Presently mining is taking place underground and opencast mining at Spencer Block. Pits A and C were mined from 1994 to 1995 and 1993 to 1994 respectively. These pits were to be rehabilitated by the end of 1997. Spencer Block opencast started in 1997 and will end in 2002.

Water from underground is pumped via a number of shafts to the plant or to evaporation dams particularly Berry's Pan and Dam No.5. The water pumped from underground via the rescue shaft is stored in a disused TPA quarry, from where it is pumped to Dam No. 5 on the Noupootspruit. There is a spill and seepage through the dam wall into the Noupootspruit. The water from # 4 shaft is pumped straight into the Greensidespruit. Overflow from Dam 2 also flows into the Greensidespruit. Stormwater from the southern section of the plant area and the northern slopes of the waste dumps is collected into a Pollution Control Dam known as the Catchment Dam. Any overflow from this dam flows into the Naauwpoortspruit. Overflow from Evaporation Pond 1 flows into the Greensidespruit which flows into the Naauwpoortspruit.

It is estimated that Pit A will never fill as the majority of the decant will flow into the underground workings. Pit C at present has no measures to control decant if it does take place but these will be implemented once the need arises.

There is presently some 12.2 million m<sup>3</sup> of water stored in water bodies in the underground workings.

The total annual average decanted from the Greenside Colliery is estimated at 237 250m<sup>3</sup>/year(0.65MI/day).

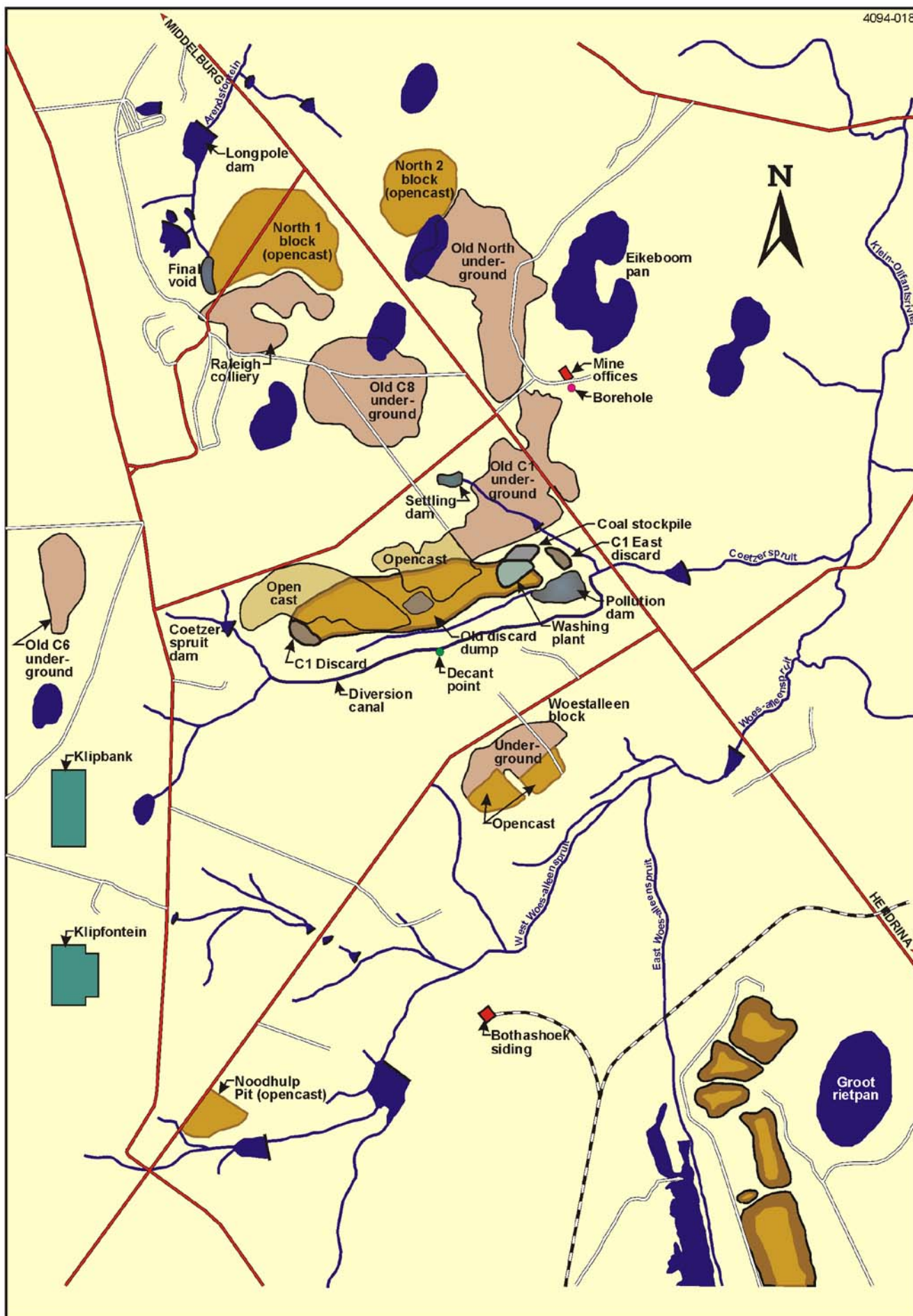


Figure 2.3.3 : Layout of Eikeboom Colliery

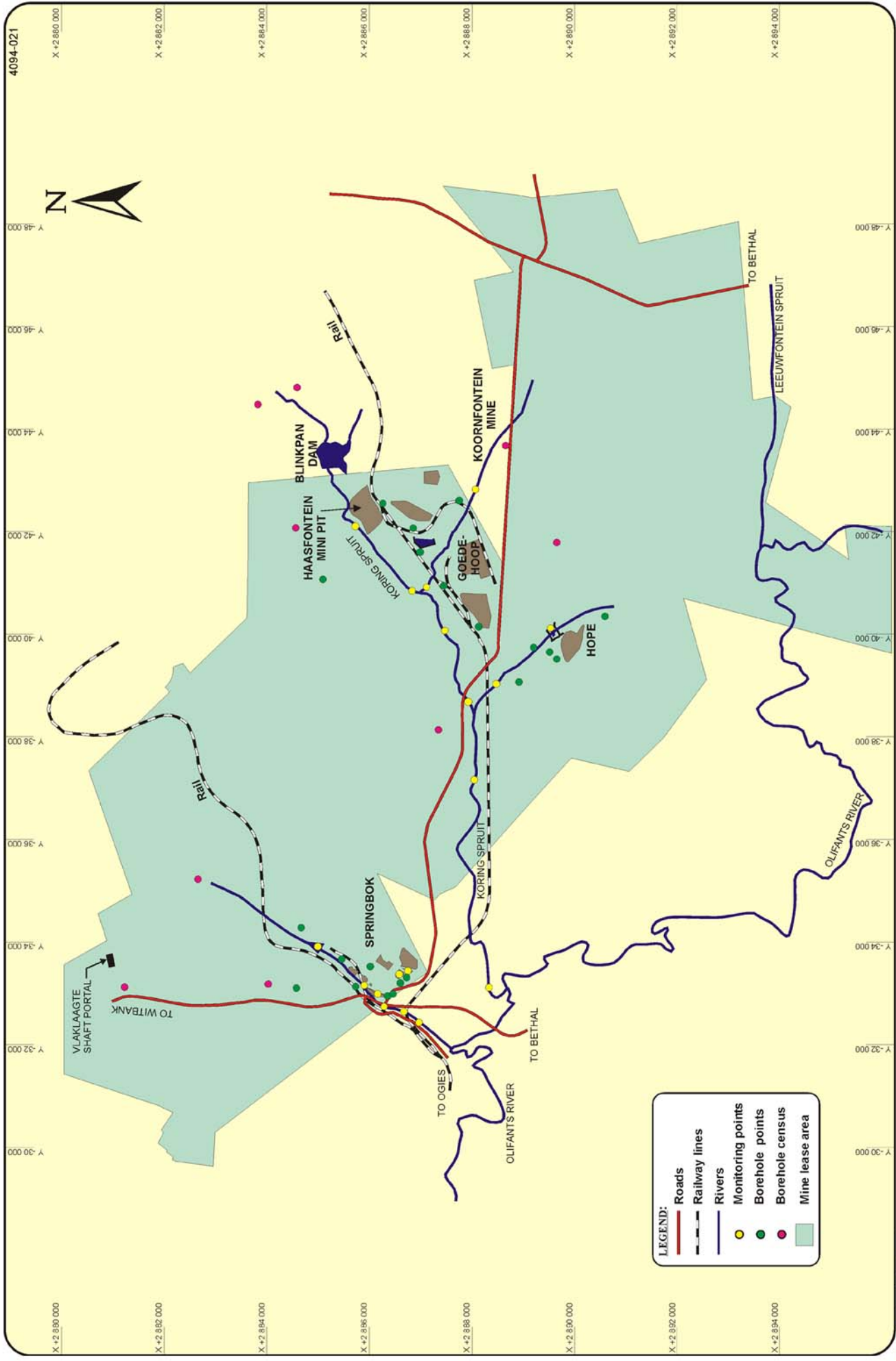


Figure 2.3.4 : Layout of Goedehoop Colliery



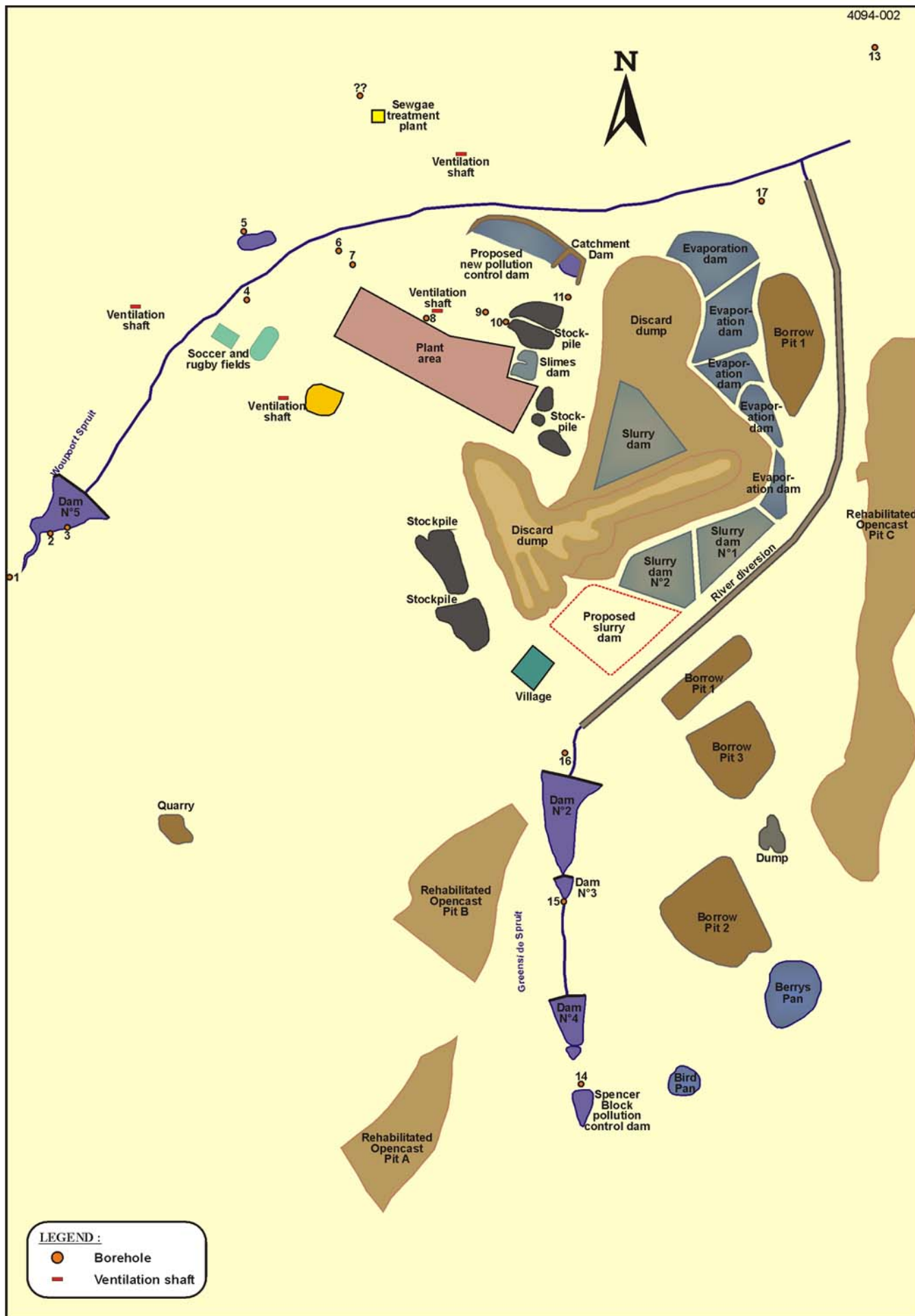


Figure 2.3.5 : Greenside Colliery

### 2.3.6 Kleinkopje and Landau Collieries

The Kleinkopje and Landau Collieries form part of South African Coal Estates. The Kleinkopje and Landau Collieries have been dealt with together as their water systems and mining operations are linked. Refer to **Figure 2.3.6** for a layout of the Kleinkopje and Landau Colliery.

The Landau Colliery consists of the following mining elements:

- Landau I, II and III underground workings
- North West and North East opencast mini-pits

The colliery consists of the following mining elements:

- 4 opencast pits viz Block 4E, Block 2A, Block 3A and Block 5W

The pit water make from block 2A is pumped to Ramp 6 holding dam from where it can be sent to the 5 West holding dam and on to Tweefontein Dam or to the clear water return dam for use in the plant. The water make from Pit 3A is sent to the Klippan co-disposal site.

Water from the Vlei Shaft Dam can be sent to the clear water return dam or released to the Olifants River. Excess polluted water in the clear water return dam can be pumped to the Tweefontein Pan. Releases of polluted water can be made from the Ramp 6 and 5 West holding dams to the Olifants River.

Due to the opencast mining of the Landau III workings in Pit 2A, extensive dewatering of the workings is undertaken so that the mining can take place in this area.

The NW and NE mini pit are integrated with the Landau III underground workings. The recharge through the NW mini pit recharges the Landau III underground water body. Part of the recharge through the NE Mini Pit will flow to the underground water body and a portion will decant to the NE spruit.

The recharge through Block 3A, Block 4E and Block 2A also joins the Landau III underground water body which decants to the Olifants River at Wolwekrans weir. Block 5W is not connected to the underground workings and will decant to the Olifants River. The positions of the decant points are shown on **Figure 2.3.6**.

The storage volume at decant, time to decant, and decant rate, for the water bodies on Kleinkopje and Landau Collieries are listed in **Table 2.3.6(a)**.

**Table 2.3.6(a) : Time to decant, average decant volume, storage volume and surface area (ha)**

Pit	Time to Post-Mining decant (yrs)	Average decant volume (MI/month)	Storage volume (million m <sup>3</sup> )	Surface Area (ha)
Landau III, 3A, 4E, 2A	15	157.8	55.2	3880
NE Mini Pit		8.2		88
Block 5W	19	55.9	13.0	891

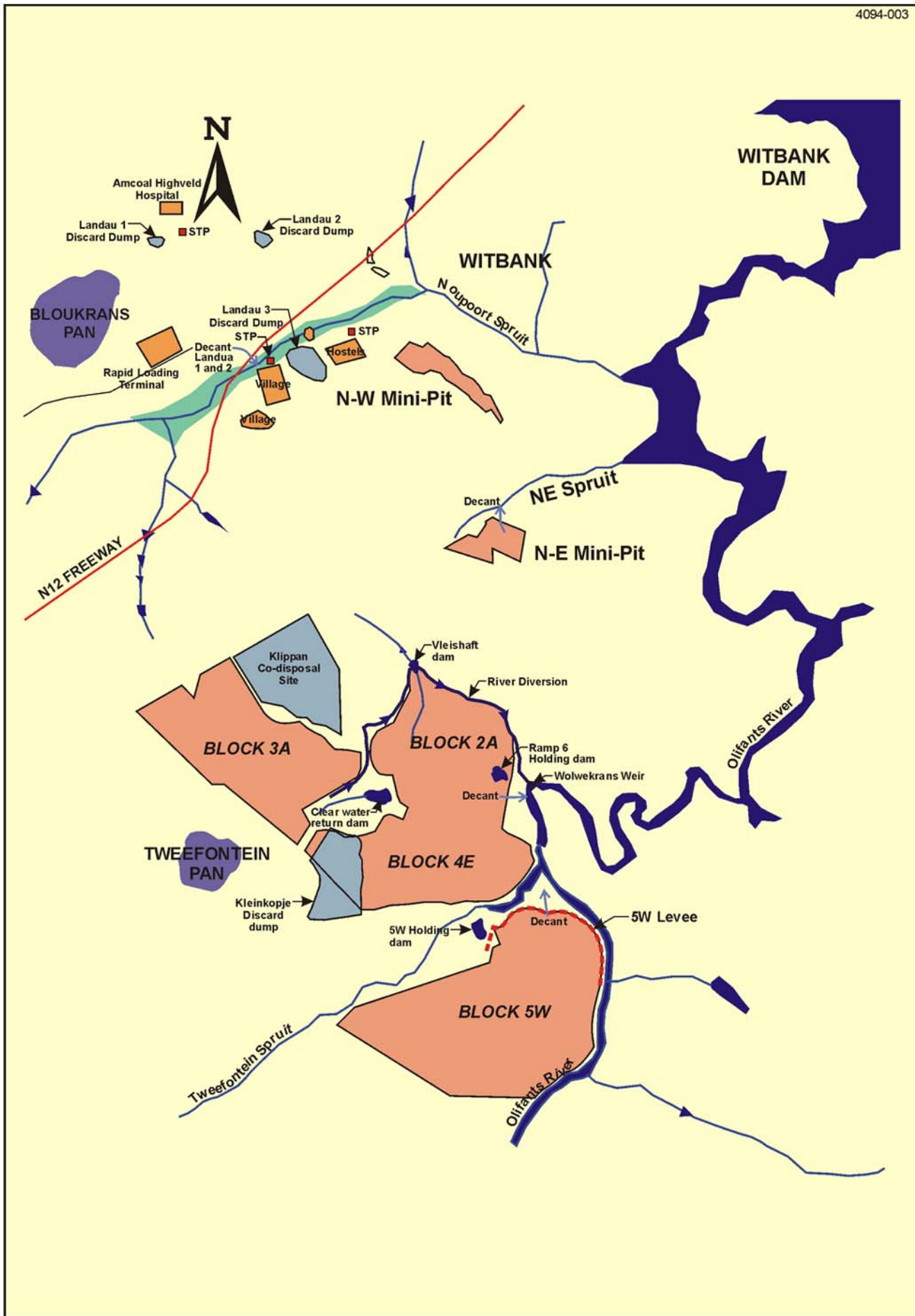


Figure 2.3.6 : Layout of Kleinkopje and Landau Collieries

There are periodic decants from the Landau land 2 underground workings into the Noupootspruit. The total annual average decant from the Kleinkopje and Landau Collieries is estimated at 1 489 800 m<sup>3</sup>/year (4.08 Ml/day).

### 2.3.7 Koornfontein Colliery

Mining operations at Koornfontein started in 1988 and are estimated to continue until the year 2009. The mine is situated in the Witbank Dam catchment in Management Unit no 3. Refer to **Figure 2.3.7** for a layout of the Koornfontein Colliery.

The mining operations at Koornfontein has the following elements:

- Block B and Block F opencast which have both been mined out. Block B has been rehabilitated and Block F was to be rehabilitated by 1998.
- Underground mining operations on the Gloria no. 2 seam, Blinkpan no. 4 seam and Blinkpan no 2 seam.

Polluted water at Block B drains to the return water dam and to the final void. It has been indicated by the mine that the return water dam will in future also release to the Block B final void. Seepage and runoff from the New Discard Dump and Slurry Dam Phase 1 is collected in the adjacent return water dam.

No information is available on the operational water balances and the quality of the water pumped from the pits. A study is currently underway to determine the time for the pits to decant, decant rate and the quality of the decanted water.

Mine water is also released from Block F final void and from Gloria. These discharges are not continuous and forms part of the controlled release scheme instituted in 1996 which will be discussed in **Section 2.4**.

Other than the control release scheme there is no other decanting of excess water. The annual average seepage is estimated to be at 34 200 m<sup>3</sup>/year (0.097 Ml/day).



Figure 2.3.7 : Koorfontein Colliery

### 2.3.8 Kriel Colliery

Mining of coal started at Kriel in 1975 and the planned mining is scheduled to end in 2019. The colliery is situated in the Witbank Dam catchment partially in Management Unit No. 2 and partially in Management Unit No. 7. The confluence of the Dwars-in-die-Wegspruit and the Steenkoolspruit is in the south eastern corner of the mine property. Other streams which cross the mine property include the Rietspruit, Disselboomlaagte and the Onverwachtspruit. Refer to **Figure 2.3.8** for a layout of the Kriel Colliery.

The mining operations at Kriel have the following elements:

- Opencast workings at Pit 23, Pit 23 Ext, Pit 4, Pit 5 and Pit 6.
- Underground workings at A1, A2, A3, A4 and North West shaft.
- Three sewage treatment plants.
- Future opencast pits 5, 6, 7, 8, 9, 10, 11, 12 and 13.
- Future underground at Block F.

The opencast mining operation at Pit 4 generate excess mine water during the operation of the mine. This excess water is pumped from the pit floor to a 20 000 m<sup>3</sup> dam. Some of the water stored in the dam is evaporated. The balance is released to the Steenkoolspruit under permitted conditions.

The opencast mining operation at Pit 23 and 23 Ext generates excess mine water. During the operation of the mine the excess water from Pit 23 was pumped to settling dams before being discharged to the Onverwachtspruit. Some of the excess water was used for dust suppression (9.167 m<sup>3</sup>/month) with the balance being discharged via the settling dams. The excess water from Pit 23 extension was pumped via 2 settling dams (capacity 1200 m<sup>3</sup>) into a wetland (13 ha area capacity 65 000 m<sup>3</sup>) on the unmined portion of Pit 23 before discharging to the Dwars-in-die-Wegspruit. After the wetland was mined out, the excess water from Pit 23 extension was pumped to the final void of Pit 23.

The pits are expected to fill and decant with time. Information pertaining to the post-mining water balance is reflected in **Table 2.3.8(a)**.

**Table 2.3.8(a) : Water-related information on post-mining storage and decant**

Pit name	Time to post mining filling of the pit (yrs )	Average decant volume (Ml/month)	Pit storage volume (million m <sup>3</sup> )
Pit 23 (seepage)	6-12	4.7	7
Pit 23 Ext (seepage)	15-28	1.6	6.5
Pit 23 (decant)	15-25	55.3-93.3	16.5
Pit 23 Ext (decant)	25-45	19.5-35.3	10.5
Pit 4	122-145	12.9-16.2	22.5

It is estimated that Kriel currently decants about 725 328 m<sup>3</sup>/year (1.99 Ml/day).

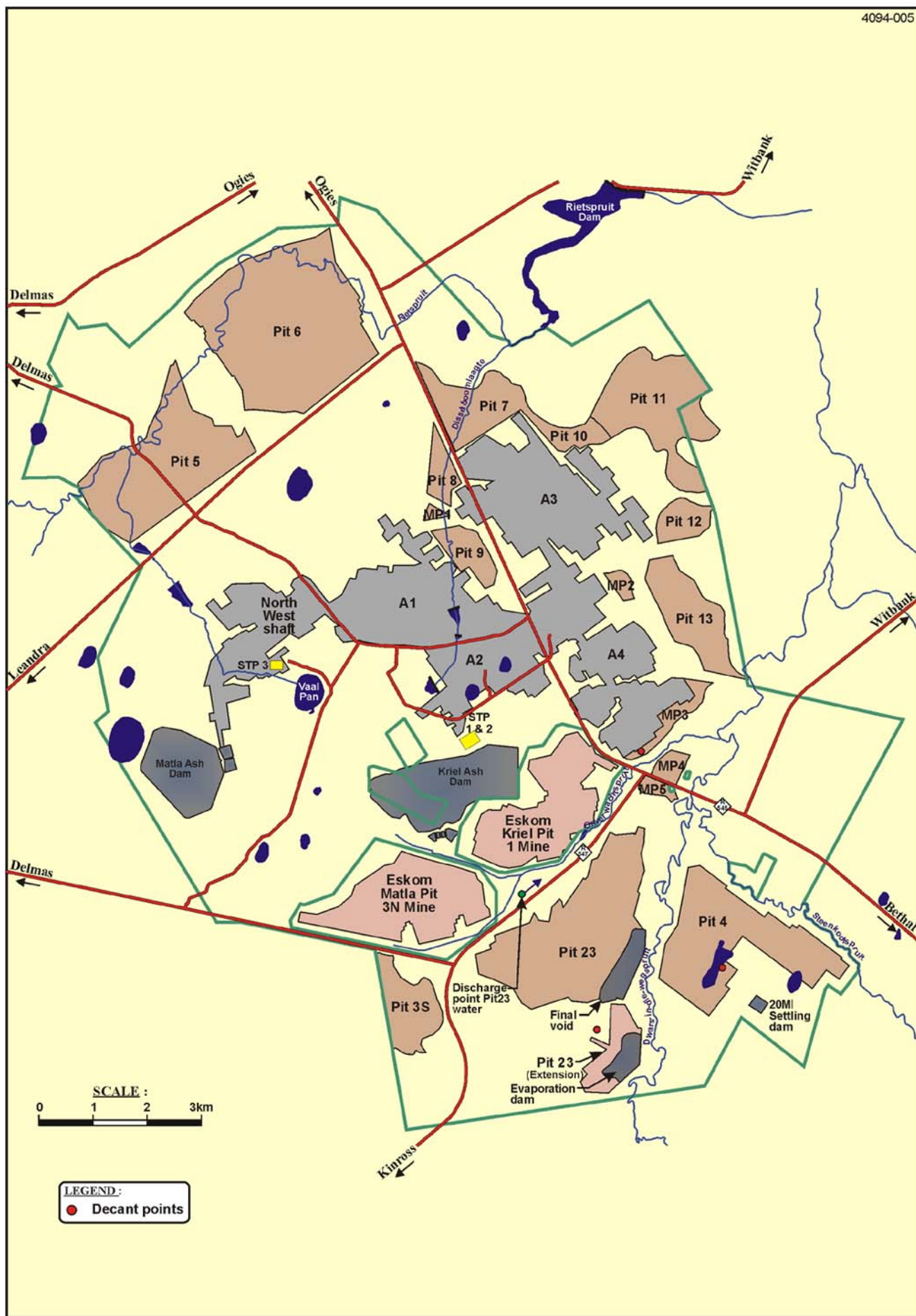


Figure 2.3.8 : Layout of Kriel Colliery

### 2.3.9 Matla Mine Services

Mining activities at Matla mine services started in 1970 and are scheduled to end in 2036. Refer to **Figure 2.3.9** for a layout of the Matla Colliery.

The mine is situated in the Witbank Dam catchment in Management Unit No. 2. The colliery is situated on either side of the Rietspruit River and the mining process at Matla has not affected the course of any rivers.

The mining operation at Matla Colliery has the following elements:

- three underground mines which operate independently viz Matla no. 1, 2 and 3 mines

The three mines on Matla Colliery are independent, meaning that they are not interlinked underground. Whatever water make occurs in a mine is confined and cannot be transferred to the other mines.

Excess water on on No. 1 mine is pumped from the underground workings to the evaporation dam. The excess water is either stored in the evaporation dam or is discharged to the Rietspruit river.

The no. 1 mine does not experience much water make but the no 2 and no 3 mines do experience a fair amount. On the no. 2 mine the recharge is estimated at 51 MI/month. The water make on the no. 3 mine is as a result of recharge from ground water at a rate of 33.150 MI/month. Since the objectives are to keep the mines dry, the recharge is pumped out. The excess water from no.2 and no.3 mines are pumped to retention dams on the mines.

The operational dewatering rate, current storage capacity, post-mining storage capacity and the post-mining decant rate for the various mines are listed in **Table 2.3.9(a)**.

**Table 2.3.9(a) : Underground mining information**

Mine Name	Operational dewatering (MI/month)	Current storage (million m <sup>3</sup> )	Post-mining storage (million m <sup>3</sup> )
No. 1 mine	21.0	13	42
No. 2 mine	75.0		
No. 3 mine	57.0	13	99.4

The total annual average rate of decanting from all three mines at Matla Mine Services is estimated at about 2 070 000 m<sup>3</sup>/year (5.67 MI/day).

### 2.3.10 Middelburg Mine Services

Mining of coal started at Middelburg mine in 1981 and is scheduled to continue until 2034. The mine consists of two sections viz the North and South Section. The South section is in the Witbank Dam catchment in Management Unit no. 4, while the North section is in the Spookspruit catchment in Management Unit No 26. Refer to **Figure 2.3.10** for a layout of the Middelburg Mine Services.

Mining operations at Middelburg mine has the following elements:-

- South Section opencast pits viz. Driefontein, Boschmanskrans, Wolwekrans North of Dyke, Vlakraagte.
- North Section viz Hartebeesfontein, Bankfontein and Goedehoop

Information with regard to pit water balances is lacking. The mine as however indicated that their pit water balances are presently under investigation.

There seems to be no decanting occurring on the South section. Excess water from the North section is pumped to five pollution water dams. The major decant points on the North section are Dams 5, 6 and 8. Excess water from Dams 5, 6 and 8 are discharged to the Spookspruit river.

The combined annual average rate of decanting from the North section and seepage from the South section is estimated at 480 800 m<sup>3</sup>/year (1.32 MI/day).

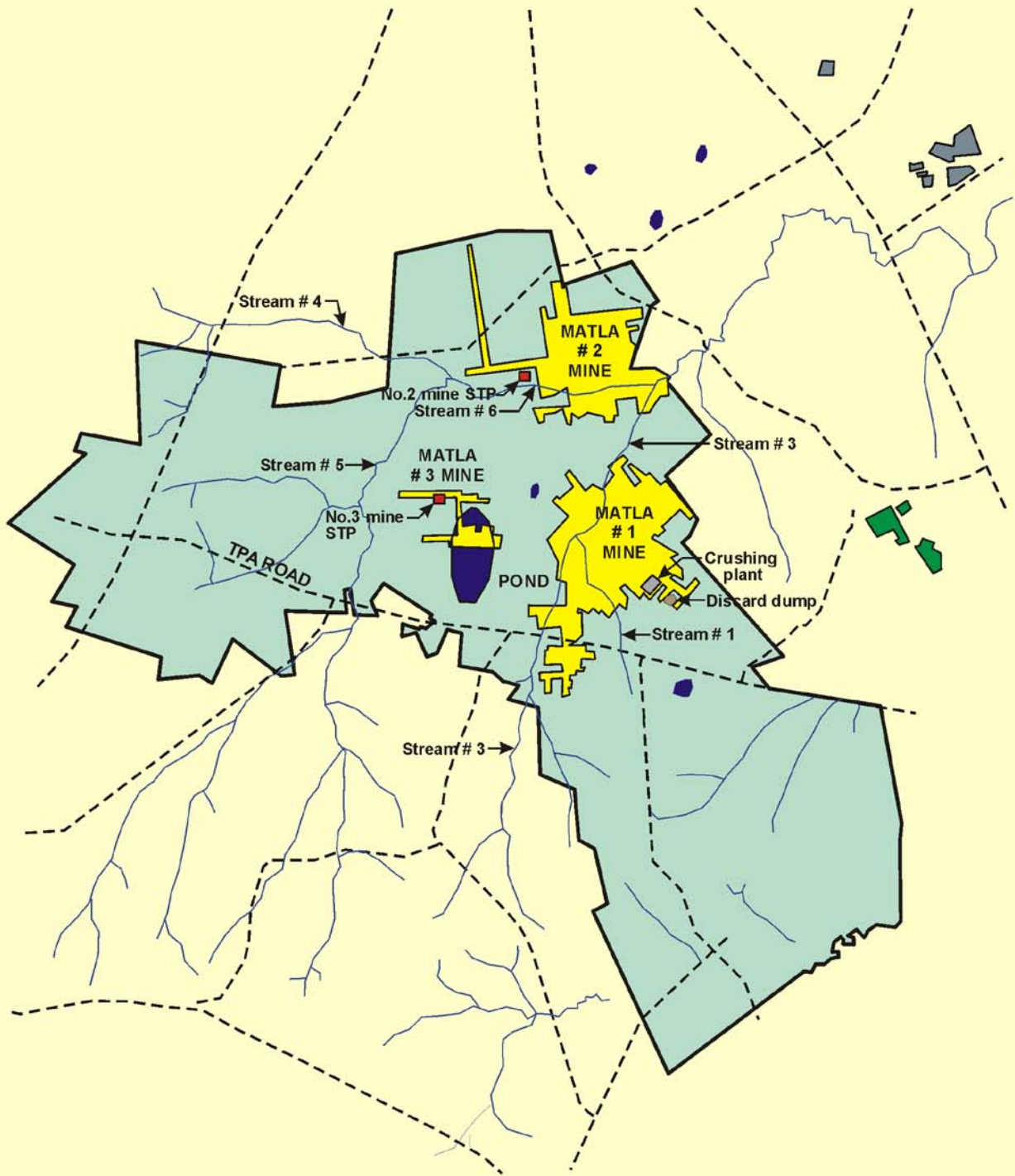


Figure 2.3.9 : Matla Mine Services



### 2.3.11 Optimum Colliery

Optimum Colliery is situated in the Mpumalanga Highveld about 30 km south east of Middelburg and about 20 km northwest of Hendrina. The mine is located in the Middelburg Dam catchment in Management Unit no. 13 which forms part of the Middelburg magisterial district. Refer to **Figure 2.3.11** for a layout of the Optimum Colliery.

The mining at Optimum consists of the following elements:

- Six opencast sections viz Bothashoek, Optimus, Zevenfontein, Pullenshope, Boschmanspoort and Kromdraai.

Water from the Bothashoek pit is pumped to the final voids which are used as evaporation dams from where it can be discharged to the Lapa Dam. Pit water from Zevenfontein is pumped to an evaporation dam and from there it can be discharged or overflow to the Zevenfonteinspruit. It has been indicated by the mine that the volumes of water used on the mine will not change significantly. A possible reduction could be realised as more water is recycled for use as process water on the plant.

The current average decant volumes for Optimus and Zevenfontein sections are shown in **Table 2.3.11(a)**. No estimations for the Bothashoek and Pullenshope sections have as yet been undertaken.

**Table 2.3.11(a) : Operational pit water balances for Optimus and Zevenfontein opencast pits**

Pit Name	Average Decant Volume (MI/month)
Optimus	270.0
Zevenfontein	18.9

The other opencast pits are expected to decant as well but no exact dates as yet been determined. It has been indicated by the mine that decanting will be managed by the controlled released strategy and treatment.

The total annual average rate of decanting from the Optimum Colliery is estimated at 3 466 800 m<sup>3</sup>/year (9.5 MI/day).

### 2.3.12 Rietspruit Mine Services

Mining of coal started at Rietspruit in 1976 and is scheduled to end in 2002. The Rietspruit Colliery is situated some 46 km south of Witbank between the towns of Ogies and Bethal. The mine is in the Witbank Dam catchment in Management Units No 2, 5 and 7. Refer to **Figure 2.3.12** for a layout of the Rietspruit mine.

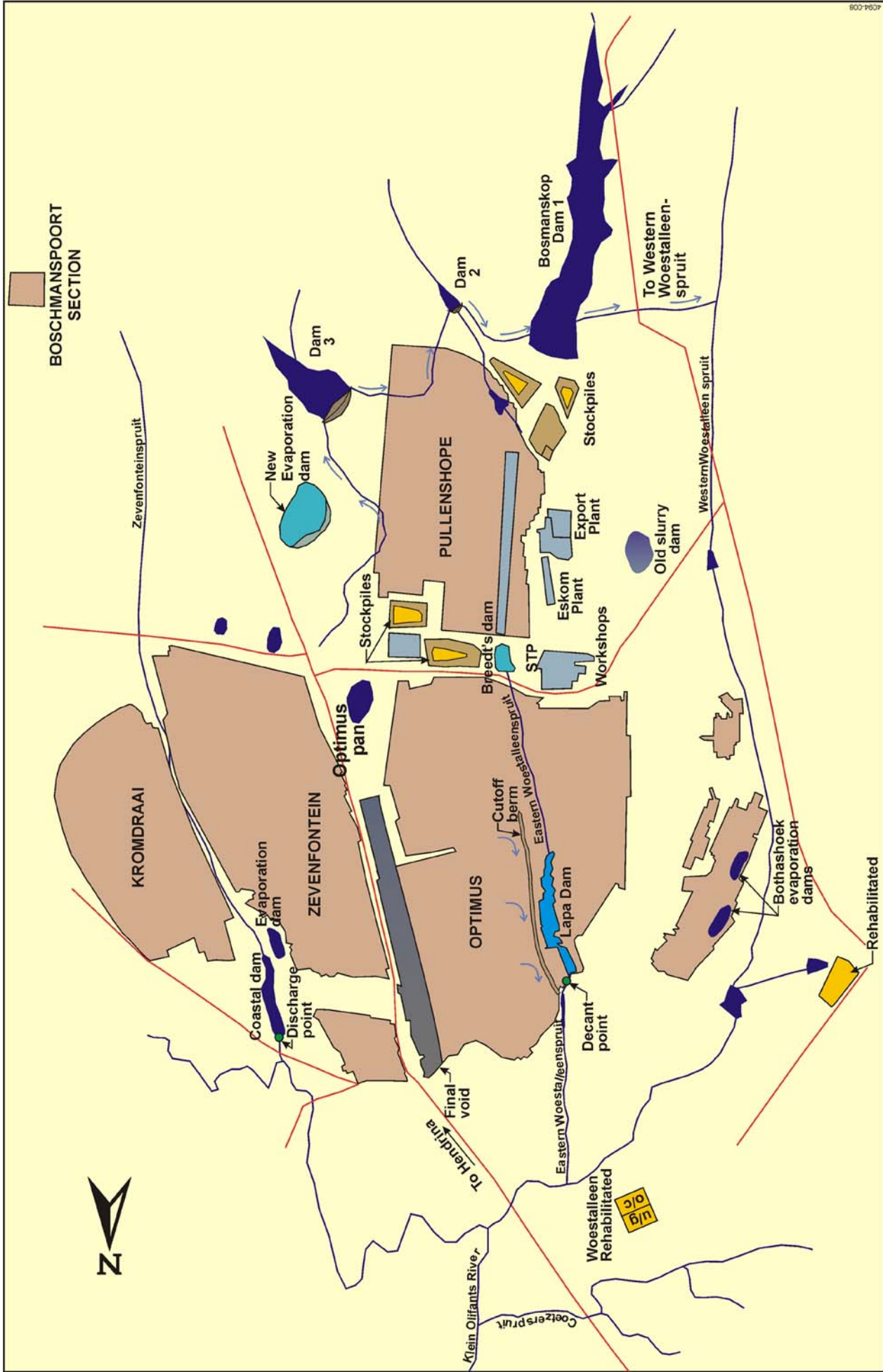


Figure 2.3.11 : Layout of Optimum Colliery



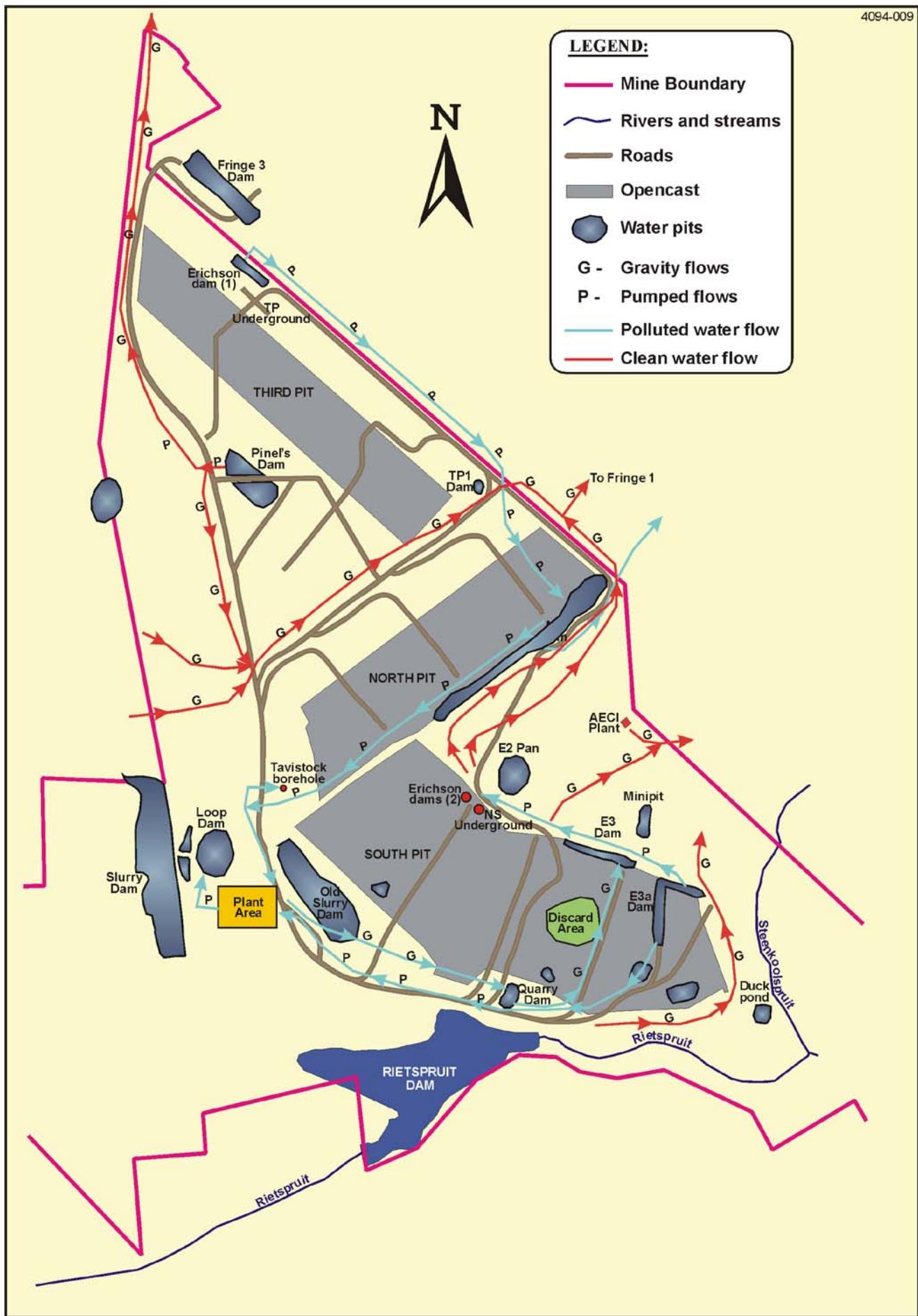


Figure 2.3.12 : Layout of Rietspruit Mine Services

The mining operation at Rietspruit has the following elements :-

- Three open cast pits viz North Pit, South Pit and Third Pit. The mining of the North and South pits is complete. Only the Third Pit is being mined
- The N/S and TP2 underground workings. The reserves of the TP2 workings have been mined out. Only the N/S workings are currently operational.

The final voids in the North and South open cast pits are being used as polluted water control dams for the management of polluted water. The surface runoff from the plant area is caught in a cut off trench which conveys the polluted water to the E3 ramp for discharge to the E3 and E3A final voids of the South Pit.

The recharge water through the spoils and the surface runoff from the rehabilitated spoils drain to the final voids N3 and E3 of the North and South pits respectively. The water from the workings of the Third pit is pumped to the N3 final void. Pumps have been installed in the N3 and E3 final voids to enable discharges of mine water to be made to the Steenkoolspruit. Water has been discharged during the 1996/97 hydrological year as a controlled release during flood conditions.

The pits are also expected to fill and decant with time. Management strategies for the future mine water decant are being investigated and developed. The general information pertaining to the post-mining water balance is reflected in **Table 2.3.12**

**Table 2.3.12 : Water-related information on post-mining storage and decant**

Pit Name	Time to post-mining filling of pit (yrs)	Average decant volume (Ml/month)	Pit Storage Volume (million m <sup>3</sup> )
North	25	65.6	18.59
South	25	74.4	21.21
Third	85	72.1	73.35

The total annual average rate of decanting at the Rietspruit Mine is estimated to be about 515 640 m<sup>3</sup>/year (1.41 Ml/day).

### 2.3.13 SA Coal Estates

South African Coal Estates consists of the Kleinkopje, Landau, Navigation, Schoongezicht, Kromdraai and Excelsoir Collieries. Kleinkopje and Landau have been covered in section 2.3.6. In this section the remaining collieries are discussed. The Navigation and Schoongezicht Collieries lie in Management Unit 16 in the headwaters of the Klipspruit catchment while Kromdraai lies partially in Management Unit 16 and Management Unit 21.

These operations consist of the following elements:

- The underground working at Kromdraai, Navigation, Schoongezicht and Excelsoir. These underground mining operations have ceased at workings.
- Opencast mining at Kromdraai and at the Schoongezicht No 2 and 4 Mini Pits.

There is no available information Navigation and Schoongezicht.

### 2.3.14 Kromdraai

The Kromdraai operation consists of the North, Central, South and Excelsoir Blocks. These underground workings have been filled with water over the years and are presently decanting. The Excelsoir Block decant is captured in a dam and piped through an adit into the Kromdraai Central Block.

The decant from the central and north blocks is conveyed via adits to a lining plant at the headwaters of the Kromdraai spruit in the Saalklap catchment area. The decant from the South block is piped into the plant for treatment. The water in the old underground workings is generally acidic and has high sulphate concentrations. The volume of water in the Kromdraai workings is about 10 million m<sup>3</sup>. The effluent from the lining plant is discharged via a series of evaporation dams into the Kromdraai spruit.

The annual average decant rate from Kromdraai is estimated at 461 112 m<sup>3</sup>/year (1.26 Ml/day).

### 2.3.15 Syferfontein Colliery

The mining activities at Syferfontein started in 1990 and are expected to proceed until 2015. Syferfontein Colliery is situated in the Mpumalanga Province approximately 120 km east of Johannesburg. The mine is in the Witbank Dam catchment in Management Unit No. 1. Refer to **Figure 2.3.14** for a layout of the Syferfontein Colliery

The mining operation at Syferfontein has the following elements:-

- Three opencast pits viz South Pit (Pit 1), Centre Pit (Pit 2 and 3) and North Pit (Pit 4, 5 & 6) which are interconnected.

The Trichardtspruit is being mined through by Syferfontein Colliery. The Rietfontein Dam as been split into two compartments. This was done as the mining operation was threatened by the water stored in the dam. The upstream section of the Rietfontein dam also forms part of the long term mining plan and must be drained. In fact the decant point from the opencast workings is likely to be into the upstream end of Rietfontein Dam. The clean water from Tweedraai Dam is discharged into the downstream compartment.

Runoff and recharge which collect in the South Pit and Centre Pit is pumped to the Dirty Water Dam. Excess water from the Dirty Water Dam is pumped to the Southern Evaporation Dam (No. 1) which has an overflow to the Otter Dam. From the Otter Dam the water is pumped, via a polluted water canal to van Schalkwyk's Dam and the Riversdale Dam, to either the Rietfontein Dam or to the Trichardtspruit downstream of the dam wall. Overflow from the Northern Evaporation Dam is routed via the polluted water canal to either the Rietfontein Dam or the Trichardtspruit.

The opencast pits are expected to fill up and decant and since the pits are interconnected they will all decant at the same time and at one point only. The time for post-mining filling of the pits was estimated to be 15 years which implies that decant will start by the year 2035, as it is anticipated that mining will stop in the year 2020. Information pertaining to post-mining decant is listed in **Table 2.3.14**. The figures are given for the total pit.

**Table 2.3.14 : Decant information for opencast pits**

Time to Post-mining surface filling of pit (yrs)	15
Average Decant Volume (Ml/month)	90.0
Storage Volume (million m <sup>3</sup> )	16.2
Surface Area of Storage (ha)	1989

Due to a lack of water in underground workings no dewatering is currently undertaken, but it is expected that the workings will. No decant rates have been predicted at this stage.

The annual average decant rate from Syferfontein Colliery is estimated at 533 256 m<sup>3</sup>/year (1.46 ml/day) .

### **2.3.16 Travistock Colliery**

The Tavistock colliery is situated 35 km South of Witbank between the towns of Ogies and Bethal and adjacent to Rietspruit Colliery. The mine is in the Witbank dam catchment in Management Unit no 2. Refer to **Figure 2.3.15** for a layout of the Travistock Colliery

The following elements are to be located on Tavistock Colliery:-

The following opencast pits:

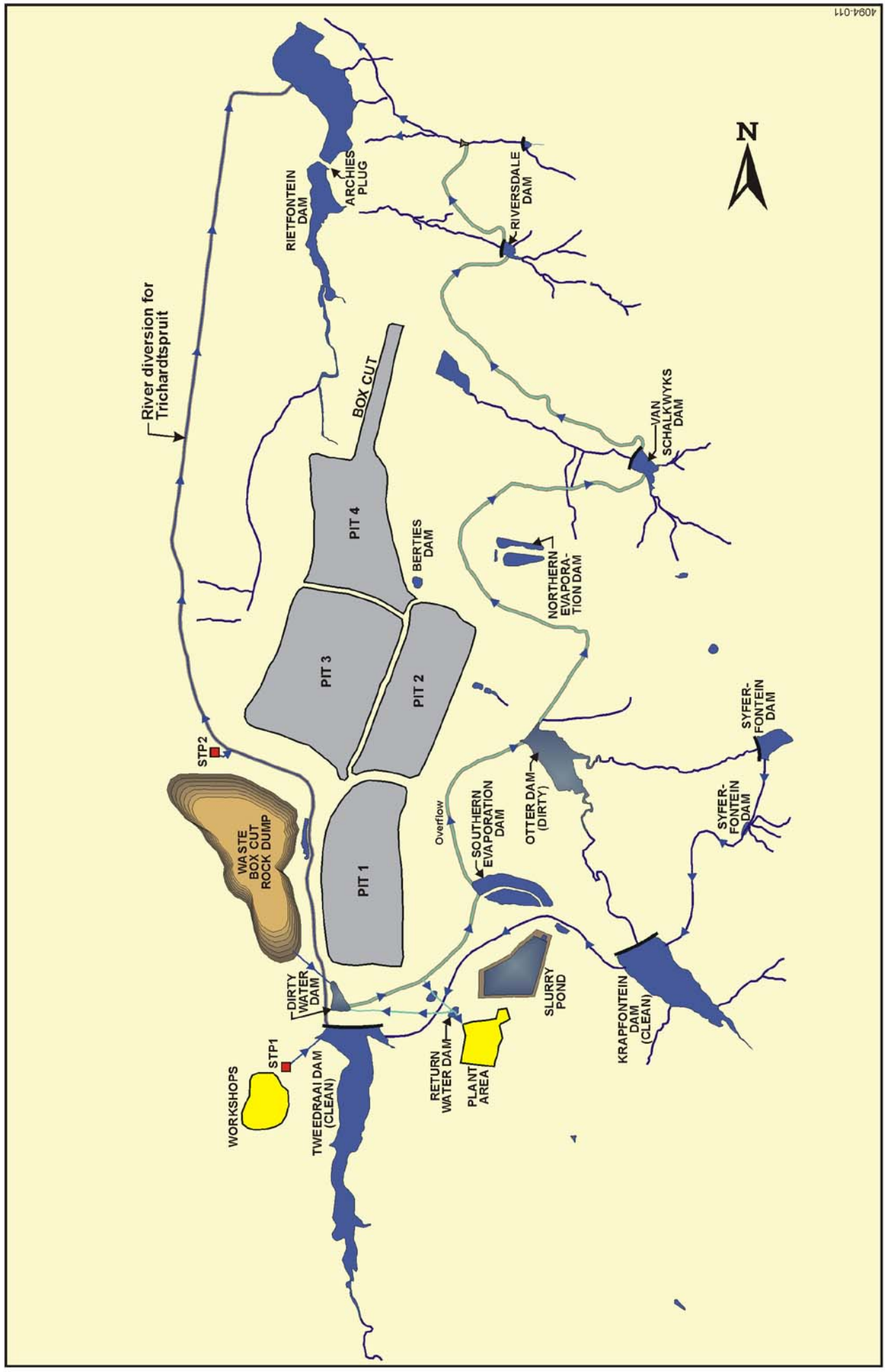
- Arthur Taylor Colliery (ATC) Pit A, ATC Pit A East, Arthur Taylor Colliery opencast mine (ATCOM), Phoenix mini pit.

The following underground mines:

- South Witbank Coal Mine (SWCM), Tavistock Colliery, ATC, Phoenix Colliery.

The mine has indicated that post-mining filling of the pits will occur and that the pits could possibly decant. An estimation of the time to decant and the decant volumes have not been undertaken as yet, but it has been decided that the decant will be treated. Currently no decanting as been detected on any of the mines within Travistock. Travistock has however participated in the Control Release Scheme.

The annual average rate of seepage from the Travistock Collieries is estimated at 180 000 m<sup>3</sup>/year ( 0.49 Ml/day).



**Figure 2.3.14 : Layout of Syferfontein Colliery**



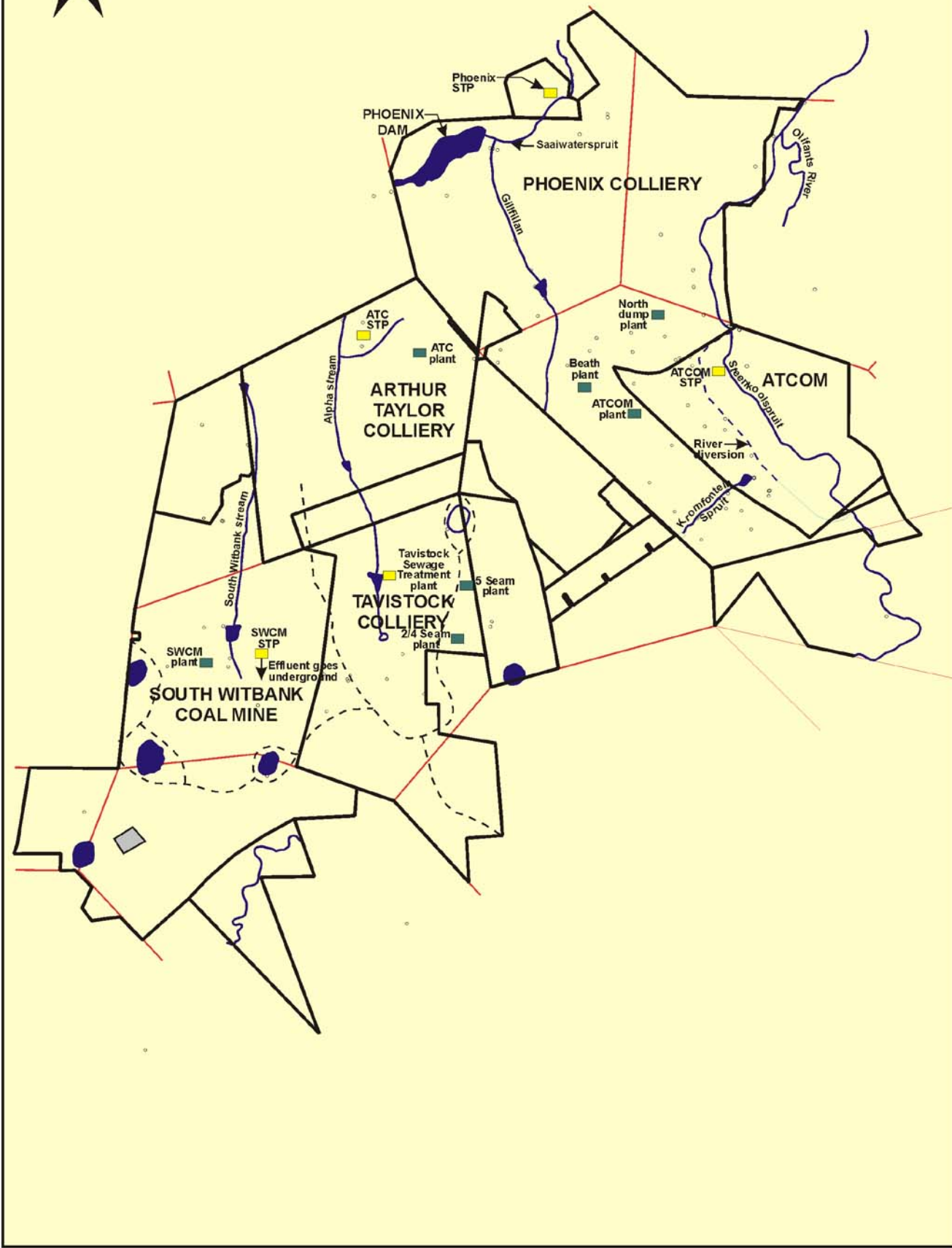


Figure 2.3.15 : Layout of Tavistock Colliery

### 2.3.17 Tweefontein Colliery

Tweefontein Colliery is located in the Witbank Municipal district in Mpumalanga. The colliery falls under the Middelburg Regional Services Council. The mine is situated in the Witbank Dam catchment in Management Unit No. 5. The mining area is transgressed by the Saaiwaterspruit and the Tweefonteinspruit.

The mining operations at Tweefontein consist of the following elements:

- Underground sections at Boschmansfontein, Waterpan and Witbank Consolidated.
- Small scale opencast workings at Boschmansfontein, Waterpan and Witbank Consolidated.

The only effluent discharge that occurs at Tweefontein is the overflow from the Tweefontein Dam. This is not a frequent occurrence and may only occur in excessively wet seasons. This can be attributed to the fact that Tweefontein has large underground storage capacity.

### 2.3.18 Woestalleen Colliery

Mining of coal at Woestalleen Colliery started in 1986 and the current reserves will be mined by the end of 1999. The colliery is situated in the Middelburg Dam catchment in Management Unit No.13. Refer to **Figure 2.3.17** for a layout of the Woestalleen Colliery

The mining operation has the following elements:

- Mined out pits on the Woestalleen Section including North Pit #1 and #2, Mini Pit, West Pit and Powerline Pit.
- Current pits on the Noodhulp Section including Western Reserves, Eastern Reserves and Central Reserves.
- Kromdraai opencast section.

The pits have been rehabilitated to give a free draining surface. However, west pit and Powerline Pit drain to final voids. The west pit is currently decanting at about 10 m<sup>3</sup>/hr.

The eastern and western reserves have been mined out. These pits have been rehabilitated and the surface runoff has been directed to the Western Woestalleenspruit. Seepage zones have developed around the eastern fringes of the Western Reserves.

Decanting at the Woestalleen Colliery is currently taking place at the Western Pit. No information is available at present on the volume and quality of the decanted water.

The annual average decanting rate from the Pollution Control Dam is 67 848 m<sup>3</sup>/year (0.19 Ml/day).

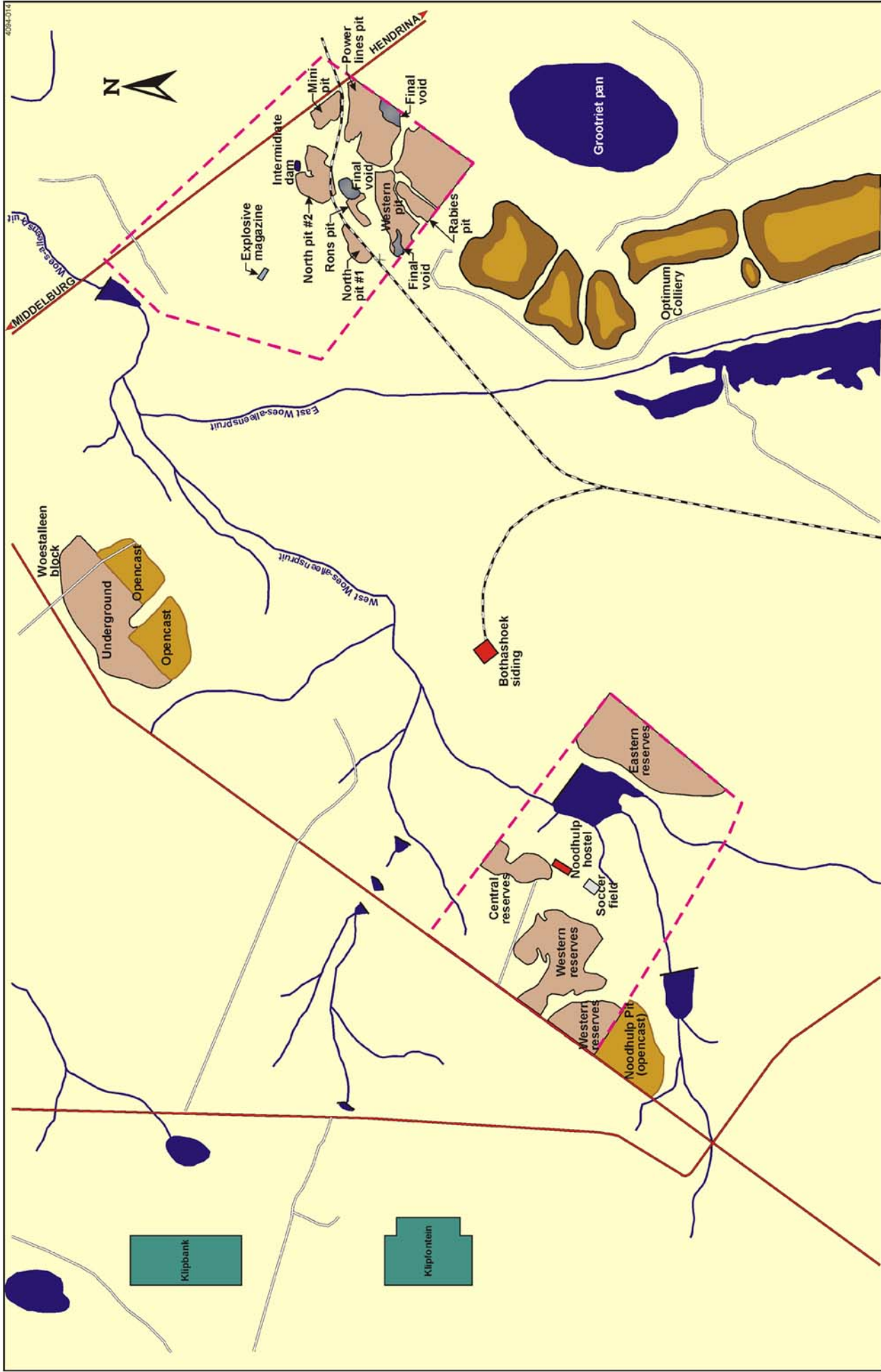


Figure 2.3.17 : Layout of Woestalleen Colliery

### **2.3.19 Khutala Colliery**

Khutala Colliery is owned and run by Ingwe Coal Corporation Ltd. It is the main supplier of coal to Kendal Power Station. Refer to **Figure 2.3.18** for a layout of the Khutala Colliery

The mining operations at Khutala Colliery has the following elements:

- The main underground shaft
- Opencast mining at Block 1

All excess water from both opencast and underground mining is pumped to a pollution control dam. No water is decanted from the pollution control dam. Water is discharged through evaporation.

Losses due to seepage from the Pollution Control Dam amounts to 802 270 m<sup>3</sup>/year (2.19 MI/day).

### **2.3.20 South Witbank**

South Witbank Colliery is an old defunct mining operation in the Klipspruit catchment. The mine complex includes large underground workings and a small opencast section. Polluted mine water accumulated in the workings and is now seeping and decanting towards the natural stream.

The mine is in the process of compiling a long term Water Management Plan. In 1997 the mine applied for an interim permit for the release of neutralised mine water to the Townshipspruit, a tributary in the Klipspruit catchment.

Most of the excess water is decanting from underground workings. The estimated average underground mine water decant rate is 1.78 MI/day and 0.695 MI/day from the opencast void area.

It is estimated that the annual average decant from the South Witbank Colliery will be about 901 550 m<sup>3</sup>/year (2.47 MI/day).

### **2.3.21 Middelburg Stream and Old Tavistock**

The Middelburg Stream and old Tavistock collieries are old defunct mining operations. Both these collieries lie in the Klipspruit catchment. In 1996 the Department of Water Affairs carried out an investigation into collecting the excess mine water from these mines (refer to report "Acid mine drainage collection and conveyance systems for abandoned mines").

It is estimated that the Middelburg Stream and Old Tavistock decant about 222 285 m<sup>3</sup>/year (0.61 MI/day) and 28 105 m<sup>3</sup>/year (MI/day) respectively.

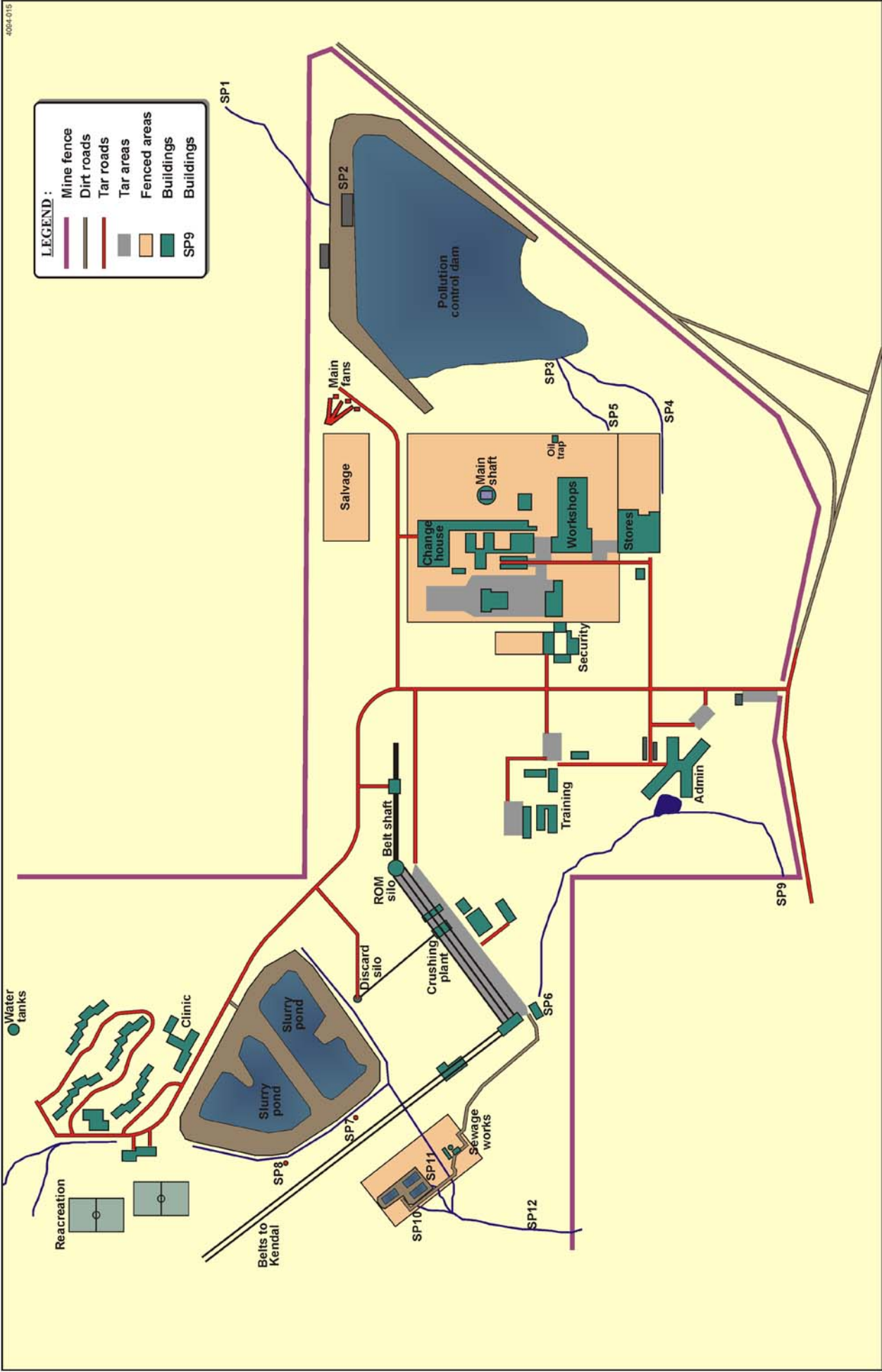


Figure 2.3.18 : Surface infrastructure layout of Khutala Colliery



### 2.3.22 Summary of Excess Mine Water Production

**Table 2.3.21(a)** gives a summary of the estimated volumes of excess water on the various mines. The volume of excess water represent in **Table 2.3.21(a)**, is that of current decanting and seepage volumes only.

**Table 2.3.21(a):**

Catchment	Mine Name	Available Water (m <sup>3</sup> /year)	Available Water (ML/day)
<b>Middelburg</b>			
	Arnot Colliery	1 615 644	4.40
	Eikeboom	168 000	0.46
	Woestalleen Colliery	67 848	0.19
	Optimum Colliery	3 466 800	9.50
<b>Witbank</b>			
	Douglas Colliery	NIA	NIA
	Goedehoop Colliery	203 091	0.56
	Greenside	237 250	0.65
	Kleinkoje & Landau	1 489 800	4.08
	Koornfontein	34 200	0.09
	Kriel	725 328	1.99
	Matla Mine	2 070 000	5.67
	Middelburg Mine - South	7 470	0.02
	Middelburg Mine - North	213 000	0.58
	Rietspruit Mine Services	515 640	1.41
	Syferfontein Colliery	533 256	1.46
	Tavistock Colliery	180 000	0.49
	Twefontein Colliery	NIA	NIA
<b>Klipspruit</b>			
	Kromdraai	461 112	1.26
	South Witbank	901 550	2.47
	Middleburg Stream	222 285	0.61
	Old Travistock	28 105	0.08
	Brugspruit		
	High TDS	985 500	2.70
	Low TDS	912 500	2.50

## 2.4 CONTROL RELEASE SCHEME

The managed release of saline mine water during high flow conditions in the Witbank Dam catchment was started as a pilot scheme in the 1996/97 hydrological year and was continued during the 1997/98 and 1998/99 hydrological years.

The 1995/96 hydrological year was one of the wettest years on record and the mines accumulated large volumes of water. This took place to such an extent that the available water storage facilities were filled and in some cases resulted in seeping and decanting in an uncontrolled manner after the wet season. In a few cases, coal reserves were also flooded and the mining of some sections had to be abandoned.

This situation resulted in uncontrolled and emergency releases of polluted mine water taking place in the early winter of 1996, resulting in the progressive deterioration of the water quality in the Witbank Dam. The dam salinity levels reached an all time high by October 1996, prompting the Department of Water Affairs and Forestry to urgently review the appropriate short term measures to address the situation.

A joint investigation between the Department and the local mining industry was conducted in late 1996 to evaluate options. It was decided to implement a scheme involving the controlled release of mine water during high flow conditions.

The application of the managed released principle to the Witbank Dam catchment has proved successful under the hydrological conditions experienced during the 1996/97 and 1997/98 hydrological years. The controlled release scheme is however dependant on rainfall levels. Reasonable rainfalls are required to give the Dams an assimilative capacity. If the hydrological year is fairly dry, as is the present case in the 1998/99 hydrological year, then releases are limited.

**Figure 2.4** gives the generic procedure for the controlled release scheme.

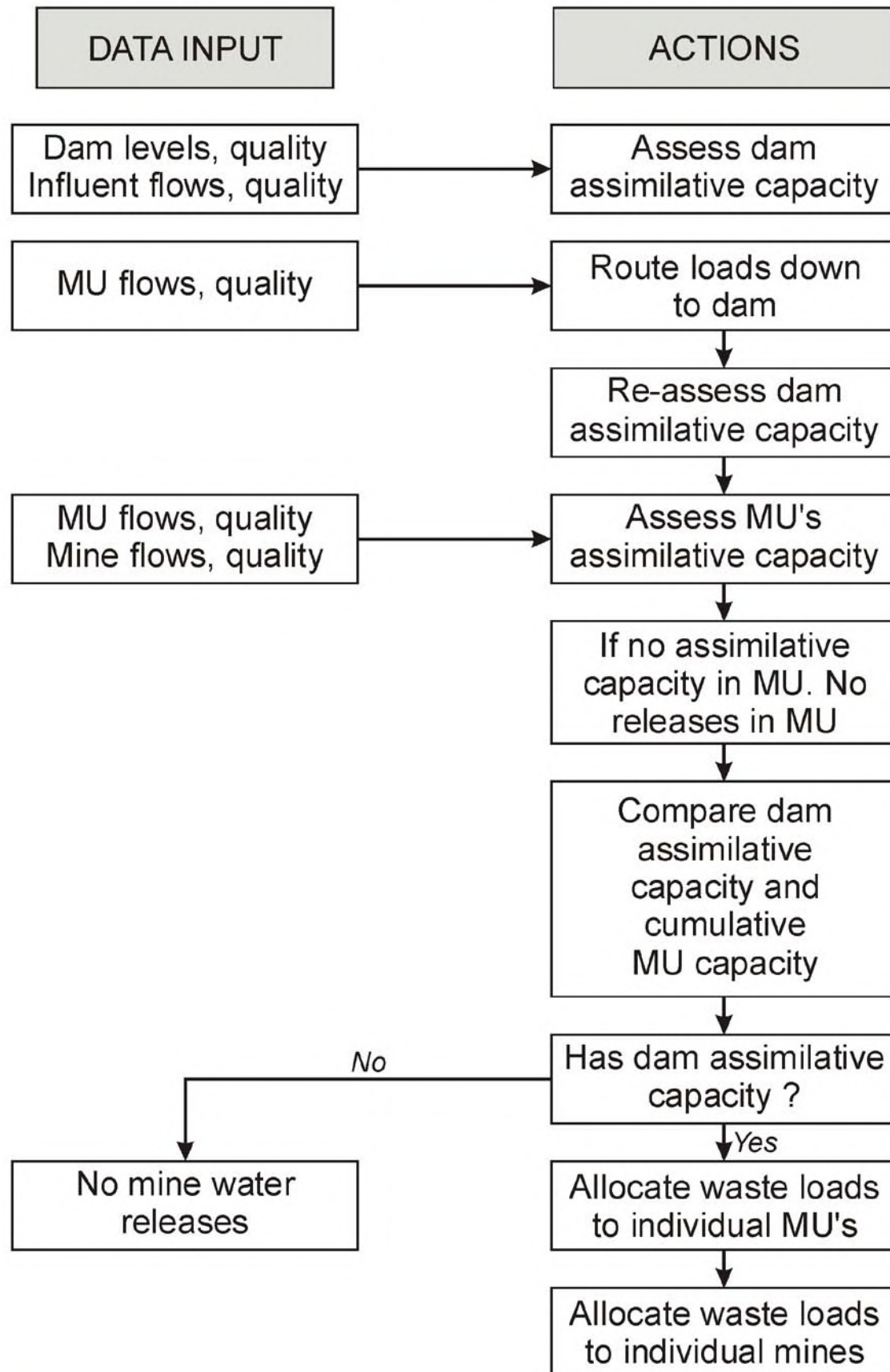
**Table 2.4.1(a)** gives the volume released through the controlled release scheme by all mines considered for the proposed Mine Water Collection System.

**Table 2.4.1(a):**

Catchment	Mine Name	Controlled Release 96/97 (MI/day)	Controlled Release 97/98 (MI/day)	Controlled Release 98/99 (MI/day)
<b>Middelburg</b>	Arnot Colliery	0	0.40	0.50
	Eikeboom	Did Not Participate(DNP)	DNP	DNP
	Woestalleen Colliery	DNP	DNP	DNP
	Optimum Colliery	0	4.93	1.66
<b>Witbank</b>	Douglas Colliery	0.15	1.53	0.66
	Goedehoop Colliery	0	0	0
	Greenside	0	0.16	0
	Kleinkoje & Landau	5.23	2.82	0.79
	Koornfontein	0	0.63	0.11
	Kriel	0.46	2.82	0.60
	Matla Mine	0.72	1.15	0.09
	Middelburg Mine			

<b>Catchment</b>	<b>Mine Name</b>	<b>Controlled Release 96/97 (MI/day)</b>	<b>Controlled Release 97/98 (MI/day)</b>	<b>Controlled Release 98/99 (MI/day)</b>
	Middelburg Mine - North	DNP	DNP	DNP
	Rietspruit Mine Services	2.97	2.25	0.19
	Syferfontein Colliery	0.40	1.97	0.17
	Tavistock Colliery	0.11	1.32	0
	Tweefontein Colliery	0	0.08	0
	Khutala	DNP	DNP	DNP
<b>Klipspruit</b>				
	Kromdraai	DNP	DNP	DNP
	South Witbank	DNP	DNP	DNP
	Middleburg Stream	DNP	DNP	DNP
	Old Travistock	DNP	DNP	DNP
	Brugspruit	DNP	DNP	DNP

## GENERIC CONTROLLED RELEASE CONTROL STRATEGY



## 2.4.1 Estimated Volume To Be Released To The Collection System

The volume of water released by each mine during the Controlled Release Scheme was compared to the estimated Excess Mine Water production from **Section 2.3 (Table 2.3.21(a))**. After comparing these two volumes an estimate was made as to the volume of water that would be released by each mine into the proposed Collection System. The estimated volumes to be released into the proposed Collection System is represented in **Table 2.4.1 (a)**.

**Table 2.4.1 (a): Estimated volume of mine water that is to be released into the proposed Collection System**

Catchment	Mine Name	Available Water (m <sup>3</sup> /year)	Available Water (ML/day)
<b>Middelburg</b>			
	Arnot Colliery	1 615 644	4.40
	Eikeboom	168 000	0.46
	Woestalleen Colliery	67 848	0.19
	Optimum Colliery	3 466 800	9.50
	<b>TOTAL</b>	<b>5 318 292</b>	<b>14.55</b>
<b>Witbank</b>			
	Douglas Colliery	239 976	0.66
	Goedehoop Colliery	203 091	0.56
	Greenside	237 250	0.65
	Kleinkoje & Landau	1 489 800	4.08
	Koornfontein	34 200	0.09
	Kriel	725 328	1.99
	Matla Mine	2 070 000	5.67
	Middelburg Mine - South	7 470	0.02
	Middelburg Mine - North	213 000	0.58
	Rietspruit Mine Services	515 640	1.41
	Syferfontein Colliery	533 256	1.46
	Tavistock Colliery	180 000	0.49
	<b>TOTAL (Including Malta and Kriel)</b>	<b>6 209 035</b>	<b>17.67</b>
	<b>TOTAL (Excluding Malta and Kriel)</b>	<b>3 413 707</b>	<b>10.01</b>
<b>Klipspruit</b>			
	Kromdraai	461 112	1.26
	South Witbank	901 550	2.47
	Middleburg Stream	222 285	0.61

Catchment	Mine Name	Available Water (m <sup>3</sup> /year)	Available Water (MI/day)
	Brugspruit		
	High TDS	985 500	2.70
	Low TDS	912 500	2.50
	<b>TOTAL</b>	<b>3 511 052</b>	<b>9.62</b>

## 2.5 MINE WATER QUALITIES

The mine water qualities were obtained from a data base set up by Wates Meiring and Barnard for the Controlled Released Scheme. **Tables 2.5.1 to 2.5.11** represents the 95, 50 and 5 percentile concentrations of the various quality parameters. The weighted average of the different quality parameters were also calculated for each of the three catchments.

Analysis was done on the information obtained from the data base to determine the 95, 50 and 5 percentiles. The 95 percentile means that, 95 percent of the time the concentration of the quality parameter is equal to or less than its 95 percentile value, i.e. the 95 percentile value is only exceeded 5 percent of the time. The same theory applies to both the 50 and 5 percentiles. The 50 percentile value would represent the mean concentration and the 5 percentile a kind of minimum. The 95, 50 and 5 percentiles give an indication of the variability of the concentration of a particular parameter.

For design purposes the 95 percentile concentration values are generally used. Using the 95 percentile allows one to be conservative in design. It is considered better than using the maximum value as the maximum may reflect a single outlier.

The method for calculating the weighted average is as follows :

$$\text{Weighted average} = \frac{Q_i \times C_i + \dots + Q_n \times C_n}{Q_i + \dots + Q_n}$$

where

Q = flow rate from individual mine (MI/day)

C = concentration of quality parameter.

## 2.5.1 Electrical Conductivity

Table 2.5.1 represent Electrical Conductivity for the various mines

Table 2.5.1

Catchment	Mine Name	Excess Water (MI/day)	Electrical Conductivity		
			5%	50%	95%
Middelburg					
	Arnot Colliery	4.40	44.4	94.4	124.0
	Eikeboom	0.46	19.7	62.0	135.8
	Woestalleen Colliery	0.19	265.8	284.5	303.7
	Optimum Colliery	9.50	86.1	118.0	128.7
	<b>Weighted Average</b>		<b>73.6</b>	<b>111.2</b>	<b>129.7</b>
Witbank					
	Douglas Colliery	0.66	105.0	210.0	303.0
	Goedehoop Colliery	0.56	-	-	-
	Greenside	0.65	3.8	386.5	406.1
	Kleinkoje & Landau	4.08	168.5	295.0	381.0
	Koornfontein	0.09	24.1	208.0	254.0
	Kriel	1.99	102.0	155.3	180.3
	Matla Mine	5.67	108.4	115.0	123.3
	Middelburg Mine – South	0.02	157.4	227.5	303.0
	Middelburg Mine – North	0.58	257.0	341.0	421.0
	Rietspruit Mine Services	1.41	279.3	331.5	363.8
	Syferfontein Colliery	1.46	48.3	79.0	228.0
	Tavistock Colliery	0.49	101.9	261.0	221.7
	<b>Weighted Average(Including Matla and Kriel)</b>		<b>131.3</b>	<b>203.9</b>	<b>251.7</b>
	<b>Weighted Average(Excluding Matla and Kriel)</b>		<b>151.3</b>	<b>267.5</b>	<b>343.8</b>
Klipspruit					
	Kromdraai	1.26	-	-	-
	South Witbank	2.47	419.1	433.0	438.4
	Middleburg Stream	0.61	-	-	-
	Old Travistock	0.08	-	-	-
	Brugspruit : High TDS	2.70	710.0	1060.0	1222.0
	Brugspruit : Low TDS	2.50	282.8	342.5	446.8
	<b>Weighted Average</b>		<b>477.1</b>	<b>624.2</b>	<b>717.0</b>

## 2.5.2 PH

Table 2.5.2 represent pH for the various mines:

Table 2.5.2

Catchment	Mine Name	Excess Water (ML/day)	pH		
			5%	50%	95%
Middelburg					
	Arnot Colliery	4.40	6.0	7.3	8.6
	Eikeboom	0.46	7.0	7.5	8.6
	Woestalleen Colliery	0.19	7.6	7.9	8.1
	Optimum Colliery	9.50	7.4	7.7	7.8
	<b>Weighted Average</b>		<b>6.9</b>	<b>7.6</b>	<b>8.1</b>
Witbank					
	Douglas Colliery	0.66	7.4	7.7	7.8
	Goedehoop Colliery	0.56	-	-	-
	Greenside	0.65	6.8	8.2	8.7
	Kleinkoje & Landau	4.08	7.0	7.4	8.9
	Koorfontein	0.09	7.1	7.9	8.5
	Kriel	1.99	7.5	8.1	8.4
	Matla Mine	5.67	8.6	8.8	8.9
	Middelburg Mine - South	0.02	6.9	7.2	7.6
	Middelburg Mine - North	0.58	2.8	3.4	3.8
	Rietspruit Mine Services	1.41	7.7	7.9	8.5
	Syferfontein Colliery	1.46	7.6	7.8	8.8
	Tavistock Colliery	0.49	7.4	8.0	9.1
	<b>Weighted Average(Including Matla and Kriel)</b>		<b>7.7</b>	<b>8.1</b>	<b>8.6</b>
	<b>Weighted Average(Excluding Matla and Kriel)</b>		<b>7.2</b>	<b>7.7</b>	<b>8.6</b>
Klipspruit					
	Kromdraai	1.26	-	-	-
	South Witbank	2.47	2.4	2.8	2.8
	Middleburg Stream	0.61	-	-	-
	Old Travistock	0.08	-	-	-
	Brugspruit : High TDS	2.70	3.0	3.3	4.0
	Brugspruit : Low TDS	2.50	2.6	3.1	3.3
	<b>Weighted Average</b>		<b>2.6</b>	<b>3.0</b>	<b>3.2</b>

## 2.5.3 TDS

Table 2.5.3 represent TDS for the various mines.

Table 2.5.3

Catchment	Mine Name	Excess Water (MI/day)	TDS		
			5%	50%	95%
Middelburg					
	Arnot Colliery	4.40	-	-	-
	Eikeboom	0.46	18.7	449.5	1208.6
	Woestalleen Colliery	0.19	2745.0	3328.7	4021.0
	Optimum Colliery	9.50	776.0	1227.2	1574.0
	<b>Weighted Average</b>		<b>777.7</b>	<b>1230.4</b>	<b>1602.3</b>
Witbank					
	Douglas Colliery	0.66	-	-	-
	Goedehoop Colliery	0.56	-	-	-
	Greenside	0.65	1273.0	2087.0	3862.3
	Kleinkoje & Landau	4.08	1646.0	2764.0	3880.0
	Koorfontein	0.09	142.1	1497.6	2413.0
	Kriel	1.99	94.7	1058.0	1390.5
	Matla Mine	5.67	803.7	836.5	869.4
	Middelburg Mine - South	0.02	1315.6	2009.0	2810.7
	Middelburg Mine - North	0.58	2040.0	3381.0	3942.0
	Rietspruit Mine Services	1.41	3247.7	3893.8	5328.9
	Syferfontein Colliery	1.46	335.0	536.0	1488.0
	Tavistock Colliery	0.49	790.7	2153.0	2326.5
	<b>Weighted Average(Including Matla and Kriel)</b>		<b>1154.1</b>	<b>1761.5</b>	<b>2399.0</b>
	<b>Weighted Average(Excluding Matla and Kriel)</b>		<b>1619.3</b>	<b>2516.8</b>	<b>3613.0</b>
Klipspruit					
	Kromdraai	1.26	-	-	-
	South Witbank	2.47	5889.1	5971.5	7040.8
	Middleburg Stream	0.61	-	-	-
	Old Travistock	0.08	-	-	-
	Brugspruit : High TDS	2.70	9216.0	10433.0	11966.0
	Brugspruit : Low TDS	2.50	2868.0	3641.0	4380.5
	<b>Weighted Average</b>		<b>6075.5</b>	<b>6782.4</b>	<b>7907.5</b>

## 2.5.4 Calcium

Table 2.5.4 represent Calcium for the various mines.

Table 2.5.4

Catchment	Mine Name	Excess Water (Ml/day)	Calcium		
			5%	50%	95%
Middelburg					
	Arnot Colliery	4.40	39.1	65.0	83.4
	Eikeboom	0.46	-	-	-
	Woestalleen Colliery	0.19	242.7	345.0	391.3
	Optimum Colliery	9.50	96.3	156.5	188.6
	<b>Weighted Average</b>		<b>80.3</b>	<b>130.3</b>	<b>158.3</b>
Witbank					
	Douglas Colliery	0.66	-	-	-
	Goedehoop Colliery	0.56	-	-	-
	Greenside	0.65	172.3	337.0	66.4
	Kleinkoje & Landau	4.08	259.9	413.5	516.8
	Koorfontein	0.09	-	-	-
	Kriel	1.99	63.9	90.6	122.8
	Matla Mine	5.67	-	-	-
	Middelburg Mine - South	0.02	158.7	248.5	353.2
	Middelburg Mine - North	0.58	246.0	449.0	529.0
	Rietspruit Mine Services	1.41	389.8	439.5	523.0
	Syferfontein Colliery	1.46	14.1	18.3	44.4
	Tavistock Colliery	0.49	165.2	328.0	370.6
	<b>Weighted Average(Including Matla and Kriel)</b>		<b>196.4</b>	<b>295.9</b>	<b>346.0</b>
	<b>Weighted Average(Excluding Matla and Kriel)</b>		<b>226.6</b>	<b>342.8</b>	<b>397.0</b>
Klipspruit					
	Kromdraai	1.26	-	-	-
	South Witbank	2.47	358.2	419.5	449.4
	Middleburg Stream	0.61	-	-	-
	Old Travistock	0.08	-	-	-
	Brugspruit : High TDS	2.70	231.0	412.0	585.0
	Brugspruit : Low TDS	2.50	22.6	180.0	469.6
	<b>Weighted Average</b>		<b>204.0</b>	<b>338.8</b>	<b>503.7</b>

## 2.5.5 Sodium

Table 2.5.5 represent Sodium for the various mines.

Table 2.5.5

Catchment	Mine Name	Excess Water (MI/day)	Sodium		
			5%	50%	95%
Middelburg					
	Arnot Colliery	4.40	29.6	46.5	57.3
	Eikeboom	0.46	5.9	26.1	75.1
	Woestalleen Colliery	0.19	84.2	99.5	114.4
	Optimum Colliery	9.50	10.9	15.0	19.3
	<b>Weighted Average</b>		<b>17.3</b>	<b>26.0</b>	<b>33.8</b>
Witbank					
	Douglas Colliery	0.66	-	-	-
	Goedehoop Colliery	0.56	-	-	-
	Greenside	0.65	39.8	58.6	145.9
	Kleinkoje & Landau	4.08	14.8	22.1	27.9
	Koorfontein	0.09	20.0	64.0	237.0
	Kriel	1.99	94.7	117.5	233.5
	Matla Mine	5.67	97.9	133.0	168.1
	Middelburg Mine - South	0.02	27.6	37.3	57.3
	Middelburg Mine - North	0.58	16.0	27.0	32.0
	Rietspruit Mine Services	1.41	96.5	103.5	110.2
	Syferfontein Colliery	1.46	68.3	190.0	440.0
	Tavistock Colliery	0.49	16.4	77.2	92.1
	<b>Weighted Average(Including Matla and Kriel)</b>		<b>66.0</b>	<b>97.3</b>	<b>152.7</b>
	<b>Weighted Average(Excluding Matla and Kriel)</b>		<b>38.9</b>	<b>69.7</b>	<b>124.4</b>
Klipspruit					
	Kromdraai	1.26	-	-	-
	South Witbank	2.47	25.1	31.0	32.7
	Middleburg Stream	0.61	-	-	-
	Old Travistock	0.08	-	-	-
	Brugspruit : High TDS	2.70	984.0	1975.0	2547.0
	Brugspruit : Low TDS	2.50	47.9	256.0	453.5
	<b>Weighted Average</b>		<b>370.1</b>	<b>788.7</b>	<b>1054.9</b>

## 2.5.6 Magnesium

Table 2.5.6 represent Magnesium for the various mines.

Table 2.5.6

Catchment	Mine Name	Excess Water (Ml/day)	Magnesium		
			5%	50%	95%
Middelburg					
	Arnot Colliery	4.40	20.7	56.5	76.9
	Eikeboom	0.46	9.2	16.0	40.6
	Woestalleen Colliery	0.19	158.3	190.0	280.0
	Optimum Colliery	9.50	52.8	78.5	90.9
	<b>Weighted Average</b>		<b>43.0</b>	<b>71.3</b>	<b>87.5</b>
Witbank					
	Douglas Colliery	0.66	-	-	-
	Goedehoop Colliery	0.56	-	-	-
	Greenside	0.65	80.6	130.0	291.8
	Kleinkoje & Landau	4.08	85.2	165.0	303.8
	Koorfontein	0.09	6.7	21.0	99.0
	Kriel	1.99	37.0	76.7	85.5
	Matla Mine	5.67	31.1	31.5	32.0
	Middelburg Mine - South	0.02	101.6	147.0	303.4
	Middelburg Mine - North	0.58	169.0	260.0	308.0
	Rietspruit Mine Services	1.41	260.3	311.0	380.0
	Syferfontein Colliery	1.46	12.6	18.7	36.6
	Tavistock Colliery	0.49	25.3	124.0	148.1
	<b>Weighted Average(Including Matla and Kriel)</b>		<b>69.9</b>	<b>107.8</b>	<b>160.4</b>
	<b>Weighted Average(Excluding Matla and Kriel)</b>		<b>102.3</b>	<b>164.0</b>	<b>260.1</b>
Klipspruit					
	Kromdraai	1.26	-	-	-
	South Witbank	2.47	116.9	147.0	160.1
	Middleburg Stream	0.61	-	-	-
	Old Travistock	0.08	-	-	-
	Brugspruit : High TDS	2.70	58.0	135.0	435.0
	Brugspruit : Low TDS	2.50	23.8	57.3	169.6
	<b>Weighted Average</b>		<b>65.8</b>	<b>113.5</b>	<b>260.0</b>

## 2.5.7 Sulphate

Table 2.5.7 represent Sulphate for the various mines

**Table 2.5.7**

Catchment	Mine Name	Excess Water (Ml/day)	Sulphate		
			5%	50%	95%
Middelburg					
	Arnot Colliery	4.40	222.0	2709.0	2832.0
	Eikeboom	0.46	40.0	53.0	75.3
	Woestalleen Colliery	0.19	1637.4	1880.0	2069.0
	Optimum Colliery	9.50	470.7	818.5	976.7
	<b>Weighted Average</b>		<b>396.4</b>	<b>1382.2</b>	<b>1525.7</b>
Witbank					
	Douglas Colliery	0.66	1.3	944.0	1645.0
	Goedehoop Colliery	0.56	-	-	-
	Greenside	0.65	911.5	1617.0	3050.3
	Kleinkoje & Landau	4.08	1111.4	1765.0	2603.7
	Koornfontein	0.09	203.0	1097.0	1360.8
	Kriel	1.99	354.1	512.0	729.1
	Matla Mine	5.67	268.2	385.0	485.0
	Middelburg Mine - South	0.02	884.3	1320.0	2018.1
	Middelburg Mine - North	0.58	1363.0	2420.0	2805.0
	Rietspruit Mine Services	1.41	2097.3	2366.0	2626.0
	Syferfontein Colliery	1.46	164.4	298.0	637.2
	Tavistock Colliery	0.49	529.6	1397.0	1520.3
	<b>Weighted Average(Including Matla and Kriel)</b>		<b>680.9</b>	<b>1056.9</b>	<b>1466.0</b>
	<b>Weighted Average(Excluding Matla and Kriel)</b>		<b>997.1</b>	<b>1574.5</b>	<b>2209.5</b>
Klipspruit					
	Kromdraai	1.26	-	-	-
	South Witbank	2.47	2800.6	4012.0	4986.3
	Middleburg Stream	0.61	-	-	-
	Old Travistock	0.08	-	-	-
	Brugspruit : High TDS	2.70	5220.0	6925.0	8203.0
	Brugspruit : Low TDS	2.50	1786.4	2437.0	3700.9
	<b>Weighted Average</b>		<b>3321.7</b>	<b>4524.1</b>	<b>5699.7</b>

## 2.5.8 Chloride

**Table 2.5.8** represent Chloride for the various mines

**Table 2.5.8**

Catchment	Mine Name	Excess Water (ML/day)	Chloride		
			5%	50%	95%
Middelburg					
	Arnot Colliery	4.40	8.0	22.0	29.8
	Eikeboom	0.46	-	-	-
	Woestalleen Colliery	0.19	-	-	-
	Optimum Colliery	9.50	-	-	-
	<b>Weighted Average</b>		<b>8.0</b>	<b>22.0</b>	<b>29.8</b>
Witbank					
	Douglas Colliery	0.66	-	-	-
	Goedehoop Colliery	0.56	-	-	-
	Greenside	0.65	29.3	46.0	90.4
	Kleinkoje & Landau	4.08	8.0	12.5	18.0
	Koorfontein	0.09	12.7	36.0	65.0
	Kriel	1.99	21.0	26.5	30.6
	Matla Mine	5.67	33.1	33.5	34.0
	Middelburg Mine - South	0.02	11.0	13.0	17.0
	Middelburg Mine - North	0.58	9.0	16.0	34.0
	Rietspruit Mine Services	1.41	16.5	20.0	24.3
	Syferfontein Colliery	1.46	7.2	10.1	21.4
	Tavistock Colliery	0.49	13.3	103.0	114.0
	<b>Weighted Average(Including Matla and Kriel)</b>		<b>19.9</b>	<b>26.2</b>	<b>32.4</b>
	<b>Weighted Average(Excluding Matla and Kriel)</b>		<b>11.2</b>	<b>21.3</b>	<b>31.9</b>
Klipspruit					
	Kromdraai	1.26	-	-	-
	South Witbank	2.47	-	-	-
	Middleburg Stream	0.61	-	-	-
	Old Travistock	0.08	-	-	-
	Brugspruit : High TDS	2.70	132.0	400.0	602.0
	Brugspruit : Low TDS	2.50	45.8	130.0	279.5
	<b>Weighted Average</b>		<b>90.6</b>	<b>270.2</b>	<b>447.0</b>

## 2.5.9 Manganese

Table 2.5.9 represent Manganese for the various mines

Table 2.5.9

Catchment	Mine Name	Excess Water (MI/day)	Manganese		
			5%	50%	95%
Middelburg					
	Arnot Colliery	4.40	0.0	0.1	1.9
	Eikeboom	0.46	-	-	-
	Woestalleen Colliery	0.19	-	-	-
	Optimum Colliery	9.50	-	-	-
	<b>Weighted Average</b>		<b>0.0</b>	<b>0.1</b>	<b>1.9</b>
Witbank					
	Douglas Colliery	0.66	-	-	-
	Goedehoop Colliery	0.56	-	-	-
	Greenside	0.65	0.0	0.2	0.4
	Kleinkoje & Landau	4.08	0.2	3.2	9.3
	Koorfontein	0.09	0.1	0.4	5.1
	Kriel	1.99	0.1	0.1	1.4
	Matla Mine	5.67	0.1	0.3	0.4
	Middelburg Mine - South	0.02	0.3	1.1	1.5
	Middelburg Mine - North	0.58	5.4	9.8	28.0
	Rietspruit Mine Services	1.41	0.2	0.2	0.4
	Syferfontein Colliery	1.46	0.0	0.0	0.2
	Tavistock Colliery	0.49	0.0	0.1	0.1
	<b>Weighted Average(Including Matla and Kriel)</b>		<b>0.3</b>	<b>1.3</b>	<b>3.7</b>
	<b>Weighted Average(Excluding Matla and Kriel)</b>		<b>0.5</b>	<b>2.2</b>	<b>6.4</b>
Klipspruit					
	Kromdraai	1.26	-	-	-
	South Witbank	2.47	15.2	26.0	39.4
	Middleburg Stream	0.61	-	-	-
	Old Travistock	0.08	-	-	-
	Brugspruit : High TDS	2.70	8.0	13.3	22.0
	Brugspruit : Low TDS	2.50	5.3	13.7	25.3
	<b>Weighted Average</b>		<b>9.4</b>	<b>17.5</b>	<b>28.7</b>

## 2.5.10 Aluminium

**Table 2.5.10** represent Aluminium for the various mines

**Table 2.5.10**

Catchment	Mine Name	Excess Water (Ml/day)	Aluminium		
			5%	50%	95%
Middelburg					
	Arnot Colliery	4.40	0.0	0.0	2.2
	Eikeboom	0.46	-	-	-
	Woestalleen Colliery	0.19	0.1	0.1	0.1
	Optimum Colliery	9.50	0.1	0.1	0.1
	<b>Weighted Average</b>		<b>0.1</b>	<b>0.1</b>	<b>0.7</b>
Witbank					
	Douglas Colliery	0.66	-	-	-
	Goedehoop Colliery	0.56	-	-	-
	Greenside	0.65	-	-	-
	Kleinkoje & Landau	4.08	0.1	0.1	0.1
	Koornfontein	0.09	-	-	-
	Kriel	1.99	0.0	0.1	0.1
	Matla Mine	5.67	0.1	0.1	0.1
	Middelburg Mine - South	0.02	0.1	0.1	0.2
	Middelburg Mine - North	0.58	3.2	9.6	49.0
	Rietspruit Mine Services	1.41	0.1	0.1	0.1
	Syferfontein Colliery	1.46	0.0	0.1	0.4
	Tavistock Colliery	0.49	0.1	0.1	0.1
	<b>Weighted Average(Including Matla and Kriel)</b>		<b>0.2</b>	<b>0.4</b>	<b>1.9</b>
	<b>Weighted Average(Excluding Matla and Kriel)</b>		<b>0.3</b>	<b>0.8</b>	<b>3.7</b>
Klipspruit					
	Kromdraai	1.26	-	-	-
	South Witbank	2.47	181.4	203.0	221.4
	Middleburg Stream	0.61	-	-	-
	Old Travistock	0.08	-	-	-
	Brugspruit : High TDS	2.70	24.0	51.5	145.0
	Brugspruit : Low TDS	2.50	8.8	148.0	322.8
	<b>Weighted Average</b>		<b>69.7</b>	<b>131.7</b>	<b>227.5</b>

## 2.5.11 Total Alkalinity

Table 2.5.11 represent Total Alkalinity for the various mines

Table 2.5.11

Catchment	Mine Name	Excess Water (MI/day)	Total Alkalinity		
			5%	50%	95%
Middelburg					
	Arnot Colliery	4.40	34.6	56.0	72.7
	Eikeboom	0.46	-	-	-
	Woestalleen Colliery	0.19	-	-	-
	Optimum Colliery	9.50	-	-	-
	<b>Weighted Average</b>		<b>34.6</b>	<b>56.0</b>	<b>72.7</b>
Witbank					
	Douglas Colliery	0.66	-	-	-
	Goedehoop Colliery	0.56	-	-	-
	Greenside	0.65	39.2	66.0	108.8
	Kleinkoje & Landau	4.08	24.2	109.0	269.5
	Koorfontein	0.09	82.0	136.0	314.0
	Kriel	1.99	164.0	243.0	345.5
	Matla Mine	5.67	336.6	342.0	377.4
	Middelburg Mine - South	0.02	15.1	29.5	39.8
	Middelburg Mine - North	0.58	-	-	-
	Rietspruit Mine Services	1.41	118.8	173.5	212.5
	Syferfontein Colliery	1.46	103.6	209.0	442.4
	Tavistock Colliery	0.49	25.4	39.0	55.8
	<b>Weighted Average(Including Matla and Kriel)</b>		<b>170.0</b>	<b>220.1</b>	<b>315.2</b>
	<b>Weighted Average(Excluding Matla and Kriel)</b>		<b>56.5</b>	<b>130.4</b>	<b>264.8</b>
Klipspruit					
	Kromdraai	1.26	-	-	-
	South Witbank	2.47	1465.1	1761.0	1960.9
	Middleburg Stream	0.61	-	-	-
	Old Travistock	0.08	-	-	-
	Brugspruit : High TDS	2.70	-	-	-
	Brugspruit : Low TDS	2.50	-	-	-
	<b>Weighted Average</b>		<b>1465.1</b>	<b>1761.0</b>	<b>1960.9</b>

## 2.6 SUMMARY OF WEIGHTED AVERAGES

Tables 2.6.1(a) to 2.6.12(a) gives a summary of the various quality parameters for each of the catchments.

### 2.6.1 Middelburg Dam Catchment

**Table 6.12.1(a)**

Parameters	5 %	50 %	95 %
Conductivity(mS/m)	73.6	111.2	129.7
PH	6.9	7.6	8.1
TDS	777.7	1230.4	1602.3
Calcium(mg/l)	80.3	130.3	158.3
Sodium(mg/l)	17.3	26.0	33.8
Magnesium(mg/l)	43.0	71.3	87.5
Sulphate(mg/l)	396.4	1382.2	1525.7
Chloride(mg/l)	8.0	22.0	29.8
Manganese(mg/l)	0.0	0.1	1.9
Aluminium(mg/l)	0.1	0.1	0.7
Total Alkalinity(mg/l)	34.6	56.0	72.7

### 2.6.2 Witbank Dam Catchment

**Table 2.2.2(a) (Including Matla and Kriel)**

Parameters	5 %	50 %	95 %
Conductivity(mS/m)	131.3	203.9	251.7
PH	7.7	8.1	8.6
TDS	1154.1	1761.5	2399.0
Calcium(mg/l)	196.4	295.9	346.0
Sodium(mg/l)	66.0	97.3	152.7
Magnesium(mg/l)	69.9	107.8	160.4
Sulphate(mg/l)	680.9	1056.9	1466.0
Chloride(mg/l)	19.9	26.2	32.4
Manganese(mg/l)	0.3	1.3	3.7
Aluminium(mg/l)	0.2	0.4	1.9
Total Alkalinity(mg/l)	170.0	220.1	315.2

**Table 2.6.2(b) (Excluding Matla and Kriel)**

Parameters	5 %	50 %	95 %
Conductivity(mS/m)	151.3	267.5	343.8
PH	7.2	7.7	8.6
TDS	1619.3	2516.8	3613.0
Calcium(mg/l)	226.6	342.8	397.0
Sodium(mg/l)	38.9	69.7	124.4
Magnesium(mg/l)	102.3	164.0	260.1
Sulphate(mg/l)	997.1	1574.5	2209.5

Aluminium(mg/l)	0.3	0.8	3.7
Total Alkalinity(mg/l)	56.5	130.4	264.8

### 2.6.3 Klipspruit Catchment

**Table 2.6.3(a)**

<b>Parameters</b>	<b>5 %</b>	<b>50 %</b>	<b>95 %</b>
Conductivity(mS/m)	477.1	624.2	717.0
PH	2.6	3.0	3.2
TDS	6075.5	6782.4	7907.5
Calcium(mg/l)	204.0	338.8	503.7
Sodium(mg/l)	370.1	788.7	1054.9
Magnesium(mg/l)	65.8	113.5	260.0
Sulphate(mg/l)	3321.7	4524.1	5699.7
Chloride(mg/l)	90.6	270.2	447.0
Manganese(mg/l)	9.4	17.5	28.7
Aluminium(mg/l)	69.7	131.7	227.5
Total Alkalinity(mg/l)	1465.1	1761.0	1960.9

## CHAPTER 3

### MINE WATER COLLECTION AND CONVEYANCE SYSTEMS

#### 3.1 INTRODUCTION

Polluted mine water decanting or seeping into Upper Olifants River Catchment poses a major threat to the environment and water storage dams in the catchment. To safeguard the environment, these mine waters need to be intercepted before they reach the natural streams and dams. This project investigates the potential for collection and treatment of excess mine water on a regional basis.

One of the options being investigated is the feasibility of constructing a regional collection system. The system would collect and transport excess mine to a regional treatment works. For the purposes of this proposed mine water collection system, the Upper Olifants River Catchment was divided into three sub-catchments, viz. :

- the Witbank Dam Catchment,
- the Middelburg Dam Catchment
- and the Klipspruit Catchment.

The selection of these three sub-catchments as the basis of a regional mine water collection and treatment system was based on the following considerations :

- geographical location of mining operations which produce excess mine water
- the existing mine water treatment infrastructure, specifically in the Klipspruit Catchment
- geographical distribution of potential users of treated mine water
- different mine water qualities are produced in the different catchment areas, which will influence the selection of treatment technology.

The current best estimates of the volumes and quality of the excess mine water was documented in the Wates, Meiring and Barnard Report with reference 4094/1985 of June 1999.

This reports aims to address two aspects of the regional collection of excess mine water :

- the preliminary design of the regional collection system and
- the capital, operating and maintenance costs of the collection system.

Three alternative surface collection systems could be considered for each sub-catchment viz. a gravity flow system, a pumping main system and a

combination of the previous two options. The practicality of a gravity flow system is dictated by the topography of the catchment. Two alternative collection systems were investigated for the Witbank Dam and Middelburg Dam Catchments respectively. Only one collection system option was investigated for the Klipspruit Catchment.

The approach followed was focused on surface infrastructure for the collection of excess mine water to regional treatment facilities. This information can be integrated with the "Inter mine flow Geo-hydrological Project" conducted by the Institute for Groundwater Studies to arrive at an optimum, least-cost, collection system. Preliminary collection system designs were done for each of the technology alternatives in each of the sub-catchments. These technology options were evaluated in terms of capital expenditure, operating and maintenance costs.

### **3.2 LOCATION OF REGIONAL TREATMENT WORKS**

The Upper Olifants River Catchment was divided into three sub-catchments for the purposes of regional mine water collection and treatment. Due to the size of the catchment, geographical location of mining operations and the quality of the excess mine water a decision was taken to locate a regional treatment plant in each of the three sub-catchments.

The proposed Middelburg Regional Treatment Works is to be located in the vicinity of the confluence of the Klein Olifants River and the Wonderfonteinspruit tributary from the east. The reasoning behind selecting this location was :

- it was the lowest topographical point in the area and therefore facilitated the collection and transport of excess mine water to the treatment works,
- new mining activities producing excess mine water would be able to gravitate to the plant site
- the plant is more or less situated between the furthest upstream mine water decant point and the Middelburg Town a potential user.

The local topography of the Witbank Dam Catchment does not practically allow for all excess mine waters in the area to drain to a single point under gravity. Since some pumping would have to be done the main factor influencing the location of the plant was the re-use of the treated water. The Treatment Works was therefore placed in close proximity to the Witbank Town as potential user.

The existing Brugspruit treatment works is located on one of the main tributaries flowing down to the Klipspruit. The Brugspruit works is however only a lime neutralisation plant. It is proposed that the new treatment works be located adjacent to the Brugspruit works on the basis of the following considerations :

- excess mine water from several old defunct mine currently draining to the Brugspruit works would be collected
- the Brugspruit works is situated to allow convenient collection of excess mine water from other mining operations in the area.

### 3.3 DESIGN CRITERIA AND ASSUMPTIONS

#### 3.3.1 Design Assumptions

The best current estimates of excess mine water production in the respective sub-catchments are contained in the WMB report entitled "Mine Water Collection" with reference 4094/1985/1/W. The preliminary design of the collection system must however also cater for the future growth in excess mine water production as mining operations extend across the catchment and as old mining operations start to decant. The current estimates of excess mine water was scaled up to reflect the future situation in the year 2020, as reflected below:

**Table 3.3.1(a) : Excess Mine Water Flows**

Sub-catchment	Excess mine water flows (mℓ/year)	
	Current	Future (2020)
Middelburg	15	45
Witbank		
Excluding Matla and Kriel	10	30
Including Matla and Kriel	17	50
Klipspruit	16	49

The future excess mine water flow predictions will be confirmed by the DWAF Upper Olifants River Water Resources Model Project, to be completed by early next year.

Mine waters in general can be abrasive, corrosive and may deposit salt precipitates in a collection system. The operational problems associated with mine water pipelines are well known and were catered for in the preliminary design. The following design assumptions were made :

**Table 3.3.1(b) : Design Assumptions**

	Middelburg Catchment	Witbank Catchment	Klipspruit Catchment
Nature of excess mine water :			
• Abrasiveness	High	High	High
• Corrosiveness	High	High	Very high
• Scale forming potential	Moderate	Moderate	Very high
Flow related parameters :			
• Pipe roughness	0.012	0.012	0.012
• Minimum flow velocity (m/sec)	0.3	0.3	0.6
Pipe capacity :			
• Allowance for scaling and grit deposition	30 %	30 %	30%

No provisions were made in the preliminary design for on-site collection and mine discharge or decant points. It is assumed that this would be the

responsibility of individual mines. As this is a pre-feasibility study no detailed surveys or geological investigation was done.

### **3.3.2 Pipeline Routes**

At the level of detail required for a pre-feasibility study, it was resolved to use 1:50 000 maps to select the routes of pipelines. The levels of detail reflected on these maps is limited and concerns were raised over the routing of pipelines over mined or potentially future mining areas. The following criteria were employed in selecting practical and feasible pipeline routes:

- pipelines routed along rivers were kept within the 1:50 year flood line, where no mining activities are likely to take place,
- pipelines were routed along roads, railway lines and existing servitudes (eg. power lines, property boundaries, etc) where possible
- pipeline crossing of rivers was done at existing bridge structures.

These criteria were achievable for the pumping mains, but were not always possible on the gravity pipelines.

Other factors taken into consideration in selecting the pipeline routes were :

- minimum crossing of privately owned land,
- the least expensive crossing of other services (roads, pipes, cables, etc) and
- future mining and other developments.

### **3.3.3 Pipeline Materials**

Pipelines constructed from uPVC, Weholite and HDPE have proven to be more resistant to corrosion and chemical attack. The quality of mine water in the Upper Olifants River catchment suggests that these waters will not attack uPVC, Weholite or HDPE pipes. No further corrosion protection of pipes would therefore be required.

The aggressive nature of the mine water would require concrete manholes to be coated with a polyurethane paint or similar surface protection system.

It was also assumed that pipelines would have to be cleaned on a regular basis using a water jet or similar cleaning system. These cleaning jets work under high pressures and may therefore damage pipe surfaces. Because a high frequency of cleaning is expected, it was assumed that pressure type pipes with a thicker wall would be used. This will reduce the risk of leakage at joints during cleaning and normal operations. Class 6 uPVC pipes and 4 kN/m<sup>2</sup> Weholite pipes were used in the preliminary design of the gravity lines. Class 9 uPVC pipes and class 6 HDPE pipes were used for the preliminary design of the pumping mains.

### 3.3.4 Pipeline Maintenance

As mentioned previously mine waters in the Upper Olifants River catchment tends to be scale-forming and may deposit grit and other precipitates. This leads to the clogging of pipelines. Maintenance on the existing collection system in the Klipspruit Catchment suggests that pipes should be cleaned at least once every three months. Pipelines in the other two sub-catchments may require a lower level of maintenance. It is therefore assumed that routine maintenance on the Witbank Dam and Middelburg Dam systems would be done at least once every 12 months.

Pipes would probably be cleaned using a high water pressure jet system. This process of cleaning is currently being applied to pipes in the existing collection system feeding the Brugspruit plant. It was assumed that each sub-catchment would be fully equipped with dedicated cleaning equipment and maintenance teams.

The preliminary design catered for manholes to be spaced at 120-meter intervals for all gravity pipelines. This is the maximum distance suggested by the manufactures of the high pressure cleaning equipment to obtain optimal cleaning results. Pumping mains are equipped with rodding eyes at 120-meter intervals. The pumping mains are also equipped with sumps to drain the pipelines during cleaning and maintenance operations. Sludge collected in sumps and manholes will be removed by pumping into tankers and disposal off-site.

## 3.4 CRITERIA FOR COST ESTIMATES

The level of accuracy aim for the purposes of this pre-feasibility study was  $\pm 30$  percent.

### 3.4.1 Capital Expenditure

It was assumed that the following unit rates apply to civil, building, mechanical and electrical work.

Civil/building engineering works :

ITEM	DESCRIPTION	UNIT	RATE (R)
<b>1</b>	<b>Site clearance :</b>		
1.1	Clear & grub strip 3m wide	m	3.95
1.2	Remove & grub trees :		
1.2.1	Over 1m up to 2m	no	1,347
1.2.2	Over 1m up to 3m	no	1,800
1.3	Take down existing fences	km	3,980

ITEM	DESCRIPTION	UNIT	RATE (R)
1.4	Temporary works : traffic & maintenance	sum	5,000
1.5	Excavations to exposed existing services	m <sup>3</sup>	70
1.6	Replace beacons & pegs	sum	10,000
<b>2</b>	<b>Excavate for pipe trenches :</b>		
2.1	Excavations for pipes over 100mm up to 300mm diameter to the following depth intervals :		
2.1.1	0.0 m to 1.0 m	m	28
2.1.2	1.0 m to 2.0 m	m	45
2.1.3	2.0 m to 3.0 m	m	67
2.1.4	3.0 m to 4.0 m	m	94
2.1.5	4.0 m to 5.0 m	m	143
2.1.6	5.0 m to 6.0 m	m	220
2.2	Excavations for pipes over 300mm diameter to the following depth intervals:		
2.2.1	0.0 m to 1.0 m	m	37
2.2.2	1.0 m to 2.0 m	m	60
2.2.3	2.0 m to 3.0 m	m	100
2.2.4	3.0 m to 4.0 m	m	210
2.2.5	4.0 m to 5.0 m	m	264
2.2.6	5.0 m to 6.0 m	m	323
2.3	Extra for :		
2.3.1	Intermediate material	m <sup>3</sup>	7
2.3.2	Hard rock material	m <sup>3</sup>	110
2.3.3	Boulders Class A	m <sup>3</sup>	60
2.3.4	Boulders Class B	m <sup>3</sup>	60
2.3.5	Excavate unsuitable material	m <sup>3</sup>	50
2.4	Backfill materials from :		
2.4.1	Borrow pits	m <sup>3</sup>	18
2.4.2	Commercial /off-site sources	m <sup>3</sup>	50
2.4.3	Compaction in road reserves	m	400
2.4.4	Truck haul over 1km	m <sup>3</sup> km	2.5
2.4.5	Shoring of trenches	m	44
2.4.6	Forming under-drains	m	100
2.4.7	Extra over 2.4.6 for lining under-drains	m	5
2.4.8	Extra over 2.4.6 for drainage pipes	m	30
2.5	Miscellaneous allowances for :		
2.5.1	Repairs to road or rail crossings	no	400
2.5.2	Inconvenience to cross existing fences, etc.	no	400
2.5.3	Care to cross-existing pipes, etc.	no	600
2.5.4	Care to adjoining trenches	m	1,000
<b>3</b>	<b>Pipework</b>		
3.1	Pipework : Supply, transport, lay, install, test (class 6 uPVC and 4 kN/m <sup>2</sup> Weholite pipes)		

ITEM	DESCRIPTION	UNIT	RATE (R)
3.1.1	110 diameter – uPVC	m	28
3.1.2	160 diameter – uPVC	m	53
3.1.3	200 diameter – uPVC	m	81
3.1.4	250 diameter – uPVC	m	119
3.1.5	300 diameter – uPVC	m	182
3.1.6	550 diameter – weholite	m	335
3.1.7	600 diameter – weholite	m	385
3.1.8	650 diameter – weholite	m	405
3.1.9	700 diameter – weholite	m	500
3.1.10	750 diameter – weholite	m	630
3.2	Pipework : Supply, transport, lay, install, test.(class 9 uPVC and class 6 HDPE pipes)		
3.2.1	160 diameter – uPVC	m	64
3.2.2	250 diameter – uPVC	m	140
3.2.3	300 diameter – uPVC	m	230
3.2.4	350 diameter – uPVC	m	295
3.3.5	400 diameter – uPVC	m	370
3.3.6	450 diameter – HDPE	m	444
3.3.7	560 diameter – HDPE	m	686
3.3.8	630 diameter – HDPE	m	867
<b>4</b>	<b>Manholes :</b>		
4.1	1250 mm inside diameter, Type 4 cover & frame :		
4.1.1	0.5 m - 1.0 m	no	2,500
4.1.2	1.0 m - 1.5 m	no	2,964
4.1.3	1.5 m - 2.0 m	no	3,290
4.1.4	2.0 m - 2.5 m	no	3,665
4.1.5	2.5 m - 3.0 m	no	4,025
4.1.6	3.0 m - 3.5 m	no	4,300
4.1.7	3.5 m - 4.0 m	no	5,000
4.2	Extra over 4.1.1 to 4.1.9 for Type 2A cover	no	980
4.3	Extra over 4.1.1 to 4.1.9 for future access	no	980
4.4	Test watertightness	no	400
4.5	Break into existing manholes	sum	1,400
<b>5</b>	<b>Hand Stops</b>		
5.1	Hand stops	no	600
<b>6</b>	<b>Bedding</b>		
6.1	From trench excavation :		
6.1.1	Selected granular material	m <sup>3</sup>	32
6.1.2	Selected fill material	m <sup>3</sup>	32
6.2	By importing material :		
6.2.1	Selected granular material	m <sup>3</sup>	69
6.2.2	Selected fill material	m <sup>3</sup>	69
<b>7</b>	<b>Cleaning Eyes</b>		
7.1	Cleaning eyes	no	2,000
<b>8</b>	<b>Pump Stations</b>		

ITEM	DESCRIPTION	UNIT	RATE (R)
8.1	Pump station civil/building cost (all inclusive)	no	150,000
<b>9</b>	<b>Valves</b>		
9.1	Air release valves	no	6,000
9.2	Non-return valves :		
9.2.1	160mm diameter	no	1,000
9.2.2	250mm diameter	no	3,800
9.2.3	300mm diameter	no	5,000
9.2.4	350mm diameter	no	6,000
9.2.5	450mm diameter	no	15,000
9.2.6	550mm diameter	no	25,000
9.3	Gate valves :		
9.3.1	160mm diameter	no	1,500
9.3.2	250mm diameter	no	4,200
9.2.3	300mm diameter	no	5,900
9.3.4	350mm diameter	no	6,800
9.3.5	400mm diameter	no	15,000
9.3.6	450mm diameter	no	20,000
9.3.7	550mm diameter	no	28,000
9.3.8	600mm diameter	no	30,000
<b>10</b>	<b>Valve Boxes</b>		
10.1	Valve boxes (all inclusive)	no	15,500
<b>11</b>	<b>Sumps</b>		
11.1	Sump costs (all inclusive)	no	35,000

Mechanical/electrical installations

ITEM	DESCRIPTION	UNIT	RATE (R)
<b>1</b>	<b>Pump sets complete with motor/control</b>		
1.1	7 ℓ/sec at 64 meters head	no	15,000
1.2	7 ℓ/sec at 102 meters head	no	25,000
1.3	48 ℓ/sec at 32 meters head	no	50,000
1.4	65 ℓ/sec at 73 meters head	no	68,000
1.5	120 ℓ/sec at 114 meters head	no	50,000
1.6	210 ℓ/sec at 88 meters head	no	50,000
1.7	420 ℓ/sec at 94 meters head	no	672,000
1.8	51 ℓ/sec at 43 meters head	no	30,000
1.9	23 ℓ/sec at 87 meters head	no	20,000
1.10	14 ℓ/sec at 31 meters head	no	15,705
1.11	23 ℓ/sec at 63 meters head	no	20,160
1.12	102 ℓ/sec at 62 meters head	no	68,440
1.13	16 ℓ/sec at 76 meters head	no	17,446
1.14	320 ℓ/sec at 59 meters head	no	600,000

ITEM	DESCRIPTION	UNIT	RATE (R)
1.15	7 ℓ/sec at 52 meters head	no	9,833
1.16	9 ℓ/sec at 54 meters head	no	11,681
<b>2</b>	<b>Cleaning Equipment</b>		
2.1	Woema cleaning system(including towing vehicle)	no	260,000
2.2	Tankers	no	160,000

### 3.4.2 Operating And Maintenance Costs

Annual operating and maintenance costs were estimated using the following rates.

ITEM	DESCRIPTION	UNIT	RATE
	Annual maintenance costs		
1	Civil structures and pipes	% of capital cost	0.5
2	Mechanical equipment	% of capital cost	4
3	Electrical installations	% of capital cost	3
4	Tankers	% of capital cost	4
	Annual operating costs		
5	Pumping electrical power		
5.1	Electricity consumption	R/kWh	0.13
5.2	Peak demand	R/kVA	44
6	Tankers (diesel consumption)	Sum/month	2 000
7	Labour	Salary/month	2 000
8	Water	m <sup>3</sup>	3

## 3.5 DESCRIPTIONS AND COST ESTIMATES

### 3.5.1 Middelburg Dam Catchment

A total of four mines were considered in the Middelburg Dam catchment for the collection system. There were a total of seven mine water decant points. The location of these decant points are shown on **Figure 3.5.1**. **Table 3.5.1(a)** shows the mines and the current best estimates of decant volumes.

**Table 3.5.1(a) : Current Excess Mine Water Production**

Catchment	Mine Name	Excess Water (m <sup>3</sup> /year)
Middelburg		
	Arnot Colliery	1,615,644
	Eikeboom Colliery	168,000
	Woestalleen Colliery	67,848
	Optimum Colliery	3,466,800
	<b>Total</b>	<b>5,318,292</b>

Two scenarios were investigated, designed and costed, for the Middelburg Dam catchment, viz :

- Scenario 1 : gravity flow system and
- Scenario 2 : combination of pumping mains and gravity flow.

### **3.5.1.1 Scenario One : Gravity flow**

The layout of the proposed pipe network for Scenario 1 is shown in **Figure 3.5.1.1**.

Due to the relatively flat nature of local catchment topography, pipe gradients and consequently flow velocities were low. The topography dictated the route of the pipelines for the gravity flow system. In some cases, the pipelines were routed over areas that could have been mined in the past or that have some mining potential. The conceptual pipe routes will have to be refined by future detailed design.



Long sections of the pipelines run along rivers in the catchment. Detailed surveys and geological investigations of these pipeline routes will also be required. From the surface surveys the exact number of river crossings can be determined. The geotechnical conditions along the pipeline route will determine if pipes in these areas need to be encased in concrete.

The civil construction and mechanical equipment capital cost estimates for Scenario 1 : Gravity Flow System are summarised in **Tables 3.5.1.1(a)** and **3.5.1.1(b)** respectively.

**Table 3.5.1.1(a) : Cost Estimate of Civil Works for Scenario 1 : Gravity Flow System**

ITEM	DESCRIPTION	UNIT	AMOUNT
<b>1</b>	<b>Site clearance :</b>		
1.1	Clear grub strip 3m wide	m	132,325
1.2	Remove trees :		
1.2.1	Over 1m up to 2m	no	22,562
1.2.2	Over 1m up to 3m	no	-
1.3	Take down existing fences	km	-
1.4	Temporary works : traffic & maintenance	sum	1,990
1.5	Excavations to exposed existing services	m <sup>3</sup>	5,000
1.6	Replace beacons & pegs	sum	10,000
<b>2</b>	<b>Excavate for pipe trenches :</b>		
2.1	Excavate for pipes to depths of :		
2.1.1	0.0 m to 1.0 m	m	56,305
2.1.2	1.0 m to 2.0 m	m	1,547,850
2.1.3	2.0 m to 3.0 m	m	293,420
2.1.4	3.0 m to 4.0 m	m	-
2.2	Extra over for :		
2.2.1	Intermediate material	m <sup>3</sup>	85,210
2.2.2	Hard rock material	m <sup>3</sup>	1,573,110
2.2.3	Boulders Class A	m <sup>3</sup>	35,507
2.2.4	Boulders Class B	m <sup>3</sup>	35,507
2.2.5	Excavate unsuitable material	m <sup>3</sup>	59,179
2.3	Backfill materials from :		
2.3.1	Borrow pits	m <sup>3</sup>	8,933
2.3.2	Commercial/off-site resources	m <sup>3</sup>	24,814
2.2.3	Compaction in road reserves	m	21,000
2.3.4	Truck haul over 1km	m <sup>3</sup> km	6,203
2.3.5	Shoring of trenches	m	48,400
2.3.6	Forming underdrains	m	110,000
2.3.7	Extra over 2.3.6 for lining underdrain	m	5,500
2.3.8	Extra over 2.3.6 for drainage pipes	m	8,250
2.4	Miscellaneous allowance for :		
2.4.1	Repairs to road or rail crossings	no	4,000

ITEM	DESCRIPTION	UNIT	AMOUNT
2.4.2	Inconvenience to cross existing fences, etc.	no	12,000
2.4.3	Care to cross existing pipes, etc.	no	6,000
2.4.4	Care to adjoining trenches	m	5,000
<b>3</b>	<b>Pipework</b>		
3.1	Pipework : Supply, transport, lay, test, etc.		
3.1.1	200 diameter - uPVC Class 6	m	696,600
3.1.2	250 diameter - uPVC Class 6	m	476,000
3.1.3	400 diameter - uPVC Class 6	m	1,829,000
3.1.4	600 diameter - Weholite	m	1,540,000
3.1.5	650 diameter - Weholite	m	283,500
3.1.6	700 diameter - Weholite	m	2,000,000
3.1.7	750 diameter - Weholite	m	3,780,000
3.2	Pipe Specials	sum	530,255
<b>4</b>	<b>Manholes :</b>		
4.1	1250 mm inside diameter, Type 4 cover & frame :		
4.1.1	0.5 m - 1.0 m	no	-
4.1.2	1.0 m - 1.5 m	no	-
4.1.3	1.5 m - 2.0 m	no	800,567
4.1.4	2.0 m - 2.5 m	no	204,629
4.1.5	2.5 m - 3.0 m	no	-
4.2	Extra over 4.1.1 to 4.1.9 for Type 2A cover	no	293,183
4.3	Extra over 4.1.1 to 4.1.9 for future access	no	-
4.4	Test watertightness	no	119,667
4.5	Break into existing manholes	sum	-
<b>5</b>	<b>Hand Stops</b>		
5.1	Hand stops	no	179,500
<b>6</b>	<b>Bedding</b>		
6.1	From trench excavation :		
6.1.1	Selected granular material	m <sup>3</sup>	568,006
6.1.2	Selected fill material	m <sup>3</sup>	215,741
6.2	By importing material :		
6.2.1	Selected granular material	m <sup>3</sup>	136,085
6.2.2	Selected fill material	m <sup>3</sup>	51,688
	<b>NET TOTAL COST</b>		<b>R 17,822,486</b>
	<b>Add : 15 % for P &amp; G'S</b>		<b>R 2,673,373</b>
	<b>SUB TOTAL</b>		<b>R 20,495,860</b>
	<b>Add : 25 % for contingencies</b>		<b>R 5,123,965</b>
	<b>ADD : 15 % for engineering and project Management</b>		<b>R 3,074,379</b>
	<b>SUB TOTAL</b>		<b>R 28,694,204</b>
	<b>Add : 10 % for cost price adjustment</b>		<b>R 2,869,420</b>
	<b>TOTAL CIVIL COST (excl. VAT)</b>		<b>R 31,563,624</b>



**Table 3.5.1.1(b) : Cost Estimate of Mechanical Equipment for Scenario 1 :Gravity Flow System.**

ITEM	DESCRIPTION	UNIT	AMOUNT
<b>1</b>	<b>Cleaning Equipment</b>		
1.1	Woma cleaning system	no	260,000
1.2	Water tankers	no	160,000
	<b>NET TOTAL COST</b>		<b>R 420,000</b>
	<b>Add : 25 % for contingencies</b>		<b>R 105,000</b>
	<b>Add : 15 %for engineering and project management</b>		<b>R 63,000</b>
	<b>SUB TOTAL</b>		<b>R 588,000</b>
	<b>Add : 10 % for cost price adjustment</b>		<b>R 58,800</b>
	<b>TOTAL FOR MECHANICAL EQUIPMENT (excl. VAT)</b>		<b>R 646,800</b>

The routine operating and maintenance costs associated with Scenario 1 : Gravity Flow System are summarised in **Table 3.5.1.1(c)**

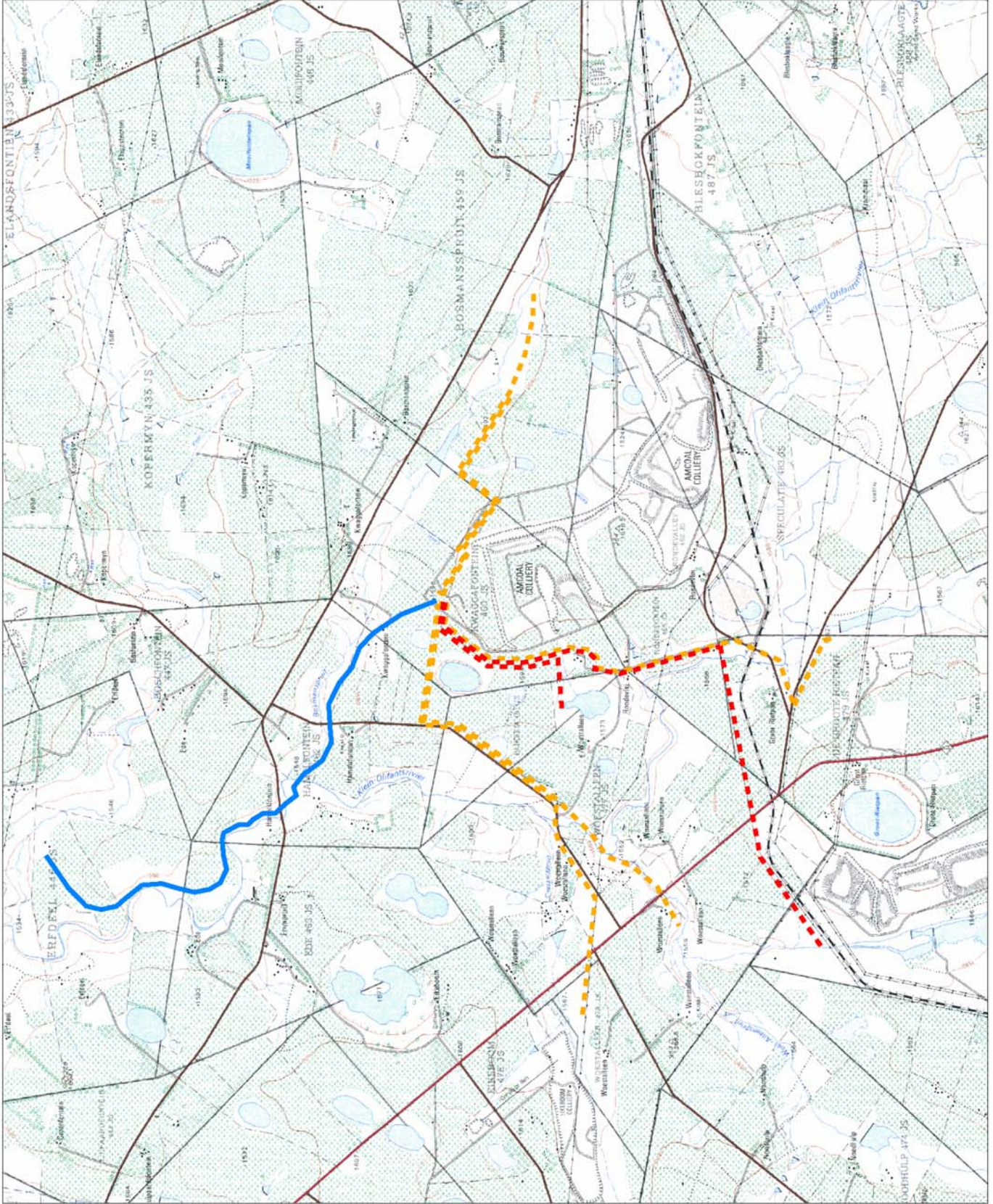
**Table 3.5.1.1(c) : Estimated Annual Operating and Maintenance Cost for Scenario 1 : Gravity Flow System**

ITEM	DESCRIPTION	UNIT	RATE
	<b>Annual maintenance costs</b>		
1	Civil structures and pipes	% of capital cost	157,818
2	Mechanical equipment	% of capital cost	25,872
3	Electrical installations	% of capital cost	-
	<b>Annual operating costs</b>		
5	Electrical power for pumping		
5.1	Electricity consumption	R/kWh	-
5.2	Peak demand	R/kVA	-
6	Tankers (diesel consumption)	Sum	24,000
7	Labour (7 labours at R 2 000/month)	Salary	168,000
8	Water consumption	m <sup>3</sup>	35,000
	<b>Annual operating and maintenance cost</b>		<b>R 410,690</b>

### 3.5.1.2 Scenario Two : Combination Pumping/Gravity Flow System

The layout of the proposed pipe network for Scenario 2 is shown on **Figure 3.5.1.2**.

Since the majority of the pipelines for this scenario are pumping mains, the pipelines could be conveniently routed along roads or railway lines. Water from the various mine decanting points are pumped to a central elevated collection box. Each pumping station is equipped with a duty and standby pump. The collection box is located on a local high point (refer to point 8 in **Figure 3.5.1.2**). The excess water pumped to the collection box will be allowed to flow under gravity to the mine water treatment works.



The construction of a pumping manifold was also considered as an alternative. The manifold system would entail pumping directly from the mine water decant points into a single pipeline running down to the treatment works. This option was ruled out due to potential risks associated with the option in the event of a single pump tripping, the pressure change in the pumping manifold might cause the other pumps to start cavitating. If a pump trip did occur, the pump would then have to be started up against a much higher head and would therefore have to be sized accordingly. Pipeline and pump protection systems to allow safe operation under all combinations of pressure and flow would be expensive. Thus the latter option was not investigated any further.

The civil construction and mechanical equipment capital cost estimates are contained in **Tables 3.5.1.2(a)** and **3.5.1.2(b)** respectively.

**Table 3.5.1.2a: Cost Estimate of Civil Works for Scenario 2 : Pumping/Gravity System**

ITEM	DESCRIPTION	UNIT	AMOUNT
<b>1</b>	<b>Site clearance :</b>		
1.1	Clear grub strip 3m wide	m	185,650
1.2	Remove trees :		
1.2.1	Over 1m up to 2m	no	31,654
1.2.2	Over 1m up to 3m	no	-
1.3	Take down existing fences	km	-
1.4	Temporary works : traffic & maintenance	sum	-
1.5	Excavation to exposed existing services	m <sup>3</sup>	5,000
1.6	Replace beacons & pegs	sum	10,000
<b>2</b>	<b>Excavate for pipe trenches :</b>		
2.1	Excavate for pipes to depths of :		
2.1.1	0.0 m to 1.0 m	m	74,125
2.1.2	1.0 m to 2.0 m	m	2,033,625
2.1.3	2.0 m to 3.0 m	m	375,950
2.1.4	3.0 m to 4.0 m	m	-
2.2	Extra over for :		
2.2.1	Intermediate material	m <sup>3</sup>	98,621
2.2.2	Hard rock material	m <sup>3</sup>	1,820,700
2.2.3	Boulders Class A	m <sup>3</sup>	41,095
2.2.4	Boulders Class B	m <sup>3</sup>	41,095
2.2.5	Excavate unsuitable material	m <sup>3</sup>	68,493
2.3	Backfill materials from :		
2.3.1	Borrow pits	m <sup>3</sup>	10,338
2.3.2	Commercial/off-site resources	m <sup>3</sup>	28,719
2.2.3	Compaction in road reserves	m	-
2.3.4	Truck haul over 1 km	m <sup>3</sup> km	7,179
2.3.5	Shoring of trenches	m	35,200
2.3.6	Forming underdrains	m	80,000
2.3.7	Extra over 2.3.6 for lining underdrain	m	4,000
2.3.8	Extra over 2.3.6 for drainage pipes	m	6,000

ITEM	DESCRIPTION	UNIT	AMOUNT
2.4	Miscellaneous allowance for :		
2.4.1	Repairs to road or rail crossings	no	4,000
2.4.2	Inconvenience to cross existing fences, etc.	no	12,000
2.4.3	Care to cross existing pipes, etc.	no	6,000
2.4.4	Care to adjoining trenches	m	5,000
<b>3</b>	<b>Pipework</b>		
3.1	Pipework : Supply, transport, lay, test, etc.		
3.1.1	160 diameter – uPVC Class 9	m	1,696,000
3.1.2	250 diameter – uPVC Class 9	m	280,000
3.1.3	560 diameter – HDPE	m	5,831,000
3.1.4	630 diameter – HDPE	m	8,670,000
3.2	Pipe Specials	sum	823,850
<b>4</b>	<b>Cleaning Eyes</b>		
4.1	Cleaning eyes	no	940,000
<b>5</b>	<b>Bedding</b>		
5.1	From trench excavation :		
5.1.1	Selected granular material	m <sup>3</sup>	349,245
5.1.2	Selected fill material	m <sup>3</sup>	249,696
5.2	By importing material :		
<b>3.5.2.1</b>	Selected granular material	m <sup>3</sup>	129,213
<b>3.5.2.2</b>	Selected fill material	m <sup>3</sup>	59,823
<b>6</b>	<b>Pump Stations</b>		
6.1	Pump stations cost, including sump costs	sum	1,050,000
<b>7</b>	<b>Valves</b>		
7.1	Air release valves	sum	477,692
7.2	Non-return valves	sum	67,600
7.3	Gate valves	sum	809,100
<b>8</b>	<b>Sumps</b>		
8.1	Sump costs (all inclusive)	no	278,500
<b>9</b>	<b>Sumps</b>		
9.1	Sump costs (all inclusive)	no	30,000
	<b>NET TOTAL COST</b>		<b>R 26,726,168</b>
	<b>Add : 15 % for P &amp; G'S</b>		<b>R 4,008,925</b>
	<b>SUB TOTAL</b>		<b>R 30,735,093</b>
	<b>Add : 25 % for contingencies</b>		<b>R 7,683,773</b>
	<b>Add : 15 % for engineering and project management</b>		<b>R 4,610,264</b>
	<b>SUB TOTAL</b>		<b>R 43,029,131</b>
	<b>Add : 10 % for cost price adjustment</b>		<b>R 4,302,913</b>
	<b>TOTAL CIVIL COST (excl. VAT)</b>		<b>R 47,332,044</b>

**Table 3.5.1.2(b): Cost Estimate of Mechanical Equipment for Scenario 2: Pumping/Gravity System**

ITEM	DESCRIPTION	UNIT	AMOUNT
<b>1</b>	<b>Pumps</b>		
1.1	14 L/sec at 31 meters head	sum	31,410
1.2	23 L/sec at 63 meters head	sum	40,320
1.3	102 L/sec at 62 meters head	sum	136,880
1.4	16 L/sec at 76 meters head	sum	34,892
1.5	320 L/sec at meters head	sum	1,200,000
1.6	7 L/sec at 52 meters head	sum	19,666
1.7	9 L/sec at 54 meters head	sum	23,362
<b>2</b>	<b>Cleaning Equipment</b>		
2.1	Woma cleaning system	no	260,000
2.3	Water tankers	no	160,000
	<b>NET TOTAL COST</b>		<b>R 1,906,530</b>
	<b>Add : 25 % for contingencies</b>		<b>R 476,632</b>
	<b>Add : 15 % for engineering and project management</b>		<b>R 285,979</b>
	<b>SUB TOTAL</b>		<b>R 2,669,142</b>
	<b>Add : 10 % for cost price adjustment</b>		<b>R 266,914</b>
	<b>TOTAL MECHANICAL EQUIPMENT (excl. VAT)</b>		<b>R 2,936,056</b>

The estimated annual operating and maintenance costs associated with Scenario 2: Pumping/Gravity System are summarised in **Table 3.5.1.2(c)**.

**Table 3.5.1.2(c) : Estimated Annual Operating and Maintenance Cost for Scenario 2 : Pumping/Gravity System**

ITEM	DESCRIPTION	UNIT	RATE
	<b>Annual maintenance costs</b>		
1	Civil structures and pipes	% of capital cost	236,660.22
2	Mechanical equipment	% of capital cost	117,442.25
3	Electrical installations	% of capital cost	4,404.08
	<b>Annual operating costs</b>		
4	Electrical power for pumping		
4.1	Electricity consumption	R/kWh	802398.48
4.2	Peak demand	R/kVA	21081.632
5	Tankers (diesel consumption)	Sum	24000
6	Labour (5 labours at R 2 000/month)	Salary	120000
7	Water consumption	m <sup>3</sup>	35,000
	<b>Annual operating and maintenance cost</b>		<b>R 1,360,987</b>

### 3.5.1.3 Cost Summary

The capital, operating and maintenance costs associated with excess mine water collection to a centralised treatment plant are summarised in **Table 3.5.1.3**.

**Table 3.5.1.3 : Cost Summary**

ITEM	Scenario 1: Gravity System	Scenario 2 : Pumping/Gravity System
Total pipeline length (km)	34	47
Number of pump stations	0	8
Civil construction costs	R 31,564,000	R 47,332,000
Mechanical equipment costs	R 647,000	R 2,936,000
<b>Total Capital Cost</b>	<b>R 32,211,000</b>	<b>R 50,268,000</b>
Operating and maintenance cost	R 411,000	R 1,361,000
Capital Interest and Redemption (at 16 %)	R 5,433,000	R 8,479,000

### 3.5.2 Witbank Dam Catchment

The proposed mine water collection system would serve at least twelve mines in the Witbank Dam Catchment. The locations of the potential decant points are shown on **Figure 3.5.2**. **Table 3.5.2(a)** lists the mines and the best estimate of current decants volumes.

**Table 3.5.2(a) : Current Excess Mine Water Production**

Catchment	Mine Name	Excess Water (m <sup>3</sup> /year)
Witbank		
	Douglas Colliery	239,976
	Goedehoop Colliery	203,091
	Greenside	237,250
	Kleinkoje & Landau	1,489,800
	Koornfontein	34,200
	Kriel	725,328
	Matla Mine	2,070,000
	Middelburg Mine - South	213,000
	Middelburg Mine - North	213,000
	Rietspruit Mine Services	515,640
	Syferfontein Colliery	533,256
	Tavistock Colliery	180,000
	<b>Total</b>	<b>6,654,541</b>

The topography of the Witbank Dam catchment does not allow for the convenient draining under gravity of all excess mine waters to a single collection point. After a detailed investigation, it became evident that the optimal and practical scheme would be a combination of pumping mains and gravity flow pipelines.

The Matla and Kriel Power Stations have indicated that they are considering treating and re-using the excess water from the Matla and Kriel Collieries. To accommodate this possibility two scenarios were investigated, viz. :

- Scenario 1 : a mine water collection system, excluding the flows from the Matla and Kriel collieries and
- Scenario 2 : a mine water collection system, including the flows from the Matla and Kriel collieries.

The Syferfontein Colliery's decant point is the furthest from the proposed site for the treatment works. The straight-line distance from the Syferfontein Colliery's decant point to the nearest point on the proposed collection system is approximately 25 km. After initial cost estimates, it became evident that if the Matla and Kriel collieries were not include into the collection system, it was not cost effective to include excess mine water from Syferfontein Colliery.

The Middelburg South Colliery is also relatively remote from the proposed mine water collection system. It lies approximately 17 km from the nearest point in the proposed collection system. Excess water from this Colliery can been included into the collection system at an estimated additional cost of about R 4,500,000.

### **3.5.2.1 Scenario One : Matla and Kriel Collieries Excluded**

The proposed layout of the pipe network for scenario 1 is shown on **Figure 3.5.2.1**.

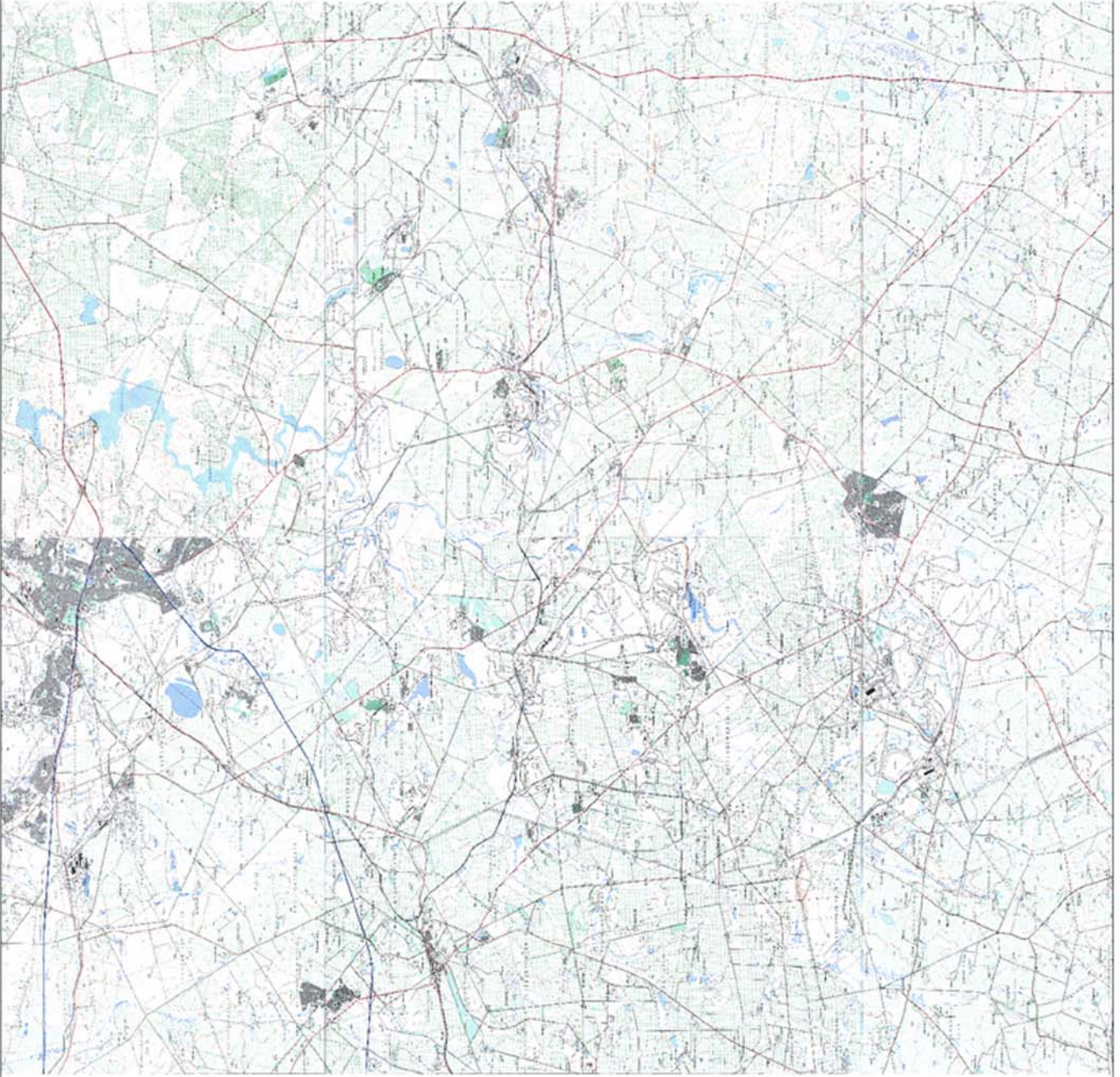
Seepage and decants along the Koringspruit river is collected by a gravity manifold system to a collection box (refer to point 6 on **Figure 3.5.2.1**). The collected water is then pumped from point 6 to point 7 (refer to **Figure 3.5.2.1**). Point 7 is positioned such that mine water collected to this point is able to gravitate to the centralised treatment works.

Excess water from the Middelburg North and South Collieries is pumped to point 9 (refer to **Figure 3.5.2.1**) from were the water is allowed, by gravity flow, to enter into the pipeline from point 7 to the centralised treatment works.

Water decanting at point 13 (refer to **Figure 3.5.2.1**) is pumped to a sump at point 14 (refer to **Figure 3.5.2.1**). Excess water in the vicinity of point 14 also drains to this sump. The water collected is then pumped to a sump at point 15 which also collects decanting water from the immediate vicinity (refer to **Figure 3.5.2.1**). The water collected to the sump at point 15 flows by gravity to the centralised treatment works.

Excess mine water at points 11 and 12 (refer to **Figure 3.5.2.1**) is transported to the plant via a gravity flow pipeline. The local topography dictates the route

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of this pipeline. The pipeline was routed over land that could have been mined or could be potential future mining areas. This aspect will have to be investigated in more detail as the project progress.

The civil construction and mechanical equipment capital cost estimates are contained in **Tables 3.5.2.1(a)** and **3.5.2.1(b)** respectively.

The operating and maintenance estimates are contained in **Table 3.5.2.1(c)**

**Table 3.5.2.1(a) : Cost Estimate of Civil Works for Scenario 1 : Kriel/Matla Collieries Excluded**

ITEM	DESCRIPTION	UNIT	AMOUNT
<b>1</b>	<b>Site clearance :</b>		
1.1	Clear & grub strip 3m wide	m	419,095
1.2	Remove trees :		
1.2.1	Over 1m up to 2m	no	71,458
1.2.2	Over 1m up to 3m	no	-
1.3	Take down existing fences	km	-
1.4	Temporary works : traffic & maintenance	sum	-
1.5	Excavation to exposed existing services	m <sup>3</sup>	5,000
1.6	Replace beacons & pegs	sum	10,000
<b>2</b>	<b>Excavate for pipe trenches :</b>		
2.1	Excavations for pipes over 100mm up to 300mm diameter to depths of :		
2.1.1	0.0 m to 1.0 m	m	142,520
2.1.2	1.0 m to 2.0 m	m	3,893,850
2.1.3	2.0 m to 3.0 m	m	682,060
2.1.4	3.0 m to 4.0 m	m	-
2.2	Excavations for pipes over 300mm diameter to depths of :		
2.2.1	0.0 m to 1.0 m	m	7,955
2.2.2	1.0 m to 2.0 m	m	219,300
2.2.3	2.0 m to 3.0 m	m	43,000
2.2.4	3.0 m to 4.0 m	m	-
2.3	Extra over for :		
2.3.1	Intermediate material	m <sup>3</sup>	105,130
2.3.2	Hard rock material	m <sup>3</sup>	3,304,070
2.3.3	Boulders Class A	m <sup>3</sup>	81,357
2.3.4	Boulders Class B	m <sup>3</sup>	81,357
2.3.5	Excavate unsuitable material	m <sup>3</sup>	135,596
2.4	Backfill materials from :		
2.4.1	Borrow pits	m <sup>3</sup>	20,468
2.4.2	Commercial/off-site resources	m <sup>3</sup>	56,856
2.4.3	Compaction in road reserves	m	2,800
2.4.4	Truck haul over 1km	m <sup>3</sup> km	14,214
2.4.5	Shoring of trenches	m	61,600
2.4.6	Forming underdrains	m	140,000
2.4.7	Extra over 2.3.6 for lining underdrain	m	7,000
2.4.8	Extra over 2.3.6 for drainage pipes	m	10,500
2.5	Miscellaneous allowance for :		

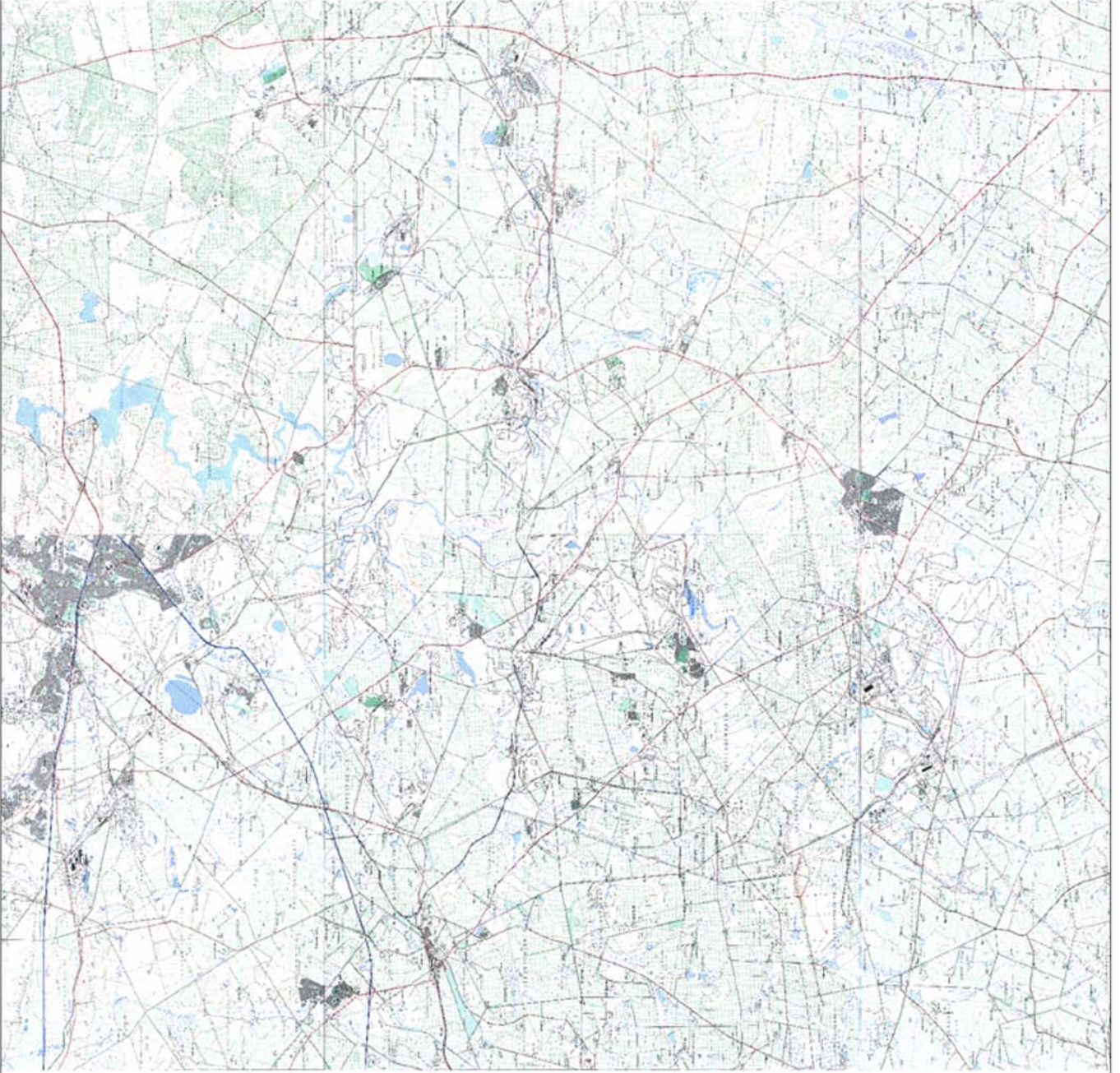
ITEM	DESCRIPTION	UNIT	AMOUNT
2.5.1	Repairs to road or rail crossings	no	4,000
2.5.2	Inconvenience to cross existing fences, etc.	no	12,000
2.5.3	Care to cross existing pipes, etc.	no	6,000
2.5.4	Care to adjoining trenches	m	5,000
<b>3</b>	<b>Pipework</b>		
3.1	Pipework : Supply, transport, lay, test, etc.(for gravatiy lines - class 6 uPVC)		
3.1.1	110 diameter - uPVC	m	296,800
3.1.2	160 diameter - uPVC	m	318,000
3.1.3	200 diameter - uPVC	m	340,200
3.1.4	250 diameter - uPVC	m	1,904,000
3.2	Pipework : Supply, transport, lay, test, etc.(for pumping mains - class 9 uPVC)		
3.2.1	160 diameter – uPVC	m	1,536,000
3.2.2	200 diameter – uPVC	m	1,581,000
3.2.3	250 diameter – uPVC	m	1,680,000
3.2.4	300 diameter – uPVC	m	2,760,000
3.3.5	400 diameter – uPVC	m	1,591,000
3.2	Pipe Specials	sum	600,350
<b>4</b>	<b>Manholes :</b>		
4.1	1250 mm inside diameter, Type 4 cover & frame :		
4.1.1	0.5 m - 1.0 m	no	-
4.1.2	1.0 m - 1.5 m	no	-
4.1.3	1.5 m - 2.0 m	no	872,947
4.1.4	2.0 m - 2.5 m	no	224,787
4.1.5	2.5 m - 3.0 m	no	-
4.2	Extra over 4.1.1 to 4.1.9 for Type 2A cover	no	320,133
4.3	Extra over 4.1.1 to 4.1.9 for future access	no	-
4.4	Test watertightness	no	130,667
4.5	Break into existing manholes	sum	-
<b>5</b>	<b>Hand Stops</b>		
5.1	Hand stops	no	196,000
<b>6</b>	<b>Bedding</b>		
6.1	From trench excavation :		
6.1.1	Selected granular material	m <sup>3</sup>	877,248
6.1.2	Selected fill material	m <sup>3</sup>	494,323
6.2	By importing material :		
6.2.1	Selected granular material	m <sup>3</sup>	210,174
6.2.2	Selected fill material	m <sup>3</sup>	118,432
<b>7</b>	<b>Cleaning Eyes</b>		
7.1	Cleaning eyes	no	1,155,000
<b>8</b>	<b>Pump Station</b>		
8.1	Pump station cost (all inclusive)	no	750,000
<b>9</b>	<b>Valves</b>		
9.1	Air release valves	no	639,692
9.2	Non-return valves		
9.2.1	150mm diameter	no	4000
9.2.2	200mm diameter	no	6000

ITEM	DESCRIPTION	UNIT	AMOUNT
9.2.3	250mm diameter	no	7600
9.2.4	300mm diameter	no	10000
9.3	Gate valves		
9.3.1	150mm diameter	no	36000
9.3.2	200mm diameter	no	84000
9.2.3	250mm diameter	no	37800
9.3.4	300mm diameter	no	70800
9.3.5	400mm diameter	no	45000
<b>10</b>	<b>Valve boxes</b>		
10.1	Valve boxes (all inclusive)	no	372,000
<b>11</b>	<b>Sumps</b>		
11.1	Sump costs (all inclusive)	no	150,000
	<b>NET TOTAL COST</b>		<b>R 28,962,138</b>
	<b>Add : 15 % for P &amp; G'S</b>		<b>R 4,344,321</b>
	<b>SUB TOTAL</b>		<b>R 33,306,459</b>
	<b>Add : 25 % for contingencies</b>		<b>R 8,326,615</b>
	<b>Add : 15 % for engineering and project Management</b>		<b>R 4,995,969</b>
	<b>SUB TOTAL</b>		<b>R 46,629,043</b>
	<b>Add : 10 % for cost price adjustment</b>		<b>R 4,662,904</b>
	<b>TOTAL CIVIL COST (excl. VAT)</b>		<b>R 51,291,947</b>

**Table 3.5.2.1(b) : Cost Estimate of Mechanical Equipment for Scenario 1 : Kriel/Matla Collieries Excluded**

ITEM	DESCRIPTION	UNIT	AMOUNT
<b>1</b>	<b>Pumps</b>		
1.1	7 l/sec at 64 meters head	no	30,000
1.2	7 l/sec at 102 meters head	no	50,000
1.3	23 l/sec at 87 meters head	no	40,000
1.4	65 l/sec at 73 meters head	no	136,000
1.5	48 l/sec at 32 meters head	no	100,000
<b>2</b>	<b>Cleaning Equipment</b>		
2.1	Woma cleaning system		260000
2.2	Water tankers		160000
	<b>NET TOTAL COST</b>		<b>R 776,000</b>
	<b>Add : 25 % for contingencies</b>		<b>R 194,000</b>
	<b>Add : 15 % for engineering and project management</b>		<b>R 116,400</b>
	<b>SUB TOTAL</b>		<b>R 1,086,400</b>
	<b>Add : 10 % For Cost Price Adjustment</b>		<b>R 108,640</b>
	<b>TOTAL FOR MECHANICAL EQUIPMENT (excl. VAT)</b>		<b>R 1,195,040</b>

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**Table 3.5.2.1(c) : Estimated Annual Operating and Maintenance Cost for Scenario 1 : Kriel/Matla Collieries Excluded**

ITEM	DESCRIPTION	UNIT	RATE
	<b>Annual maintenance costs</b>		
1	Civil structures and pipes	% of capital cost	256,460
2	Mechanical equipment	% of capital cost	47,802
3	Electrical installations	% of capital cost	3,300
	<b>Annual operating costs</b>		
4	Electrical power for pumping		
4.1	Electricity consumption	R/kWh	204,984
4.2	Peak demand	R/kVA	5,386
5	Tankers (diesel consumption)	Sum	24,000
6	Labour	Salary	168,000
7	Water consumption	m <sup>3</sup>	35,000
	<b>Annual operating and maintenance cost</b>		<b>R 744,931</b>

### 3.5.2.2 Scenario Two : Kriel and Matla Collieries Included

The proposed layout of the pipe network for Scenario 2 is shown in **Figure 3.5.2.2**.

All the pipelines routes and collection systems described in Scenario 1 apply. Pipeline sizes have however been changed to accommodate the increased flow. Excess water from the Matla Colliery is collected to point 17 (refer to **Figure 3.5.2.2**). This water is then pumped to a collection sump at point 22. Excess water from the Kriel and Syferontein Collieries is collected to point 21 from where it is pumped to the collection sump at point 22. Water in the collection sump is then allowed to gravitate into the collection sump at point 6. From here the flow collection system described in Scenario 1 applies.

The civil construction and mechanical equipment capital cost estimates are contained in **Tables 3.5.2.2(a)** and **3.5.2.2(b)** respectively.

**Table 3.5.2.2(a) : Cost Estimate of Civil Works for Scenario 2 : Kriel/Matla Collieries Included**

ITEM	DESCRIPTION	UNIT	AMOUNT
<b>1</b>	<b>Site clearance :</b>		
1.1	Clear grub strip 3m wide	m	693,225
1.2	Remove trees :		
1.2.1	Over 1m up to 2m	no	118,199
1.2.2	Over 1m up to 3m	no	-
1.3	Take down existing fences	km	-
1.4	Temporary works : traffic & maintenance	sum	-
1.5	Excavation to exposed existing services	m <sup>3</sup>	5,000
1.6	Replace beacons & pegs	sum	10,000
<b>2</b>	<b>Excavate for pipe trenches :</b>		
2.1	Excavations for pipes over 100mm up to 300mm diameter to depths of :		

ITEM	DESCRIPTION	UNIT	AMOUNT
2.1.1	0.0 m to 1.0 m	m	144,900
2.1.2	1.0 m to 2.0 m	m	3,958,875
2.1.3	2.0 m to 3.0 m	m	693,450
2.1.4	3.0 m to 4.0 m	m	-
2.2	Excavations for pipes over 300mm diameter to depths of :		
2.2.1	0.0 m to 1.0 m	m	133,200
2.2.2	1.0 m to 2.0 m	m	3,672,000
2.2.3	2.0 m to 3.0 m	m	720,000
2.2.4	3.0 m to 4.0 m	m	-
2.3	Extra over for :		
2.3.1	Intermediate material	m <sup>3</sup>	197,862
2.3.2	Hard rock material	m <sup>3</sup>	6,218,520
2.3.3	Boulders Class A	m <sup>3</sup>	153,121
2.3.4	Boulders Class B	m <sup>3</sup>	153,121
2.3.5	Excavate unsuitable material	m <sup>3</sup>	255,202
2.4	Backfill materials from :		
2.4.1	Borrow pits	m <sup>3</sup>	38,523
2.4.2	Commercial/off-site resources	m <sup>3</sup>	107,007
2.4.3	Compaction in road reserves	m	30,000
2.4.4	Truck haul over 1km	m <sup>3</sup> km	26,752
2.4.5	Shoring of trenches	m	92,400
2.4.6	Forming underdrains	m	210,000
2.4.7	Extra over 2.3.6 for lining underdrain	m	10,500
2.4.8	Extra over 2.3.6 for drainage pipes	m	15,750
2.5	Miscellaneous allowance for :		
2.5.1	Repairs to road or rail crossings	no	4,000
2.5.2	Inconvenience to cross existing fences, etc.	no	12,000
2.5.3	Care to cross existing pipes, etc.	no	6,000
2.5.4	Care to adjoining trenches	m	5,000
<b>3</b>	<b>Pipework</b>		
3.1	Pipework : Supply, transport, lay, test, etc.(for gravatiy lines - class 6 uPVC and 4 kN/m <sup>2</sup> weholite pipes)		
3.1.1	110 diameter - uPVC	m	296,800
3.1.2	160 diameter - uPVC	m	318,000
3.1.3	200 diameter - uPVC	m	745,200
3.1.4	250 diameter - uPVC	m	2,939,300
3.1.5	300 diameter - uPVC	m	910,000
3.1.6	550 diameter - weholite	m	4,422,000
3.2	Pipework : Supply, transport, lay, test, etc.(for pumping mains - class 9 uPVC and HDPE pipes)		
3.2.1	160 diameter - uPVC	m	1,536,000
3.2.2	250 diameter - uPVC	m	1,680,000
3.2.3	300 diameter - uPVC	m	2,760,000
3.2.4	350 diameter - uPVC	m	3,835,000
3.3.5	400 diameter - uPVC	m	1,591,000
3.3.6	450 diameter - HDPE	m	9,102,000
3.3.7	560 diameter - HDPE	m	11,662,000

ITEM	DESCRIPTION	UNIT	AMOUNT
3.3.8	630 diameter -HDPE	m	3,468,000
3.2	Pipe Specials	sum	2,263,265
<b>4</b>	<b>Manholes :</b>		
4.1	1250 mm inside diameter, Type 4 cover & frame :		
4.1.1	0.5 m - 1.0 m	no	-
4.1.2	1.0 m - 1.5 m	no	-
4.1.3	1.5 m - 2.0 m	no	1,598,940
4.1.4	2.0 m - 2.5 m	no	419,643
4.1.5	2.5 m - 3.0 m	no	-
4.2	Extra over 4.1.1 to 4.1.9 for Type 2A cover	no	588,490
4.3	Extra over 4.1.1 to 4.1.9 for future access	no	-
4.4	Test watertightness	no	240,200
4.5	Break into existing manholes	sum	-
<b>5</b>	<b>Hand Stops</b>		
5.1	Hand stops	no	360,300
<b>6</b>	<b>Bedding</b>		
6.1	From trench excavation :		
6.1.1	Selected granular material	m <sup>3</sup>	1,954,006
6.1.2	Selected fill material	m <sup>3</sup>	930,355
6.2	By importing material :		
6.2.1	Selected granular material	m <sup>3</sup>	468,147
6.2.2	Selected fill material	m <sup>3</sup>	222,898
<b>7</b>	<b>Cleaning Eyes</b>		
7.1	Cleaning eyes	no	1,780,000
<b>8</b>	<b>Pump Stations</b>		
8.1	Pump station cost (all inclusive)	no	1,200,000
<b>9</b>	<b>Valves</b>		
9.1	Air release valves	no	985,846
9.2	Non-return valves		
9.2.1	160mm diameter	no	4,000
9.2.2	250mm diameter	no	15,200
9.2.3	300mm diameter	no	10,000
9.2.4	350mm diameter	no	12,000
9.2.5	450mm diameter	no	30,000
9.2.6	550mm diameter	no	50,000
9.3	Gate valves		
9.3.1	160mm diameter	no	36,000
9.3.2	250mm diameter	no	37,800
9.2.3	300mm diameter	no	70,800
9.3.4	350mm diameter	no	102,000
9.3.5	400mm diameter	no	45,000
9.3.6	450mm diameter	no	420,000
9.3.7	550mm diameter	no	672,000
9.3.8	600mm diameter	no	90,000
<b>10</b>	<b>Valve Boxes</b>		
10.1	Valve boxes (all inclusive)	no	573,500
<b>11</b>	<b>Sumps</b>		

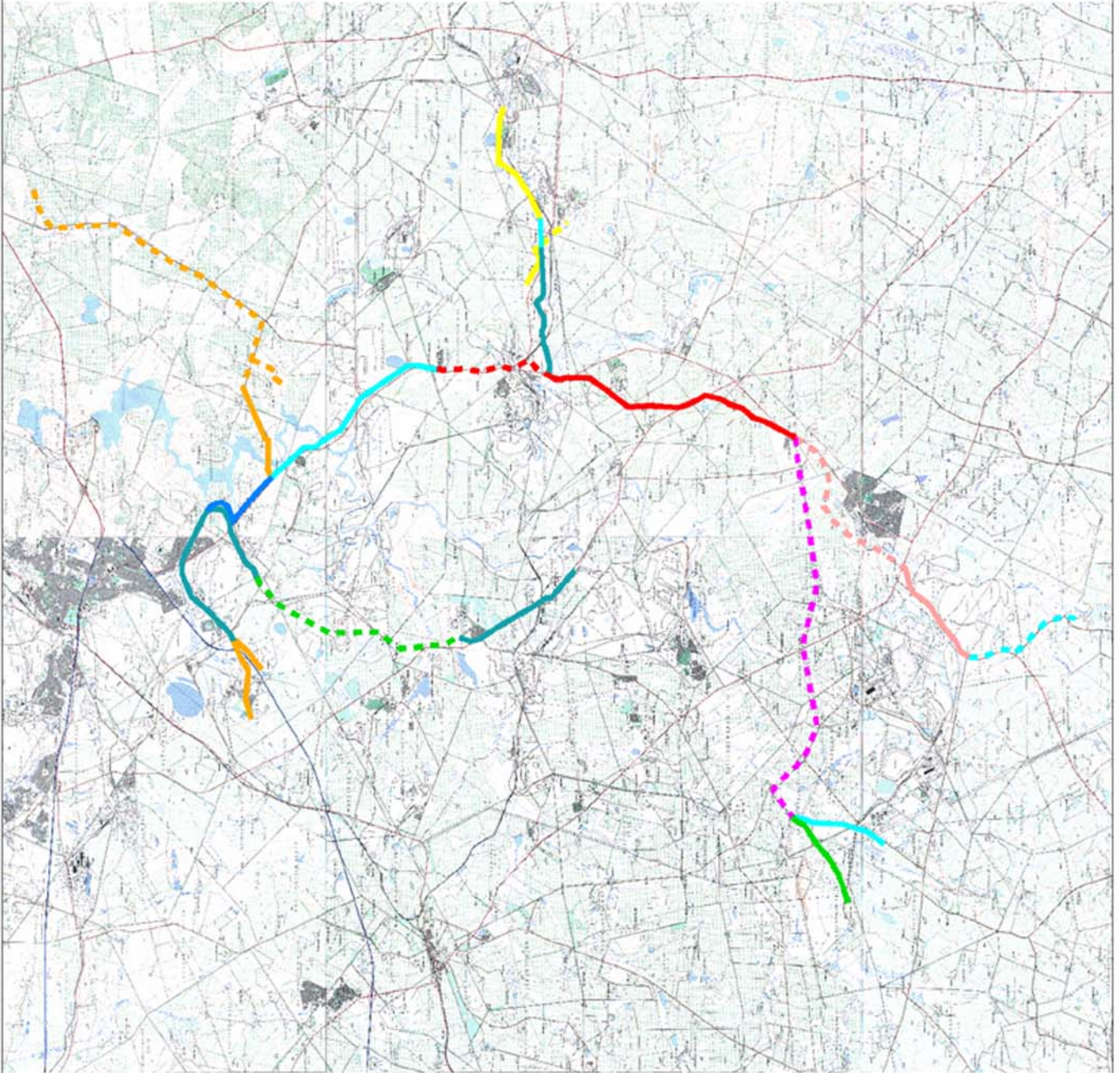
ITEM	DESCRIPTION	UNIT	AMOUNT
11.1	Sump costs (all inclusive)	no	240,000
	<b>NET TOTAL COST</b>		<b>R 78,370,296</b>
	<b>Add : 15 % for P &amp; G'S</b>		<b>R 11,755,544</b>
	<b>SUB TOTAL</b>		<b>R 90,125,840</b>
	<b>Add : 25 % for contingencies</b>		<b>R 22,531,460</b>
	<b>Add : 15 % for engineering and project management</b>		<b>R 13,518,876</b>
	<b>SUB TOTAL</b>		<b>R 126,176,177</b>
	<b>Add : 10 % for cost price adjustment</b>		<b>R 12,617,617</b>
	<b>TOTAL CIVIL COST (excl. VAT)</b>		<b>R 138,793,794</b>

**Table 3.5.2.2(b) : Cost Estimate of Mechanical Equipment for Scenario 2 : Kriel/Matla Included**

ITEM	DESCRIPTION	UNIT	AMOUNT
<b>1</b>	<b>Pumps</b>		
1.1	7 l/sec at 64 meters head	no	30,000
1.2	7 l/sec at 102 meters head	no	50,000
1.3	48 l/sec at 32 meters head	no	100,000
1.4	65 l/sec at 73 meters head	no	136,000
1.5	120 l/sec at 114 meters head	no	100,000
1.6	210 l/sec at 88 meters head	no	100,000
1.7	420 l/sec at 94 meters head	no	1,344,000
1.8	51 l/sec at 43 meters head	no	60,000
<b>2</b>	<b>Cleaning Equipment</b>		
2.1	Woma cleaning system		260,000
2.2	Water tankers		160,000
	<b>NET TOTAL COST</b>		<b>R 2,340,000</b>
	<b>Add : 25 % for contingencies</b>		<b>R 585,000</b>
	<b>Add : 15 % For engineering and project management</b>		<b>R 351,000</b>
	<b>SUB TOTAL</b>		<b>R 3,276,000</b>
	<b>Add : 10 % for cost price adjustment</b>		<b>R 327,600</b>
	<b>TOTAL FOR MECHANICAL EQUIPMENT (excl. VAT)</b>		<b>R 3,603,600</b>



WMS



The operating and maintenance cost estimates are contained in **3.5.2.2(c)**

**Tables**

**Table 3.5.2.2(c) : Estimated Annual Operating and Maintenance Cost for Scenario 2 : Kriel/Matla Included**

ITEM	DESCRIPTION	UNIT	RATE
	<b>Annual maintenance costs</b>		
1	Civil structures and pipes	% of capital cost	693,969
2	Mechanical equipment	% of capital cost	144,144
3	Electrical installations	% of capital cost	12,973
	<b>Annual operating costs</b>		
4	Electrical power for pumping		
4.1	Electricity consumption	R/kWh	1,160,437
4.2	Peak demand	R/kVA	30,488
5	Tankers (diesel consumption)	Sum	24,000
6	Labour	Salary	168,000
7	Water consumption	m <sup>3</sup>	35,000
	<b>Annual operating and maintenance cost</b>		<b>R 2,269,011</b>

### 3.5.2.3 Cost Summary

ITEM	Scenario 1 : Kriel and Matla Excluded	Scenario 2 : Kriel and Matla Included
Total pipeline length (km)	106	176
Number of pump stations	5	8
Civil costs	R 51,292,000	R 138,794,000
Mechanical costs	R 1,195,000	R 3,604,000
<b>Total Capital Costs</b>	<b>R 52,487,000</b>	<b>R 142,398,000</b>
Operating and maintenance cost	R 745,000	R 2,269,000
Capital Interest and Redemption (at 16 %)	R 8,853,000	R 24,018,000

### 3.5.3 Klipspruit Catchment

As mentioned previously the Klipspruit catchment as existing infrastructure for the collection of excess mine produced in the area. A large percentage of excess mine water in this catchment is currently collected and treated at the Brugspruit treatment works. The Brugspruit works is however only a lime neutralisation plant. The active and closed mines located within the Klipspruit catchment considered for the collection system is shown in **Table 3.5.3** along with the current best estimates of decant volumes.

**Table 3.5.3 : Current Excess Mine Water Production**

Catchment	Mine Name	Excess Water (m <sup>3</sup> /year)
Klipspruit		
	Kromdraai	1,825,000
	South Witbank	901,550
	Skoongesicht	1,095,000
	Middleburg Steam	222,285
	Old Travistock	28,105
	Brugspruit : High TDS	985,500
	Brugspruit : Low TDS	912,500
	<b>Total</b>	<b>5,068,390</b>

The proposed layout of the collection system is shown on **Figure 3.5.3**. The system designed for the Klipspruit catchment is a combination of gravity flow pipelines and pumping mains.

A proposal was done in October 1996 for the Department of Water Affairs and Forestry by Keeve Steyn for the collection and transport of excess mine water, from the Middelburg Steam and Travistock collieries, to the Brugspruit treatment works (refer to report WQ/B104/03/01/96). On reviewal of this proposal, it was decided that the system designed would still apply to the new proposed collection system. Prices from the original proposal were escalated from October 1996 to October 1999.

The proposal by Keeve Steyn entailed collecting excess mine in the Blesbokspruit using sub-soil drains and decanting structures at the Tavistock and Middelburg Steam Collieries. From these collecting structures the excess water is to be conveyed in a gravity pipe system to a central location equipped with a pumpstation, sump and a rising main to the Brugspruit catchment. The interface between the Brugspruit networks is the existing Douglas balancing dam.



Decanting water from the South Witbank and Skoongesicht (points 1 and 2 on **Figure 3.5.3**) collieries is transported to the centralised treatment works via a gravity flow pipeline. The pipeline crosses a national road and the most efficient method of doing this crossing was found to be by pipe jacking. Excess water from Kromdraai (point 3 on **Figure 3.5.3**) is pumped across the catchment to the centralised treatment works.

The civil construction and mechanical equipment capital cost estimates are contained in **Tables 3.5.3(a)** and **3.5.3(b)** respectively.

**Table 3.5.3(a) : Cost Estimate of Civil Works**

ITEM	DESCRIPTION	UNIT	AMOUNT
<b>1</b>	<b>Site clearance :</b>		
1.1	Clear grub strip 3m wide	m	89,191
1.2	Remove trees :		
1.2.1	Over 1m up to 2m	no	15,208
1.2.2	Over 1m up to 3m	no	-
1.3	Take down existing fences	km	-
1.4	Temporary works : traffic & maintenance	sum	-
1.5	Excavation to exposed existing services	m <sup>3</sup>	5,000
1.6	Replace beacons & pegs	sum	10,000
<b>2</b>	<b>Excavate for pipe trenches :</b>		
2.1	Excavations for pipes over 100mm up to 300mm diameter to depths of :		
2.1.1	0.0 m to 1.0 m	m	20,412
2.1.2	1.0 m to 2.0 m	m	557,685
2.1.3	2.0 m to 3.0 m	m	97,686
2.1.4	3.0 m to 4.0 m	m	-
2.2	Excavations for pipes over 300mm diameter to depths of :		
2.2.1	0.0 m to 1.0 m	m	14,800
2.2.2	1.0 m to 2.0 m	m	408,000
2.2.3	2.0 m to 3.0 m	m	80,000
2.2.4	3.0 m to 4.0 m	m	-
2.3	Extra over for :		
2.3.1	Intermediate material	m <sup>3</sup>	24,561
2.3.2	Hard rock material	m <sup>3</sup>	771,925
2.3.3	Boulders Class A	m <sup>3</sup>	19,007
2.3.4	Boulders Class B	m <sup>3</sup>	19,007
2.3.5	Excavate unsuitable material	m <sup>3</sup>	31,679
2.4	Backfill materials from :		
2.4.1	Borrow pits	m <sup>3</sup>	4,782
2.4.2	Commercial/off-site resources	m <sup>3</sup>	13,283
2.4.3	Compaction in road reserves	m	-
2.4.4	Truck haul over 1 km	m <sup>3</sup> km	3,321
2.4.5	Shoring of trenches	m	22,000
2.4.6	Forming underdrains	m	50,000

ITEM	DESCRIPTION	UNIT	AMOUNT
2.4.7	Extra over 2.3.6 for lining underdrain	m	2,500
2.4.8	Extra over 2.3.6 for drainage pipes	m	3,750
2.5	Miscellaneous allowance for :		
2.5.1	Repairs to road or rail crossings	no	4,000
2.5.2	Inconvenience to cross existing fences, etc.	no	12,000
2.5.3	Care to cross existing pipes, etc.	no	6,000
2.5.4	Care to adjoining trenches	m	5,000
<b>3</b>	<b>Pipework</b>		
3.1	Pipework : Supply, transport, lay, test, etc.(for gravatiy lines - class 6 uPVC and 4 kN/m <sup>2</sup> weholite pipes)		
3.1.2	160 diameter – uPVC	m	18,550
3.1.4	350 diameter – uPVC	m	1,920,000
3.2	Pipework : Supply, transport, lay, test, etc.(for pumping mains - class 9 uPVC)		
3.2.2	200 diameter – uPVC	m	579,390
3.2.4	300 diameter – uPVC	m	1,840,000
3.2	Pipe Specials	sum	217,897
<b>4</b>	<b>Manholes :</b>		
4.1	1250 mm inside diameter, Type 4 cover & frame :		
4.1.1	0.5 m - 1.0 m	no	-
4.1.2	1.0 m - 1.5 m	no	-
4.1.3	1.5 m - 2.0 m	no	196,303
4.1.4	2.0 m - 2.5 m	no	51,005
4.1.5	2.5 m - 3.0 m	no	-
4.2	Extra over 4.1.1 to 4.1.9for Type 2A cover	no	72,112
4.3	Extra over 4.1.1 to 4.1.9 for future access	no	-
4.4	Test watertightness	no	29,433
4.5	Break into existing manholes	sum	-
<b>5</b>	<b>Hand Stops</b>		
5.1	Hand stops	no	44,150
<b>6</b>	<b>Bedding</b>		
6.1	From trench excavation :		
6.1.1	Selected granular material	m <sup>3</sup>	227,843
6.1.2	Selected fill material	m <sup>3</sup>	115,488
6.2	By importing material :		
6.2.1	Selected granular material	m <sup>3</sup>	54,587
6.2.2	Selected fill material	m <sup>3</sup>	27,669
<b>7</b>	<b>Cleaning Eyes</b>		
7.1	Cleaning eyes	no	237,167
<b>8</b>	<b>Pump Stations</b>		
8.1	Pump station cost (all inclusive)	no	300,000
<b>9</b>	<b>Valves</b>		
9.1	Air release valves	no	131,354
9.2	Non-return valves		
9.2.2	200mm diameter	no	12,000
9.2.4	300mm diameter	no	10,000
9.3	Gate valves		

ITEM	DESCRIPTION	UNIT	AMOUNT
9.3.2	200mm diameter	no	10,500
9.3.4	300mm diameter	no	35,400
<b>10</b>	<b>Valve Boxes</b>		
10.1	Valve boxes (all inclusive)	no	46,500
11	Pipe jacking	no	1,000,000
	<b>NET TOTAL COST</b>		<b>R 9,468,144</b>
	<b>ADD : 15 % for P &amp; G'S</b>		<b>R 1,420,222</b>
	<b>SUB TOTAL</b>		<b>R 10,888,366</b>
	<b>Add : 25 % for contingencies</b>		<b>R 2,722,092</b>
	<b>Add : 15 % for engineering and project management</b>		<b>R 1,633,255</b>
	<b>SUB TOTAL</b>		<b>R 15,243,713</b>
	<b>Add : 10 % for cost price adjustment</b>		<b>R 1,524,371</b>
	<b>TOTAL CIVIL COST (excl. VAT)</b>		<b>R 16,768,084</b>

**Table 3.5.3(b) : Cost Estimate of Mechanical Equipment**

ITEM	DESCRIPTION	UNIT	AMOUNT
<b>1</b>	<b>Pumps</b>		
1.1	57 l/sec at 36 meters head	no	90,000
1.2	Existing Proposal	no	80,000
<b>2</b>	<b>Cleaning Equipment</b>		
2.1	Woma cleaning system		260,000
2.2	Water tankers		160,000
	<b>NET TOTAL COST</b>		<b>R 590,000</b>
	<b>Add : 25 % for contingencies</b>		<b>R 147,500</b>
	<b>Add : 15 % for engineering and project management</b>		<b>R 88,500</b>
	<b>SUB TOTAL</b>		<b>R 826,000</b>
	<b>Add : 10 % for cost price adjustment</b>		<b>R 82,600</b>
	<b>TOTAL MECHANICAL EQUIPMENT (excl. VAT)</b>		<b>R 908,600</b>

**Table 3.5.3(c) : Estimated Annual Operating and Maintenance Cost**

ITEM	DESCRIPTION	UNIT	RATE
	<b>Annual maintenance costs</b>		
1	Civil structures and pipes	% of capital cost	83,840
2	Mechanical equipment	% of capital cost	36,344
3	Electrical installations	% of capital cost	4,089
	<b>Annual operating costs</b>		
4	Electrical power for pumping		
4.1	Electricity consumption	R/kWh	56,940
4.2	Peak demand	R/kVA	1,496
5	Tankers (diesel consumption)	Sum	24,000
6	Labour	Salary	168,000

ITEM	DESCRIPTION	UNIT	RATE
7	Water consumption	m <sup>3</sup>	25,000
	<b>Annual operating and maintenance cost</b>		<b>R 399,709</b>

### 3.5.3.1 Cost Summary

ITEM	AMOUNT
Total pipeline length (km)	23
Number of pump stations	2
Civil costs	R 16,768,000
Mechanical costs	R 909,000
<b>Total Capital Costs</b>	<b>R 17,677,000</b>
Operating and maintenance cost	R 400,000
Capital Interest and Redemption (at 16 %)	R 2,981,000

## 3.6 CONCLUDING COMMENTS

The preliminary design of the proposed mine water collection system for the Upper Olifants River Catchment as yielded the following :

- Gravity flow systems in general are cheaper than pumping/gravity flow systems
- Regional collection is technically feasible, using established technology
- The regional collection infrastructure cost is probably lower than the treatment cost
- Matla, Kriel and Syferfontein Collieries incremental collection cost is very high. It would probably be more economical to go for a local plant
- Adequate maintenance resources need to be provided.

A summary of the scenarios investigated and their related cost are given below.

#### ***Middelburg Dam Catchment :***

Item	Scenario 1 : Gravity Flow System	Scenario 2 : Pumping/Gravity Flow System
Pipeline Length	34 km	47 km
Total Capital Cost (excl. VAT)	R 32,211,000	R 50,268,000
Annual Operating and Maintenance Costs	R 411,000	R 1,361,000

**Witbank Dam Catchment :**

<b>Item</b>	<b>Scenario 1 : Collection System Excluding Kriel &amp; Matla</b>	<b>Scenario 2 : Collection System Including Kriel &amp; Matla</b>
Pipeline Length	106 km	176 km
Total Capital Cost (excl. VAT)	R 52,487,000	R 142,398,000
Annual Operating and Maintenance Costs	R 745,000	R 2,269,000

**Klipspruit Catchment :**

<b>Item</b>	<b>Scenario 1 : Pumping/Gravity Flow System</b>
Pipeline Length	23 km
Total Capital Cost (excl. VAT)	R 17,677,000
Annual Operating and Maintenance Costs	R 400,000

## CHAPTER 4.

### ASSESSMENT OF VARIOUS MINE WATER TREATMENT TECHNOLOGIES

#### 4.1 INTRODUCTION

Part I showed that currently an estimated 45 Mℓ/d of mine water needs to be treated in the Upper Olifants River Catchment. The water would be treated for one or a combination of the following uses:

- Irrigation (pH 6 to 9, 1500 mg/ℓ SO<sub>4</sub>, 100 mg/ℓ Mg)
- Industrial processes e.g. coal processing (1000 mg/ℓ SO<sub>4</sub>)
- Discharge into local streams (500 mg/ℓ SO<sub>4</sub>)
- Potable water (200 mg/ℓ SO<sub>4</sub>)
- Power station cooling water (30 to 50 mg/ℓ SO<sub>4</sub>)

The purpose of this part of the investigation was to assess various treatment technologies and arrive at capital and running cost estimates for the various technologies. The technologies evaluated and suppliers are given in Table 4.1.

**TABLE 4.1** *The various treatment technologies for acid mine water.*

Process	Supplier(s)
Aqua-K	Aqua Technologies (Pty) Ltd
Barium Process	CSIR
Biological Sulphate Removal	CSIR, Paques, Biothane
Electrodialysis Reversal (EDR)	Various
Electrolytic Process	
Gypcix	Chemeffco
Spiral Reverse Osmosis (SRO)	Various
Savmin	Mintek

## 4.2 ASSESSMENT BASIS

The detailed evaluation for each treatment process was based on a plant flow rate of 15 Mℓ/d.

### 4.2.1 Water quality

The water in the Upper Olifants River Catchment shows significant variation in composition. To allow for this, it was decided to divide the catchment in three “collection-treatment-utilisation” (CTU) regions, namely:

1. Witbank Dam Catchment
2. Middelburg Dam Catchment
3. Klipspruit Catchment

The typical excess mine-water composition for each CTU region is given below (Table 4.2):

**TABLE 4.2** *Mine-water composition in sub-catchment regions of the Upper Olifants River.*

Parameters	Collection-treatment-utilisation Area		
	Witbank	Middelburg	Klipspruit
Ph	7.7	7.6	2.6
TDS (mg/ℓ)	3221	2174	3645
Calcium (mg/ℓ)	500	450	400
Sodium (mg/ℓ)	50	4	50
Magnesium (mg/ℓ)	260	88	100
Sulphate (mg/ℓ)	2210	1526	3000
Chloride (mg/ℓ)	32	30	30
Manganese (mg/ℓ)	6.4	1.9	15
Aluminium (mg/ℓ)	3.7	0.7	50
Total alkalinity (mg/ℓ as CaCO <sub>3</sub> )	265	73	-
HCO <sub>3</sub> <sup>-</sup> -acidity (mg/ℓ as CaCO <sub>3</sub> )	-	-	1500

#### 4.2.2 Target treated water quality

Three treated water quality scenarios were evaluated and costed (Table 4.3):

**TABLE 4.3. Target treated water sulphate levels.**

Use of water	Sulphate less than, mg SO <sub>4</sub> /ℓ
Eskom Power Stations, cooling water	30
Potable use	200
Discharge to streams (dilution)	500

Other treatment objectives which applied included:

pH : 7.0  
Temperature : < 25 °C  
Manganese : < 0.1 mg/ℓ

#### 4.3 ASSESSMENT PROCESS

Meetings were arranged with the various technology suppliers where the project was discussed and their response to the questionnaire obtained. The updated questionnaire was sent to the suppliers for final review.

The questionnaire required the following information to be provided (the complete questionnaire is attached as Appendix A):

Section A: Budget Capex (capital expenditure) and Omex (operating and maintenance expenditure) estimates for the three target treated water qualities considered, for treatment of each water type to a sulphate levels of 30, 200 and 500 mg/ℓ.

Section B: Detailed process and cost information was requested for a typical combined water quality. These included a process flow diagram, equipment list, battery limit definition, waste disposal requirements, and information on maintenance, operations, byproducts, process control and safety.

Capital and operating costs, as well as the general characteristics associated with the various technologies were subsequently confirmed from the feedback received from the various technology suppliers.

#### 4.4 ASSUMPTIONS

To ensure that the various processes be assessed on a similar basis, the following assumptions were made and budget costs adapted accordingly:

- a. Waste disposal CAPEX was taken as R30 million per Mℓ/d of waste brine/slurry produced. This assumption was introduced as the cost estimates associated to waste disposal given by various technology suppliers differed significantly. The value of R30 million per Mℓ/d is based on the following brine disposal cost values obtained from the sources as indicated (Table 4.4):

**TABLE 4.4 Capital cost of waste disposal operation.**

Disposal Type	Capital cost and amount of waste disposed	Source of information	Capital cost <sup>1</sup> Rmillion/(Mℓ/d)
Evaporator	~R200 million for 5 Mℓ/d brine	SASOL, Secunda, 1999	40
Evaporation pond (unlined)	~R5.5 million per Mℓ brine evaporated	CSIR, Grootvlei investigation, 1996	5.5
Evaporation pond (lined)	~R192 million for 9 Mℓ/d brine	CSIR, Grootvlei investigation, 1996	21.4
Evaporation pond	~R50 million for 0.7 Mℓ/d concentrated brine	SASOL, Secunda, 1999	70

Notes:

- 1) The capital cost values given by the various sources have been normalized to a 1 Mℓ/d basis, by dividing the given capital cost by the waste flow rate to be treated.

- b. For technologies that required lime softening or neutralization pre-treatment, the capital cost for a 15 Mℓ/d liming plant was estimated at R8 million. For the barium and biological process technologies, R1.0 million was added to this amount to allow for the inclusion of a gypsum crystallization zone in the lime neutralization reactor.

#### 4.5 PRE-TREATMENT

All the sulphate removal technologies evaluated subsequently required or incorporated neutralization as pre-treatment. Assessment of various neutralization configurations reveals that the following approach would significantly reduce neutralization cost and the subsequent sulphate removal cost (Design and costing detail is included in Appendix B.0):

- **Limestone neutralization** of strong / free acid. By replacing the main part of the alkali used for neutralization with limestone, a running cost reduction of R0.34/m<sup>3</sup> can be obtained for an acidic water (Table 4.5):

**TABLE 4.5. CAPEX and OPEX for a neutralization plant including limestone neutralization and gypsum crystallization, compared to a conventional lime softening plant, based on Klipspruit-type water.**

CAPEX	R million	R million per Ml/d
Limestone neutralisation & lime softening & crystallization	13.2	0.88
Conventional liming plant (lime softening)	8.0	0.53
OMEX	R/month	R/m <sup>3</sup>
Limestone neutralisation & lime softening & crystallization	456,761	1.02
Conventional liming plant (lime softening)	613,237	1.36

- **High-lime treatment** could be applied for metal and associated sulphate removal by **gypsum crystallization**. The over-saturated portion of the sulphate that is thus removed by precipitation (at low cost) reduces the sulphate load and therefore cost of downstream sulphate removal processes significantly. The cost of sulphate removal by gypsum crystallization, of R0.08/kg SO<sub>4</sub>, compares favourably with the cost of the various advanced process technologies (Table 4.6).

**TABLE 4.6. Sulphate removal cost of gypsum crystallization and advanced sulphate removal processes (based on Witbank-type water, containing magnesium, and excluding byproduct revenue).**

Process technology	Amount	OMEX	OMEX
	kg SO <sub>4</sub> /h	R/(kg SO <sub>4</sub> )	R/month
A) Limestone neutralization, lime softening & crystallisation	537		276,395
B) Conventional liming plant (lime softening)	284		261,471
Difference (A minus B, equals the impact of a gypsum crystalliser)	253	0.08	14,924
<b>SPECIALISED SULPHATE REMOVAL TECHNOLOGIES (removal to 200 mg/l SO<sub>4</sub>)</b>			
Aqua-K	1,256	1.54	1,390,000
Barium process	1,256	0.49	443,000
Biological	1,256	0.85	768,000

Electrodialysis Reversal	1,256	0.68	613,000
Gypcix	1,256	0.87	784,000
Spiral Reverse Osmosis	1,256	0.94	849,000
Savmin	1,256	1.00	906,000

#### 4.6 TREATMENT TECHNOLOGIES

The main characteristics of the various treatment processes and the CAPEX and OMEX cost estimates for a 15 M $\ell$ /d plant are presented in this part of the report. Cost estimates were prepared with the byproducts income taken in account, as well as with byproducts income excluded.

The CAPEX and OMEX estimates for treatment of mine water in the different CTU regions to a target sulphate level of 200 mg/ $\ell$  are presented in Tables 4.7 to 4.9 and Figures 4.1 and 4.2 (Detailed information on costing and process design are given in Appendix B).

**TABLE 4.7. CAPEX and OMEX estimates for a sulphate removal plant for mine water from the Witbank Dam CTU region (July 1999 figures)**

Treatment technology	CAPEX (R million for 15 Ml/d plant)				CAPEX (R million per Ml/d)			Appendix B reference Table
	Pretreatment <sup>1</sup>	SO <sub>4</sub> -removal	Waste disposal <sup>2</sup>	TOTAL	Treatment	Waste disposal	TOTAL	
Aqua-K		44.9	24.9	69.9	3.0	1.7	4.7	Table B1.3
Barium	9.0	38.8	9.5	57.3	3.2	0.6	3.8	Table B2.3
Biological	9.0	33.8	11.1	53.9	2.9	0.7	3.6	Table B3.3
EDR	8.0	47.8	89.0	144.8	3.7	5.9	9.7	Table B4.1
Electrolytic								
Gypcix	8.0	42.3	33.7	84.0	3.4	2.2	5.6	Table B6.3
SRO	8.0	27.8	69.4	105.2	2.4	4.6	7.0	Table B7.1
Savmin		43.0	18.6	61.6	2.9	1.2	4.1	Table B8.3

**TABLE 4.7 (continue).**

Treatment technology	OMEX (R/month)				Byproduct revenue	OMEX with Byproduct revenue	OMEX	Appendix B reference Table
	Pretreatment <sup>1</sup>	SO <sub>4</sub> -removal	Waste	TOTAL	R/month	R/m <sup>3</sup>	R/m <sup>3</sup>	
Aqua-K		1,517,000	168,000	1,685,000	1,098,000	1.30	3.74	Table B1.4
Barium	268,000	443,000	700	712,000	69,000	1.43	1.58	Table B2.4
Biological	268,000	768,000	1,000	1,037,000	69,000	2.15	2.30	Table B3.4
EDR	207,000	613,000	269,000	1,089,000		2.42	2.42	Table B4.2
Electrolytic							3.58	Appendix B5
Gypcix	232,000	963,000		1,195,000	189,000	2.24	2.66	Table B6.4
SRO	194,000	849,000	215,000	1,258,000		2.80	2.80	Table B7.2
Savmin		896,000	50,000	946,000	108,000	1.86	2.10	Table B8.4

**TABLE 4.8. CAPEX and OMEX estimates for a sulphate removal plant for mine water from the Middelburg Dam CTU region (July 1999 figures)**

Treatment technology	CAPEX (R million for 15 MI/d plant)				CAPEX (R million per MI/d)			Appendix B reference Table
	Pretreatment <sup>1</sup>	SO <sub>4</sub> -removal	Waste disposal <sup>2</sup>	TOTAL	Treatment	Waste disposal	TOTAL	
Aqua-K		38.4	16.6	55.0	2.6	1.1	3.7	Table B1.3
Barium	9.0	36.7	5.7	51.4	3.0	0.4	3.4	Table B2.3
Biological	9.0	33.2	7.1	49.3	2.8	0.5	3.3	Table B3.3
EDR	8.0	48.1	82.6	138.7	3.7	5.5	9.2	Table B4.1
Electrolytic								
Gypcix		42.3	33.8	76.1	2.8	2.3	5.1	Table B6.3
SRO	8.0	28.0	63.5	99.5	2.4	4.2	6.6	Table B7.1
Savmin		43.0	10.6	53.6	2.9	0.7	3.6	Table B8.3

Treatment technology	OMEX (R/month)				Byproduct revenue	OMEX with Byproduct revenue	OMEX	Appendix B reference Table
	Pretreatment <sup>1</sup>	SO <sub>4</sub> -removal	Waste	TOTAL	R/month	R/m <sup>3</sup>	R/m <sup>3</sup>	
Aqua-K		1,144,000	120,000	1,264,000	950,000	0.70	2.81	Table B1.4
Barium	155,000	412,000	628	568,000	61,000	1.13	1.26	Table B2.4
Biological	155,000	705,000	900	861,000	61,000	1.78	1.91	Table B3.4
EDR	80,000	619,000	272,000	971,000		2.16	2.16	Table B4.2
Electrolytic							2.57	Appendix B5
Gypcix		958,000		958,000	194,000	1.70	2.13	Table B6.4
SRO	66,000	856,000	217,000	1,139,000		2.53	2.53	Table B7.2
Savmin		819,000	50,000	869,000	76,000	1.76	1.93	Table B8.4

**TABLE 4.9. CAPEX and OMEX estimates for a sulphate removal plant for mine water from the Klipspruit CTU region (July 1999 figures)**

Treatment technology	CAPEX (R million for 15 MI/d plant)				CAPEX (R million per MI/d)			Appendix B reference Table
	Pretreatment <sup>1</sup>	SO <sub>4</sub> -removal	Waste disposal <sup>2</sup>	TOTAL	Treatment	Waste disposal	TOTAL	
Aqua-K		52.4	30.2	82.6	3.5	2.0	5.5	Table B1.3
Barium	9.0	41.4	14.9	65.3	3.4	1.0	4.4	Table B2.3
Biological	9.0	34.7	16.7	60.4	2.9	1.1	4.0	Table B3.3
EDR	8.0	47.4	93.5	148.9	3.7	6.2	9.9	Table B4.1
Electrolytic								
Gypcix	8.0	42.0	37.9	87.9	3.3	2.5	5.9	Table B6.3
SRO	8.0	27.4	78.6	114.0	2.4	5.2	7.6	Table B7.1
Savmin		43.0	32.4	75.4	2.9	2.2	5.0	Table B8.3

Treatment technology	OMEX (R/month)				Byproduct revenue	OMEX with Byproduct revenue	OMEX	Appendix B reference Table
	Pretreatment <sup>1</sup>	SO <sub>4</sub> -removal	Waste	TOTAL	R/month	R/m <sup>3</sup>	R/m <sup>3</sup>	
Aqua-K		1,780,000	108,000	1,888,000	1,255,000	1.41	4.20	Table B1.4
Barium	619,000	479,000	800	1,099,000	78,000	2.27	2.44	Table B2.4
Biological	619,000	842,000	1,100	1,462,000	78,000	3.08	3.25	Table B3.4
EDR	484,000	606,000	266,000	1,356,000		3.01	3.01	Table B4.2
Electrolytic							4.73	Appendix B5
Gypcix	700,000	461,000		1,161,000	164,000	2.22	2.58	Table B6.4
SRO	481,000	828,000	211,000	1,520,000		3.38	3.38	Table B7.2
Savmin		846,000	50,000	896,000	95,000	1.78	1.99	Table B8.4

Notes:

1. Pretreatment: For Aqua-K the pretreatment costs are included in the sulphate removal treatment cost. For Savmin, no pretreatment cost was assumed as the process incorporate a liming plant. For the other processes the pretreatment cost was taken as the cost of a lime neutralization/softening plant. The cost of further pretreatment steps for the membrane processes is included in the sulphate removal treatment cost.
2. Waste disposal capital cost was taken as R30 million per Mℓ/d for all processes. The volume of waste sludge/brine was estimated from a mass balance on the amount of waste solids produced. The assumption is made that no byproducts are recovered and the "byproduct"-solids was also added in the waste calculation.
3. The capital and running expenditures are based on the assumption that no byproducts are recovered. This assumption would penalize the Aqua-K technology as equipment cost and operating costs for byproduct purification are also included (As byproduct recovery forms a integral part of the Aqua-K technology, differentiation of costs could not be made).

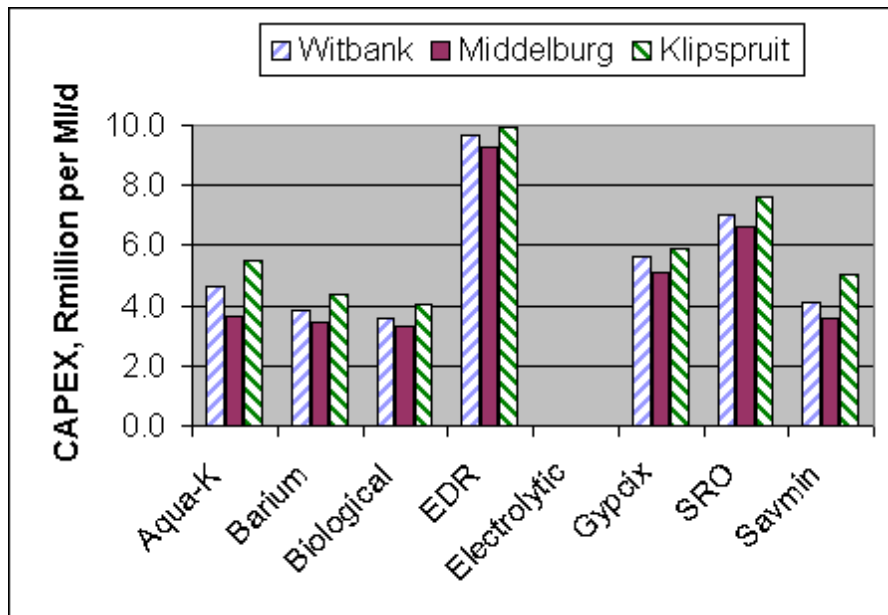


Figure 4.1. CAPEX for various sulphate removal technologies for mine water (July 1999 figures)

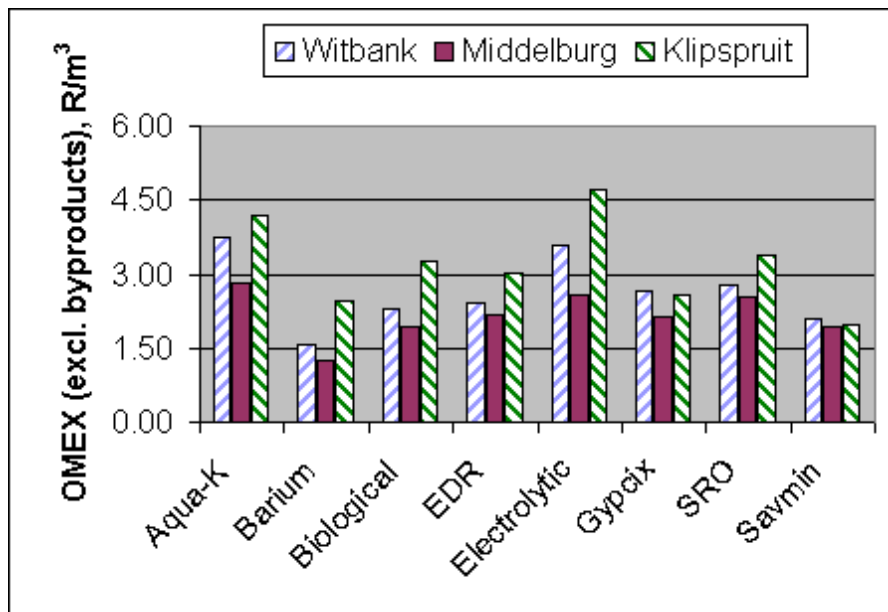


Figure 4.2. OMEX for various sulphate removal technologies for mine water (July 1999 figures)

#### **4.6.1 Aqua-K**

The treatment process is membrane based, and converts most of the impurities in the water to useful byproducts, including glauber salt, iron-oxide, magnesium hydroxide and calcium carbonate. The attractiveness of the process economics is dependent on the saleability of these byproducts. A small stream of waste brine is produced.

Lime neutralization is used as pre-treatment or in the initial stages.

The process is in the final development stage. The license for the process technology to Aqua Technologies has unfortunately been terminated, and they have withdrawn the process and requested that process documentation be returned.

The cost estimates as submitted by Aqua Technologies are given in Appendix B1, Tables B1.1 to B1.4.

#### **4.6.2 Barium**

The treatment process utilizes the insolubility of barium sulphate to achieve sulphate removal. The sulphate removal stage is relatively simple and reliable, comprising a completely mixed reactor followed by a settler for separation of the precipitate. However, the recovery of the soluble barium reactant (e.g. barium sulphide) requires thermal reduction, while the removal/conversion of hydrogen sulphide to sulphur further comprises relatively complex technology.

The toxicity of dissolved barium would require a safety mechanism to prevent overdosage. This also impacts negatively on the social acceptability of the process to produce potable water, and the environmental acceptability to discharge treated mine water.

Barytes (barium sulphate) is used as raw material for barium make-up. The process wastes may include ash from the reduction furnace as well as metal sulphide sludge. By-products include sulphur and calcium carbonate.

The process development is still at laboratory scale and no demonstration plants have been constructed.

The budget costs and preliminary process design (PFD, equipment sizing and costing) is given in Appendix B2.

#### **4.6.3 Biological**

Sulphate reducing bacteria is utilized to convert sulphate to sulphide. Sulphide is stripped as hydrogen sulphide or further biologically or chemically oxidized to sulphur. The process has a number of variations, presented by the different technology suppliers.

For highly acidic wastes or high sulphate containing waters, it is advisable and economically attractive to use a limestone/lime neutralization pre-treatment stage to

allow crystallization and removal of the over-saturated sulphate fraction, and provide pH protection for the downstream biological stage.

Process stability and a lack of performance consistency may result if the process is not properly operated and controlled. Slow process recovery prevails as biomass development and build-up takes about a month, in case of loss or destruction of the biomass.

A suitable carbon-and-energy source is required as raw feed (e.g. ethanol, hydrogen gas, sewage, or sugar). By-products could include sulphur and calcium carbonate. A final aerobic polishing stage may be needed to remove unutilized carbon source from the treated water. A small bio-sludge waste stream is produced.

Variations of the process have been extensively tested on pilot scale, and full-scale application is in progress.

The budget costs and preliminary process design (process flow diagram, equipment sizing and costing) is given in Appendix B3.

#### **4.6.4 Electrodialysis Reversal**

An electrical field is used to drive the migration of ions through ion-selective membranes. By using an appropriate arrangement of membranes, desalination is obtained as water moves through the membrane stack.

Pretreatment requirements mainly include lime neutralization for metal removal, as well as filtration to remove organics and suspended solids.

Pre-treatment sludge(s) as well as brine waste-streams are produced.

Many full-scale plants are in operation, but a limited number operate on mine water.

The budget costs and preliminary process design (PFD, equipment sizing and costing) is given in Appendix B4. These costs are based on EDR cost data from Eskom (Dirk Hanekom), Sasol Secunda (Peter Gordon), as well as the CSIR's Grootvlei study (Japie Schoeman, 1996, No. ENV/P/C 96061).

#### **4.6.5 Electrolytic Process**

The process is based on the insolubility of a zinc-hydroxide-sulphate complex, which precipitates to reduce sulphate to low levels. Process details and costs still have to be provided by supplier. Preliminary information is included in Appendix B5.

#### **4.6.6 Gypcix**

A system of cascading reactors containing ion-exchange resin is used to firstly exchange the calcium in water with hydrogen ions and thereafter sulphate with hydroxide ions. The

regeneration of the resin is done batch-wise and entails a relatively complex number of steps. Lime and sulphuric acid is used for regeneration.

Lime neutralization as pretreatment is necessary.

Gypsum is produced as byproduct, while a gypsum brine is also discharged.

The process has been extensively tested on demonstration plant scale.

The budget costs and process details as obtained from Chemeffco are given in Appendix B6.

#### **4.6.7 Spiral Reverse Osmosis**

The process uses high pressure to drive the movement of water through a spirally-arranged membrane. Salt removal to low levels can be attained.

Pretreatment consist of lime and soda-ash softening and filtration followed by sulphuric acid addition for pH-adjustment.

A brine waste-stream is produced.

Many full-scale plants are in operation, but none of these operate on mine water.

The budget costs and preliminary process design (PFD, equipment sizing and costing) is given in Appendix B7. These costs are based on SRO cost data from Eskom (Dirk Hanekom), Sasol (Peter Gordon), as well as the CSIR's Grootvlei study (Japie Schoeman, 1996, No. ENV/P/C 96061).

#### **4.6.8 Savmin**

The Savmin or Ettringite process utilizes the insolubility of a aluminium-hydroxide-sulphate complex, called ettringite, for the precipitation and removal of sulphate. The process comprises a number of lime-saturaters, completely mixed tanks and settlers.

Gypsum is produced as byproduct.

The process is being evaluated on demonstration plant scale.

The budget costs and process details as obtained from Mintek are given in Appendix B8.

The general characteristics of the various processes are summarized in Table 4.10 below, while a comparative assessment of the processes on various soft issues is given in Table 4.11.

**TABLE 4.10. CHARACTERISTICS OF VARIOUS SULPHATE REMOVAL TECHNOLOGIES**

Technology	Principle	Pre-treatment	Process Chemicals	Waste production
Aqua-K	Membrane based separation	Lime neutralization, filtration, pH correction		Lime sludge, brine
Barium	Insolubility of BaSO <sub>4</sub> salt	Lime neutralisation	Barytes	Lime sludge, furnace ash, metal sulphides
Biological	Biological sulphate reduction using external carbon source	Limestone / lime neutralisation	Carbon source, nutrients	Lime sludge, biological sludge
EDR	Ion-selective membrane separation	Lime neutralization, filtration, pH correction		Lime sludge, brine
Electrolytic	Insolubility of Zn-OH-SO <sub>4</sub> complex		Zinc	Gypsum brine
Gypcix	Ion exchange separation	Lime neutralization	Lime, sulphuric acid	Lime sludge, gypsum brine
SRO	Membrane based separation (mechanical pressure)	Lime-soda softening, filtration, pH correction	Various chemicals	Lime sludge, brine
Savmin	Insolubility of Al-OH-SO <sub>4</sub> complex (ettringite)	None (lime neutralization based process)	Lime, alum	Gypsum brine

**TABLE 4.11. ASSESSMENT OF VARIOUS TREATMENT TECHNOLOGIES W.R.T. EXPECTED CONFIGURATION AND PERFORMANCE CHARACTERISTICS**

Technology	Mechanical complexity / specialized	Number of stages / units	Expected availability	Complexity of process control	Required operator skill level	Safety / Health Risk	Development confidence	Expected treatment consistency	Water recovery	Overall confidence in process
Aqua-K	High	High	High	High	High	Medium	High	High	Medium	Medium
Barium	High	High	Medium	Medium	High	High	Low	High	High	Medium
Biological	Low	Medium	High	Low	Medium	Low	Medium	Low	High	Medium
EDR	High	High	High	High	High	High	High	High	High	High
Electrolytic	Medium	Medium	Medium	Medium	Medium	Medium	Low	Low	Medium	Low
Gypcix	High	High	Medium	Medium	High	Medium	Medium	Low	Medium	Low
SRO	High	High	High	High	High	Medium	High	High	High	High
Savmin	Medium	High	High	Medium	Medium	Low	Medium	Low	Medium	Low

Note:

Refer to Appendix C for the details of this assessment.

#### 4.7 CONCLUSIONS

The present volume of excess mine water in the Upper Olifants River Catchment is estimated at about 45 Mℓ/d, which can be divided into three according to region and quality, namely Witbank Dam area, Middelburg Dam area, and the Klipspruit area. Alternative treatment options and process technologies were investigated for 15 Mℓ/d of each type of water, and the following findings made:

##### **Pretreatment**

For magnesium-rich mine water, the inclusion of a gypsum crystallization stage (subsequent to high lime softening) is advisable. The cost of sulphate removed in this manner is R0.08/kg SO<sub>4</sub>, compared to advanced sulphate removal process technologies with costs ranging between R0.49 to R1.54/kg SO<sub>4</sub> removed.

For acidic mine waters (e.g. Klipspruit), limestone neutralization could be applied to reduce alkali cost. A reduction in running cost of R0.34/m<sup>3</sup> water neutralized is estimated for a Klipspruit-type of acidic water. The benefit increases as the acid content of the mine water increase.

## Sulphate removal

Treatment to target sulphate levels of 30, 200, and 500 mg/ℓ were evaluated. Only the membrane based technologies (Aqua-K and SRO) would be able to attain the low 30 mg/ℓ sulphate level. The CAPEX and OMEX estimates for treatment of mine water in the different regions to a target sulphate level of 200 mg/ℓ were as follow (July 1999 figures):

### Witbank Dam CTU Region

Treatment technology	CAPEX (R million for 15 MI/d plant)				CAPEX (R million per MI/d)		
	Pretreatment	SO <sub>4</sub> -removal	Waste disposal	TOTAL	Treatment	Waste disposal	TOTAL
Aqua-K		44.9	22.5	67.4	3.0	1.5	4.5
Barium	9.0	38.8	5.2	53.1	3.2	0.3	3.5
Biological	9.0	33.8	6.6	49.4	2.9	0.4	3.3
EDR	8.0	47.8	89.0	144.8	3.7	5.9	9.7
Electrolytic							
Gypcix	8.0	42.3	31.5	81.8	3.4	2.1	5.5
SRO	8.0	27.8	69.4	105.2	2.4	4.6	7.0
Savmin		43.0	44.0	87.0	2.9	2.9	5.8

### Witbank Dam CTU Region

Treatment technology	OMEX (R/month)				Byproduct revenue	OMEX minus Byproduct revenue	OMEX
	Pretreatment	SO <sub>4</sub> -removal	Waste	TOTAL	R/month	R/m <sup>3</sup>	R/m <sup>3</sup>
Aqua-K		1,390,000	168,000	1,558,000	1,098,000	1.02	3.46
Barium	268,000	443,000	0	711,000	69,000	1.43	1.58
Biological	268,000	768,000	200	1,036,000	69,000	2.15	2.30
EDR	207,000	613,000	269,000	1,089,000		2.42	2.42
Electrolytic							
Gypcix	232,000	784,000		1,016,000	189,000	1.84	2.26
SRO	194,000	849,000	215,000	1,258,000		2.80	2.80
Savmin		906,000	50,000	956,000	108,000	1.88	2.12

**Middelburg Dam CTU Region**

Treatment technology	CAPEX (R million for 15 MI/d plant)				CAPEX (R million per MI/d)		
	Pretreatment	SO <sub>4</sub> -removal	Waste disposal	TOTAL	Treatment	Waste disposal	TOTAL
Aqua-K		38.4	15.0	53.4	2.6	1.0	3.6
Barium	9.0	36.7	1.9	47.6	3.0	0.1	3.2
Biological	9.0	33.2	3.1	45.3	2.8	0.2	3.0
EDR	8.0	48.1	82.6	138.7	3.7	5.5	9.2
Electrolytic							
Gypcix		42.3	31.5	73.8	2.8	2.1	4.9
SRO	8.0	28.0	63.5	99.5	2.4	4.2	6.6
Savmin		43.0	44.0	87.0	2.9	2.9	5.8

Treatment technology	OMEX (R/month)				Byproduct revenue	OMEX minus Byproduct revenue	OMEX
	Pretreatment	SO <sub>4</sub> -removal	Waste	TOTAL	R/month	R/m <sup>3</sup>	R/m <sup>3</sup>
Aqua-K		1,016,000	120,000	1,136,000	950,000	0.41	2.52
Barium	155,000	412,000	0	567,000	61,000	1.12	1.26
Biological	155,000	705,000	200	860,000	61,000	1.78	1.91
EDR	80,000	619,000	272,000	971,000		2.16	2.16
Electrolytic							
Gypcix		779,000		779,000	194,000	1.30	1.73
SRO	66,000	856,000	217,000	1,139,000		2.53	2.53
Savmin		830,000	50,000	880,000	76,000	1.79	1.96

**Klipspruit CTU Region**

Treatment technology	CAPEX (R million for 15 MI/d plant)				CAPEX (R million per MI/d)		
	Pretreatment	SO <sub>4</sub> -removal	Waste disposal	TOTAL	Treatment	Waste disposal	TOTAL
Aqua-K		52.4	27.6	80.0	3.5	1.8	5.3
Barium	9.0	41.4	10.1	60.5	3.4	0.7	4.0
Biological	9.0	34.7	11.6	55.3	2.9	0.8	3.7
EDR	8.0	47.4	93.5	148.9	3.7	6.2	9.9
Electrolytic							
Gypcix	8.0	42.0	36.0	86.0	3.3	2.4	5.7
SRO	8.0	27.4	78.6	114.0	2.4	5.2	7.6
Savmin		43.0	44.0	87.0	2.9	2.9	5.8

Treatment technology	OMEX (R/month)				Byproduct revenue	OMEX minus Byproduct revenue	OMEX
	Pretreatment	SO <sub>4</sub> -removal	Waste	TOTAL	R/month	R/m <sup>3</sup>	R/m <sup>3</sup>
Aqua-K		1,652,000	108,000	1,760,000	1,255,000	1.12	3.91
Barium	619,000	479,000	0	1,098,000	78,000	2.27	2.44
Biological	619,000	842,000	300	1,461,000	78,000	3.07	3.25
EDR	484,000	606,000	266,000	1,356,000		3.01	3.01
Electrolytic							
Gypcix	700,000	705,000		1,405,000	164,000	2.76	3.12
SRO	481,000	828,000	211,000	1,520,000		3.38	3.38
Savmin		857,000	50,000	907,000	95,000	1.80	2.02

## CHAPTER 5

### RECLAMATION AND RE-USE OF TREATED MINE WATER

#### 5.1 INTRODUCTION

Extensive coal mining, power generation and industrial operations has resulted in a deteriorating water quality in the Upper Olifants River. This has led to some users having to import higher quality water from alternative sources outside the catchment. During 1995, 12 Mℓ/day (7 %) of the urban water consumption was imported from outside the catchment (mainly transfers from Trichardtsfontein Dam). This imported water is expected to grow to 15.9 Mℓ/day by the year 2020. The entire cooling water intake to all the coal-fired power stations located in the Upper Olifants River Catchment is imported from neighbouring catchments.

The local rivers and streams have been extensively impounded with the result that the streamflow is now highly regulated. The two major impoundments in the study catchment are the Witbank and Middelburg Dams. Industrial, mining and urban growth are putting these water sources under strain. According to information from the Vaal Augmentation Planning Study, augmentation of the local water sources in the catchment to meet the increasing urban and industrial requirements will continue to grow. The two major metropolitan centres in the study catchment are Witbank and Middelburg. These urban centres form the major concentrations of urban/commercial development in the catchment.

The Upper Olifants River water resources are under constant pressure from both a supply/demand perspective as well as from a water quality perspective. This project investigates the feasibility of regional mine water collection and treatment to improve the water quality status. The general approach incorporated :

- the collection of excess mine water and
- treatment of regional facilities
- re-use of treated mine water.

For this approach to be feasible, there needs to be a demand for the treated mine water. This report aims to identify possible users of the treated mine water and to quantify potential demands.

The following possible users of excess mine water were identified and investigated :

- irrigation
- stock watering
- urban and industrial
- mining
- power generation

These potential users of the treated mine water are briefly evaluated in terms of their water quantity and quality requirements.

## 5.2 IRRIGATION

The Water Research Commission and Anglo Coal are currently executing a full-scale project to demonstrate the irrigation of gypsiferous mine water to agricultural land. The demonstration project is located at Kleinkopje Colliery, Mphumalanga Province. The project involves three centre pivots operated under different operational and field conditions:

- soil/growth media types include an undisturbed natural Clovelly soil and rehabilitated mine spoils ( ± 900mm soil cover)
- crops included sugar beans, maize, babala and wheat
- water application ranging from leaching regime, field capacity regime and moisture deficient regime.

The demonstration sites are intensively monitored to collect information on a variety of crop, soil, weather, water and other aspects :

- weather data collection includes temperature, relative humidity, solar radiation, wind speed and rainfall
- soil data collection includes soil profiling, soil matrix potential, soil moisture content and soil water quality
- crop data collection included root depth, leaf area and production
- irrigation water data collection included application rates and water quality.

A Soil Water Balance (SWB) model is also being developed to simulate the migration of water and associated salts through the soil profile under different operating and cropping conditions.

The interim results of the first year of the project indicated that :

- satisfactory sugar beans yields were obtained, with virgin land performing better than the rehabilitated land. The poor yield on the rehabilitated land was ascribed to soil compaction and nutritional deficiency
- a plinthic layer in the virgin Clovelly soil resulted in poor drainage and effectively prevented leaching of salts
- the soil salinity increased, especially during the growing season, small amounts of gypsum precipitated in the soil, but negligible salt leaching took place. Soil water quality profiles indicated that, only sodium, chloride and nitrate salts would be readily mobilised.

The demonstration project indicated that a wide variety of crops could potentially be cultivated ranging from beans, sorghum, maize, peas and a variety of fodder crops. The average annual irrigation water consumption is 720 – 1000 mm/year (assuming a two crop rotation approach).

The capital cost of developing the infrastructure for mine water irrigation schemes was estimated to be R 29,100/ha for a small-scale operation and R 12,000/ha for large-scale operations (1998 price levels).

The economic viability of the irrigation project was also investigated. The results indicated that from an irrigation/farming perspective, it could be a profitable venture. The cost of mine water pre-treatment (if mine water is acidic) and distribution will be site specific and will have to be considered in the detailed feasibility of such a project.

Using an average irrigation water application of 850mm/year, the area of land that can be watered with the current and future predicted volumes of excess mine water is reflected in **Tables 5.2.1** and **5.2.2**.

**Table 5.2.1 : Area of land that can be irrigated with current volumes of excess mine water**

Catchment	Annual Water Application (mm/year)	No. of crop Rotations per year	Available Excess Mine Water (Mℓ/d)	Area of Irrigated Land (ha)
Middelburg	850	2	14,55	625
Witbank	850	2	19,20	825
Klipspruit	850	2	9,62	410
<b>Total</b>			<b>43,37</b>	<b>1,860</b>

**Table 5.2.2 : Area of land that can be irrigated with future predicted volumes of excess mine water**

Catchment	Annual Water Application (mm/year)	No. of crop Rotations per year	Available Excess Mine Water (Mℓ/d)	Area of Irrigated Land (ha)
Middelburg	850	2	44	1,875
Witbank	850	2	58	2,475
Klipspruit	850	2	29	1,230
<b>Total</b>			<b>131</b>	<b>5,580</b>

**Table 5.2.3** indicates the historical, current and expected future irrigated areas in the Upper Olifants River Catchment (excluding Loskop Dam Irrigation Scheme). The future projections were done using growth rates suggested by the Extension Officers from the Department of Agriculture.

**Table 5.2.3 : Estimated Historical, Current and Future Irrigated Areas**

Catchment	Planning Year				
	1970	1995	2000	2010	2020
Middelburg	891	2,029	2,029	2,029	2,029
Witbank	975	2,438	2,438	2,438	2,438
Klipspruit	1,967	4,542	4,630	4,630	4,630
<b>Total Irrigated Areas (ha)</b>	<b>3,833</b>	<b>9,009</b>	<b>9,097</b>	<b>9,097</b>	<b>9,097</b>

Irrigation application of the excess mine water generated in the catchment will require a substantial increase in the land to be developed for such projects. Such a substantial increase in the irrigation allocation of water is not currently reflected in the Department of Water Affairs and Forestry water demand projections for the catchment.

### 5.3 STOCK WATERING

The main source of information concerning livestock watering was the Olifants River Basin Study Report and Census of Agriculture 1988 Report. Livestock numbers were quantified in terms of “large stock units” (LSU).

In the Olifants River Basin Study Report, the average water requirement per LSU per day is estimated to be 50 litres. This figure has been confirmed by the Department of Agriculture. The total impact of stock watering on the Catchment water demand will be relatively small in comparison with other water users. It is estimated that approximately 70% of the water supply for stock watering comes from boreholes and approximately 30% from surface water resources.

**Table 5.3.1** reflects the historical and expected future water consumption for stock watering, based on an average consumption of 50 litres/LSU/day.

**Table 5.3.1: Projected Livestock Numbers and Water Requirements**

Catchment	Year	LSU (#)	Water Requirements (Mℓ/day)	
			Boreholes	Surface Waters
Witbank	1990	174,176	6.00	2.60
	1995	192,290	6.74	2.87
	2000	212,321	7.42	3.17
	2010	234,441	8.21	3.50
	2020	234,441	8.21	3.50
Middelburg	1990	93,284	3.30	1.39
	1995	102,986	3.60	1.50
	2000	113,713	4.00	1.69
	2010	125,560	4.40	1.89
	2020	125,560	4.40	1.89
Klipspruit	1990	19,153	0.66	0.27
	1995	21,145	0.74	0.33
	2000	23,348	0.82	0.36
	2010	25,780	0.90	0.38
	2020	25,780	0.90	0.38

There are five major feedlots in the catchment, including :

- Kanhym Estates,
- Beefcor Bayview Feedlot,
- O.T.K Bedfry Maatskappy,
- Ranch Estates Feedlots and
- SIS Farming

It is not confirmed whether the stock numbers kept in feedlots are included in the livestock numbers given in Table 3.1. The current water demand of the feedlots is estimated to be 5.5 Mℓ/day. This water demand is expected to rise to 5.8 Mℓ/day by the year 2020.

## 5.4 URBAN AND INDUSTRIAL

The total annual urban water demand for the Upper Olifants River Catchment at 1995 development was 173 Mℓ/day. This includes industries supplied through local authorities, but excludes mines, power stations and most feedlots. The annual requirement is expected to rise to 504 Mℓ/day by the year 2020.

The two main industrial centres are Witbank and Middelburg Towns. The Witbank and Middelburg Dams are currently meeting the water requirements of these towns. The Mphumalanga Highveld Region is fast emerging as a growing industrial area. The combined urban requirement of Witbank, Middelburg and the Mphumalanga Highveld comprises nearly 71.5 % of the total water demand of the Upper Olifants River Catchment, excluding power generation. Six major industrial facilities are present in the catchment. Most of the industries are associated with steel, iron, and vanadium production. **Figure 5.4.1** indicates the locations of these facilities.

### 5.4.1 Witbank

The Transitional Local Council (TLC) of Witbank is the largest domestic and industrial complex in the region. The primary source of water is the Witbank Dam. The local water supply is augmented from the Grootdraai Dam in the Vaal River Catchment.

The water requirements of the Witbank TLC include the following communities and industries :

- Witbank Proper and Kwa-Guqa Towns
- Ogies and Phola
- Polifin, Samancor Ferrometals, Landau, TransAlloys, Vantra, Highveld Steel and Vanadium
- Witbank Collieries
- Witbank abattoir.

The historical, current and future water demands for the Witbank TLC are present in **Tables 5.4.1(a)** and **5.4.1(b)**.

**Table 5.4.1(a) : Historical water demands of the Witbank TLC**

Water Requirement						
Year	1930	1950	1960	1970	1980	1990
Mℓ/year	300	2,000	3,000	11,000	22,000	26,000
Mℓ/day	0.8	6	8	30	60	71

**Table 5.4.1(b) : Current and future water demands of the Witbank TLC**

Water Requirement						
Year	1995	2000	2005	2010	2015	2020
Mℓ/year	28,000	29,000	33,000	37,000	42,000	48,000
Mℓ/day	77	80	90	101	115	132

## 5.4.2 Middelburg

The Middelburg TLC is second largest domestic and industrial complex in the Upper Olifants River Catchment. The town has a current population of approximately 100,000 people and is estimated to increase to 250,000 people by the year 2020.

The primary source of water is the Middelburg Dam. An additional water source will be transfers from the Witbank Dam, which will in turn be supplemented from Grootdraai Dam. The Middelburg TLC has an allocation of 13,300 Mℓ/year (36.4 Mℓ/day) from the Middelburg Dam, which was exceeded by the Town's requirements in 1997. The transfer of supplemental water from Witbank Dam to Middelburg Dam was postponed until the year 2000, by recycling of purified sewage effluent to the industrial sector. The amount of available water from this source is expected to reach 2,440 Mℓ/year (6.7 Mℓ/day).

The water requirements of the Middelburg TLC include the following towns and industries :

- Columbus Stainless Steel
- Middelburg Ferrochrome
- Middelburg Town

The historical, current and future water requirement of the Middelburg TLC is reflected in **Tables 4.2(a)** and **5.4.2(b)**.

**Table 5.4.2(a): Historical water requirement of the Middelburg TLC on the Middelburg Dam**

Water Requirement						
Year	1930	1950	1960	1970	1980	1990
Mℓ/year	50	300	1,000	2,000	5,000	10,000
Mℓ/day	0.1	0.8	3	6	14	27

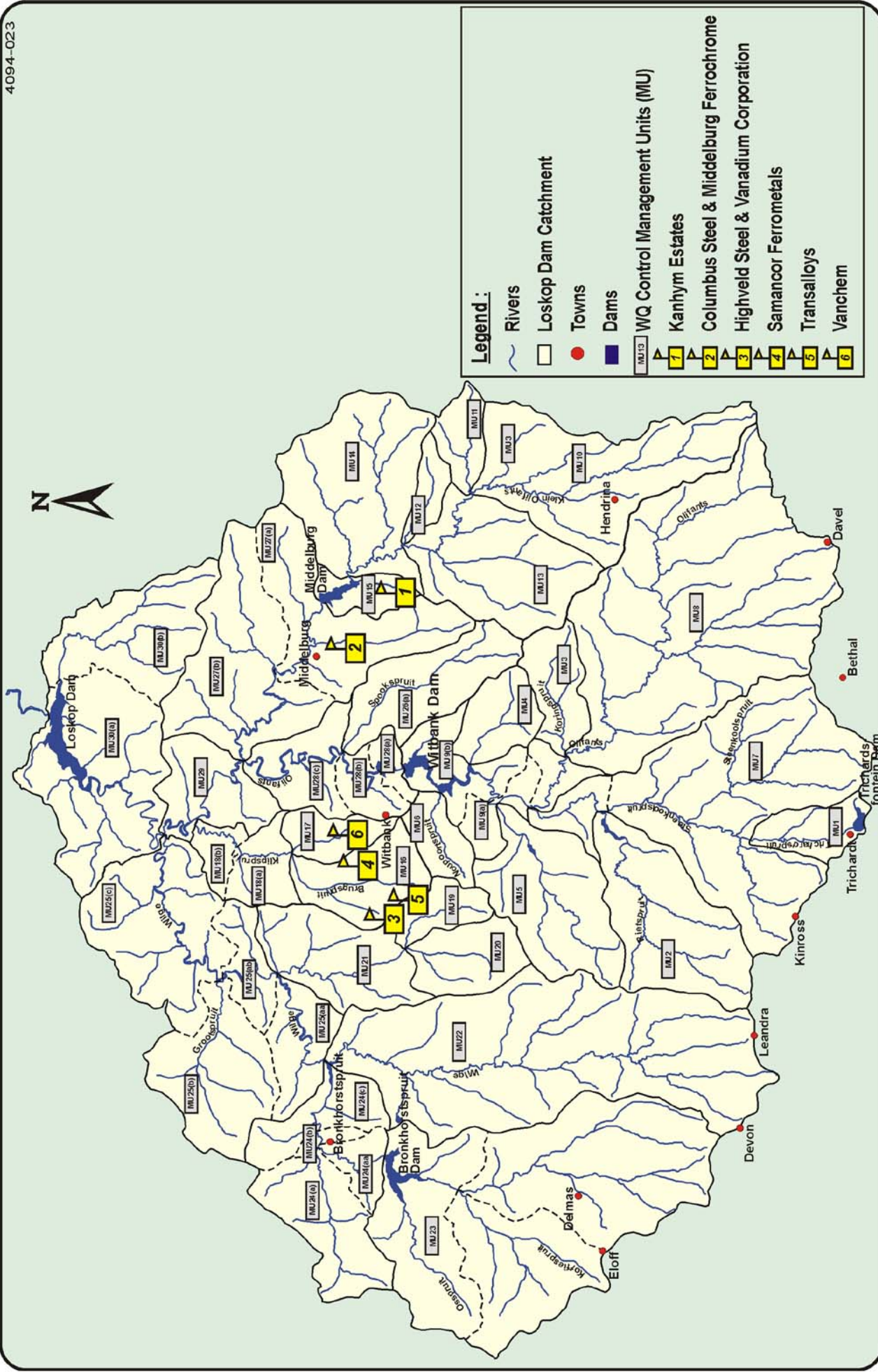


Figure 5.4.1 : Location of Major Industries in the Loskop Dam Catchment



**Table 5.4.2(b): Current and future water requirement of the Middelburg TLC**

Imposed On :	Water Requirement					
	1995	2000	2005	2010	2015	2020
Middelburg Dam	9,000	13,000	13,000	13,000	13,000	13,000
Witbank Dam	0	4,000	8,000	12,000	17,000	22,000
<b>Total (Mℓ/year)</b>	<b>9,000</b>	<b>17,000</b>	<b>21,000</b>	<b>25,000</b>	<b>30,000</b>	<b>35,000</b>
<b>Total (Mℓ/day)</b>	<b>25</b>	<b>47</b>	<b>58</b>	<b>69</b>	<b>82</b>	<b>96</b>

### 5.4.3 Other Urban and Industrial Users

There are a number smaller towns also located in the Upper Olifants River Catchment. These towns include :

- Leandra
- Kriel
- Kinross
- Trichardt
- Bronkhorstspuit
- Sundra
- Hendrina
- Devon
- Davel

Several of these towns are supplied from water sources outside the catchment. The current water demands imposed by these towns are negligible and the future water demands are not expected to rise to any significant level in the catchment perspective.

## 5.5 COAL MINING

Extensive coal mining activities in the Upper Olifants River Catchment have various impacts on the water quality and quantity of the catchment. Water resources exploited by the mines include the following :

- imported water from the Usutu River and Komati River Systems
- Witbank Dam
- Middelburg Dams
- natural rivers/streams of the Upper Olifants River System
- underground water (available due to mining operations).

Some of the mines have an integrated management structure and therefore their water circuits are linked. The historical (1994/95) mine water requirements and water sources exploited are reflected in Table 5.1. The future mine water demand projections are

currently being revised by the DWAF Project investigating the water resources of the Upper Olifants River Catchment. It however expected that the mine water demand will drop to about 10,000 Mℓ/year (27.3 Mℓ/day). This is due to anticipated future mine closures as coal reserves in the catchment are depleted.

**Table 5.5.1 : Mine Water Requirements and Water Resources Exploited**

Colliery	Water Demands		Water Resource Exploited
	(Mℓ/year)	(Mℓ/day)	
Arnot	900	2.5	Arnot Power Station (Komati River)
Bank	1,900	5.2	Komati River Bankfontein Dam
Douglas Including : Albion, Vandyksdrift, Wolverdiend & Wolwekrans	5,400	14.8	Olifants River and Usutu-Vaal River
Eikeboom	10	0.03	Middelburg Dam and boreholes
Elandsfontein	40	0.1	Grootspruit and Clewer Township
Goedehoop, including : Springbok, Hope section, Haasfontein and Vlaklaagte Sections	1,000	2.7	Komati River
Greenside	800	2.2	Witbank Town
Khutala	50	0.1	Kendal Power Station (Usutu River)
Kleinkopje and Landau	1,500	4.1	Olifants River and Witbank Town
Koornfontein	800	2.2	Komati River via Eskom
Kriel	600	1.6	Camden (Usutu River)
Matla	1,500	4.1	Eskom (Usutu & Vaal River)
Middelburg	1,000	2.7	Komati River via Duvha Power Station
New Clydesdale	100	0.3	Olifants River
Optimum	1,110	3.0	Hendrina Power Station (Komati River)
Rietspruit	1,170	3.2	Rietspruit Dam
Syferfontein	262	0.7	Rand Water
Tavistock including: Arthur Taylor, Phoenix, South Witbank and ATCOM	3,685	10.1	Phoenix Dam, Olifants River and underground mine water.
Tweefontein including : Boschmansfontein, Waterpan and Witbank Consolidated.	2,740	7.5	Boschmansfontein underground water, Witbank Consolidated underground water and Saaiwaterspruit.
Woestalleen	580	1.59	Woestalleen Mine Dam
S A Coal Estates	0	0	Witbank Town
<b>Total</b>	<b>25,15</b>	<b>168.9</b>	

## 5.6 POWER GENERATION

Several large coal-fired power stations are located in the study area, which includes Arnot, Hendrina, Komati, Duvha, Matla, Kriel and Kendal power stations (refer to **Figure 5.6**).

Most Coal-fired power stations utilise water for cooling purposes. These power stations require typically between 0.15 and 2 litres of water for a kWhr unit of energy generated. The unit water consumption is reduced to approximately 0.15 ℓ/kWh for air cooled power stations. Cooling water for the power stations in the Upper Olifants River Catchment has to be imported from several catchments, where a high quality water is still available. Water is imported from the Usutu, Komati and Vaal catchments.

Komati, Arnot, Hendrina and Duvha Power Stations are supplied with cooling water from the Komati River system. Duvha Power Station can, however, also be supplied via Witbank Dam from Grootdraai Dam. The current approach is to supply the total Duvha Power Station water requirement from the Komati River System until a shortage occurs. Water can then also be supplied from the Usutu River System to support the Komati River System. Only when both the Komati River and Usutu River systems are stressed, will water be transferred from the Grootdraai Dam.

Kriel, Matla and Kendal Power Stations are supplied mainly from the Usutu River System. Matla Power Station is, however, also supplied from the Vaal River System. Matla Power Station also receives filtered water from the Kriel Power Station.

The historical water requirements for these power stations are listed in **Table 5.6.1** with the current and future water requirements for the power stations given in **Table 5.6.2**.



Figure 6.1 : Positions of Power Stations in the Loskop Dam Catchment



**Table 5.6.1 : Historical water usage at Power Stations (Mℓ/day)**

Power Station	1984	1989	1990	1991	1992	1993	1994
<b>Komati River System</b>							
Komati	49.3	32.9	21.9	8.2	11.0	8.2	8.2
Arnot	82.2	76.7	65.8	63.0	49.3	24.7	24.7
Hendrina	68.5	68.5	79.5	57.5	54.8	57.5	54.8
Duvha	115.1	112.3	117.8	117.8	109.6	90.4	101.4
(supplied from Witbank Dam)	*	(27.4)	(19.2)	(11.0)	(21.9)	(13.7)	(5.5)
<b>Usutu River System</b>							
Kriel	95.9	87.7	84.9	74.0	71.2	82.2	71.2
(supplied from Matla)	*	(19.2)	(16.4)	(22.0)	(11.0)	(19.2)	(5.5)
Matla	115.1	120.6	115.1	120.6	117.8	123.3	109.6
(supplied from Kriel)	*	(5.5)	(2.7)	(5.5)	(5.5)	(5.5)	(13.7)
Kendal	0	5.5	8.2	8.2	8.2	8.2	11.0
Wilge	16.4	11.0	8.2	5.5	5.5	2.7	2.7

Note : \* No data available

**Table 5.6.2 : Current and Future water usage at Power Stations (Mℓ/day)**

Power Station	1997	1998	1999	2000	2005	2010	2015	2020
<b>Komati River System</b>								
Komati	5.5	5.5	5.5	5.5	5.5	8.2	38.4	41.1
Arnot	38.4	41.1	46.6	60.3	82.2	82.2	84.93	87.7
Hendrina	74.0	71.2	76.7	76.7	79.5	82.2	82.2	82.2
Duvha	112.3	112.3	115.1	120.6	123.3	131.5	134.3	134.3
<b>Usutu River System</b>								
Kriel	85.0	87.7	90.4	98.6	109.6	117.8	115.1	117.8
Matla	126.0	134.3	134.3	134.5	145.2	145.2	148.0	148.0
Kendal	11.0	11.0	11.0	13.7	13.7	13.7	13.7	13.7
Wilge	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006

The poor quality of water in the Upper Olifants River Catchment contributes to the need for inter-basin transfer of water. Power stations require water of relatively good quality. **Table 5.6.3** gives the quality parameters of concern at each of the power stations in the catchment.

**Table 5.6.3 : Quality Parameters of Concern**

Catchment	Power Station	Quality Parameters of Concern
Klipspruit/Wilge River	Kendal	EC, SiO <sub>2</sub> , Na
Klipspruit/Wilge River	Wilge	pH, EC, total hardness, Mn, CaCO <sub>3</sub> , SO <sub>4</sub> , Cl, Fe, COD, suspended solids
Middelburg Dam	Arnot	CaCO <sub>3</sub> , SO <sub>4</sub> , Ca

Catchment	Power Station	Quality Parameters of Concern
Middelburg Dam	Hendrina	Na, K, Ca, Mg, Cl, SO <sub>4</sub> , SiO <sub>2</sub> , TOC
Witbank Dam	Matla	Na, SiO <sub>2</sub> , pH, EC, organic matter, TOC, CaCO <sub>3</sub>
Witbank Dam	Kriel	SO <sub>4</sub> , Ca
Witbank Dam	Duvha	pH, EC, Ca, Mg, Na, SO <sub>4</sub> , Cl, NO <sub>3</sub> -N M-alkalinity, K, NO <sub>3</sub> -N, SiO <sub>2</sub> , CaCO <sub>3</sub> , HCO <sub>3</sub>
Witbank Dam	Komati	turbidity, colour, EC, Mg, Cl, Mn, total hardness, Na, F, Zn, As, Cd, Cu, CN, Fe, Bp, Hg, phenol, THM, Se, coliform counts, NO <sub>3</sub> -N, SO <sub>4</sub>

## 5.7 DISTRIBUTION COST

The distribution cost associated with the collection and treatment of excess mine water, is the cost of transporting the treated water to the local water purification works. This distribution network satisfies the urban and industrial re-use options as treated mine water is discharged into the local municipality's water supply. It is assumed that 90 % of mine water treated at the regional treatment works would be recovered in the treatment process.

### 5.7.1 Klipspruit

The civil construction and mechanical equipment capital cost estimates for the Klipspruit system are summarised in **Tables 5.7.1(a)** and **5.7.1(b)** respectively.

**Table 5.7.1(a) : Cost Estimate of Civil Works for the Klipspruit System**

ITEM	DESCRIPTION	UNIT	QUANTITY	AMOUNT(R)
<b>1</b>	<b>Site clearance :</b>			
1.1	Clear & grub strip 3m wide	m	7,000	27,650
1.2	Remove & grub trees :			
1.2.1	Over 1m up to 2m	no	4	4,715
1.2.2	Over 1m up to 3m	no	0	-
1.3	Take down existing fences	km	0	-
1.4	Temporary works : traffic & maintenance	sum	3	5,000
1.5	Excavations to exposed existing services	m <sup>3</sup>	0	5,000
1.6	Replace beacons & pegs	sum	0	10,000
<b>2</b>	<b>Excavate for pipe trenches :</b>			
2.1	Excavations for pipes over 300mm diameter to the following depth intervals			

ITEM	DESCRIPTION	UNIT	QUANTITY	AMOUNT(R)
2.1.1	0.0 m to 1.0 m	m	350	12,950
2.1.2	1.0 m to 2.0 m	m	5,950	357,000
2.1.3	2.0 m to 3.0 m	m	700	70,000
2.1.4	3.0 m to 4.0 m	m	0	-
2.2	Extra over for :			
2.2.1	Intermediate material	m <sup>3</sup>	1,348	17,518
2.2.2	Hard rock material	m <sup>3</sup>	2,695	323,400
2.2.3	Boulders Class A	m <sup>3</sup>	121	7,300
2.2.4	Boulders Class B	m <sup>3</sup>	121	7,300
2.2.5	Excavate unsuitable material	m <sup>3</sup>	243	12,166
2.3	Backfill materials from :			
2.3.1	Borrow pits	m <sup>3</sup>	102	1,836
2.3.2	Commercial/off-site sources	m <sup>3</sup>	102	5,101
2.2.3	Compaction in road reserves	m	45	9,000
2.3.4	Truck haul over 1km	m <sup>3</sup> km	510	1,275
2.3.5	Shoring of trenches	m	0	-
2.3.6	Forming underdrain	m	0	-
2.3.7	Extra for 2.3.6 lining underdrain	m	0	-
2.3.8	Extra for 2.3.6 drainage pipes	m	0	-
2.4	Miscellaneous allowances for :			
2.4.1	Repairs to road or rail crossings	no	10	4,000
2.4.2	Inconvenience to cross existing fences, etc.	no	30	12,000
2.4.3	Care to cross existing pipes, etc.	no	10	6,000
2.4.4	Care to adjoining trenches	m	5	5,000
<b>3</b>	<b>Pipework</b>			
3.1	Pipework : Supply, transport, lay, install, test			
3.1.1	500 diameter - HDPE	m	7,000	4,200,000
3.2	Pipe Specials	sum	210,000	210,000
<b>4</b>	<b>Cleaning Eyes</b>			
4.1	Cleaning eyes	no	35	84,000
<b>5</b>	<b>Bedding</b>			
5.1	From trench excavation			
5.1.1	Selected granular material	m <sup>3</sup>	3449	110,376
5.1.2	Selected fill material	m <sup>3</sup>	1386	44,352
5.2	By Importing material			
5.2.1	Selected granular material	m <sup>3</sup>	383	26,444
5.2.2	Selected fill material	m <sup>3</sup>	154	10,626
<b>6</b>	<b>Pump Station</b>			
6.1	Pump station civil/building cost including sump cost	sum	1	150,000
<b>7</b>	<b>Valves</b>			
7.1	Air release valves	sum	11	64,615
7.2	Non-return valves	sum	2	2,000
	<b>NET TOTAL COST</b>			<b>R 5,806,624</b>
	<b>Add : 15 % for P &amp; G'S</b>			<b>870,994</b>
	<b>SUB TOTAL</b>			<b>R 6,677,617</b>

ITEM	DESCRIPTION	UNIT	QUANTITY	AMOUNT(R)
	Add : 25 % for contingencies			1,669,404
	Add : 15 % for engineering and project management			1,001,643
	<b>SUB TOTAL</b>			<b>R 9,348,664</b>
	Add : 10 % for cost price adjustment			934,866
	<b>TOTAL CIVIL COST (excl. VAT)</b>			<b>R 10,283,531</b>

**Table 5.7.1(b) : Cost Estimate of Mechanical Equipment for the Klipspruit System.**

ITEM	DESCRIPTION	UNIT	QUANTITY	AMOUNT(R)
<b>1</b>	<b>Pumps</b>			
1.1	300 L/sec at 98 meters head	no	2	1,300,000
	<b>NET TOTAL COST</b>			<b>1,300,000</b>
	Add : 25 % for contingencies			325,000
	Add : 15 % for engineering and project management			195,000
	<b>SUB TOTAL</b>			<b>1,820,000</b>
	Add : 10 % for cost price adjustment			182,000
	<b>TOTAL MECHANICAL EQUIPMENT (excl. VAT)</b>			<b>2,002,000</b>

The routine operating and maintenance costs associated with the Klipspruit distribution network system is summarised in **Table 5.7.1(c)**

**Table 5.7.1(c) : Estimated Annual Operating and Maintenance Cost for the Klipspruit System**

ITEM	DESCRIPTION	UNIT	AMOUNT(R)
	<b>Annual maintenance costs</b>		
1	Civil structures and pipes	% of capital cost	51,418
2	Mechanical equipment	% of capital cost	80,080
3	Electrical installations	% of capital cost	3,003
	<b>Annual operating costs</b>		
4	Pumping electrical power		
4.1	Electricity consumption	R/kWhr	455,520
4.2	Peak demand	R/kVA	11,968
	<b>Annual operating and maintenance cost</b>		<b>r 601,989</b>

## 5.7.2 Witbank

Two scenarios were investigated for the Witbank system viz. :

- Scenario 1 : System including flows from the Matla and Kriel Collieries.
- Scenario 2 : System excluding flows from the Matla and Kriel Collieries.

The civil construction and mechanical equipment capital cost estimates for scenario 1 : System including flows from the Matla and Kriel Collieries are summarised in **Tables 5.7.2.1(a)** and **5.7.2.1(b)** respectively.

**Table 5.7.2.1(a) : Cost Estimate of Civil Works for Scenario 1 :System Including Matla and Kriel**

ITEM	DESCRIPTION	UNIT	QUANTITY	AMOUNT(R)
<b>1</b>	<b>Site clearance :</b>			
1.1	Clear & grub strip 3m wide	m	9,500	37,525
1.2	Remove & grub trees :			
1.2.1	Over 1m up to 2m	no	5	6,398
1.2.2	Over 1m up to 3m	no	0	-
1.3	Take down existing fences	km	0	-
1.4	Temporary works : traffic & maintenance	sum	-	5,000
1.5	Excavations to exposed existing services	m <sup>3</sup>	0	5,000
1.6	Replace beacons & pegs	sum	-	10,000
<b>2</b>	<b>Excavate for pipe trenches :</b>			
2.1	Excavations for pipes over 300mm diameter to the following depth intervals :			
2.1.1	0.0 m to 1.0 m	m	475	17,575
2.1.2	1.0 m to 2.0 m	m	8,075	484,500
2.1.3	2.0 m to 3.0 m	m	950	95,000
2.1.4	3.0 m to 4.0 m	m	0	0
2.2	Extra over for :			
2.2.1	Intermediate material	m <sup>3</sup>	2,494	32,419
2.2.2	Hard rock material	m <sup>3</sup>	4,988	598,500
2.2.3	Boulders Class A	m <sup>3</sup>	225	13,509
2.2.4	Boulders Class B	m <sup>3</sup>	225	13,509
2.2.5	Excavate unsuitable material	m <sup>3</sup>	450	22,515
2.3	Backfill materials from :			
2.3.1	Borrow pits	m <sup>3</sup>	189	3,399
2.3.2	Commercial/off-site sources	m <sup>3</sup>	189	9,441
2.2.3	Compaction in road reserves	m	45	9,000
2.3.4	Truck haul over 1km	m <sup>3</sup> km	944	2,360
2.3.5	Shoring of trenches	m	0	-
2.3.6	Forming underdrain	m	0	-
2.3.7	Extra for 2.3.6 lining underdrain	m	0	-
2.3.8	Extra for 2.3.6 drainage pipes	m	0	-
2.4	Miscellaneous allowances for :			
2.4.1	Repairs to road or rail crossings	no	10	4,000
2.4.2	Inconvenience to cross existing fences, etc.	no	30	12,000
2.4.3	Care to cross existing pipes, etc.	no	10	6,000
2.4.4	Care to adjoining trenches	m	5	5,000
<b>3</b>	<b>Pipework</b>			
3.1	Pipework : Supply, transport, lay, install, test			
3.1.1	700 diameter - HDPE	m	9,500	8,550,000
3.2	Pipe Specials	sum		427,500
<b>4</b>	<b>Cleaning Eyes</b>			
4.1	Cleaning eyes	no	48	114,000
<b>5</b>	<b>Bedding</b>			
5.1	From trench excavation			

ITEM	DESCRIPTION	UNIT	QUANTITY	AMOUNT(R)
5.1.1	Selected granular material	m <sup>3</sup>	8,315	266,076
5.1.2	Selected fill material	m <sup>3</sup>	2,565	82,080
5.2	By Importing material			
5.2.1	Selected granular material	m <sup>3</sup>	924	63,747
5.2.2	Selected fill material	m <sup>3</sup>	285	19,665
<b>6</b>	<b>Pump Station</b>			
6.1	Pump station civil/building cost including sump cost	Sum	1	150,000
<b>7</b>	<b>Valves</b>			
7.1	Air release valves	Sum	15	87,692
7.2	Non-return valves	Sum	2	2,000
	<b>NET TOTAL COST</b>			<b>R 11,155,410</b>
	<b>Add : 15 % for P &amp; G'S</b>			<b>1,673,312</b>
	<b>SUB TOTAL</b>			<b>R 12,828,722</b>
	<b>Add : 25 % for contingencies</b>			<b>3,207,180</b>
	<b>Add : 15 % for engineering and project management</b>			<b>1,924,308</b>
	<b>SUB TOTAL</b>			<b>R 17,960,210</b>
	<b>Add : 10 % for cost price adjustment</b>			<b>1,796,021</b>
	<b>TOTAL CIVIL COST (excl. VAT)</b>			<b>R 19,756,231</b>

**Table 5.7.2.1(b) : Cost Estimate of Mechanical Equipment for Scenario 1 : System Including Matla and Kriel**

ITEM	DESCRIPTION	UNIT	QUANTITY	AMOUNT(R)
<b>1</b>	<b>Pumps</b>			
1.1	600 L/sec at 100 meters head	no	2	1,900,000
	<b>NET TOTAL COST</b>			<b>1,900,000</b>
	<b>Add : 25 % for contingencies</b>			<b>475,000</b>
	<b>Add : 15 % for engineering and project management</b>			<b>285,000</b>
	<b>SUB TOTAL</b>			<b>2,660,000</b>
	<b>Add : 10 % for cost price adjustment</b>			<b>266,000</b>
	<b>TOTAL MECHANICAL EQUIPMENT (excl. VAT)</b>			<b>2,926,000</b>

The routine operating and maintenance costs associated with Scenario 1 : System including Matla and Kriel are summarised in **Table 5.7.2.1(c)**

**Table 5.7.2.1(c) : Estimated Annual Operating and Maintenance Cost for Scenario 1 : System Including Matla and Kriel**

ITEM	DESCRIPTION	UNIT	AMOUNT(R)
	<b>Annual maintenance costs</b>		
1	Civil structures and pipes	% of capital cost	98,781
2	Mechanical equipment	% of capital cost	117,040
3	Electrical installations	% of capital cost	4,389
	<b>Annual operating costs</b>		

4	Pumping electrical power		
4.1	Electricity consumption	R/kWhr	626,340
4.2	Peak demand	R/kVA	16,456
	<b>Annual operating and maintenance cost</b>		<b>R 863,006</b>

The civil construction and mechanical equipment capital cost estimates associated Scenario 2 : System excluding flows from the Matla and Kriel Collieries are summarised in **Tables 5.7.2.2(a)** and **5.7.2.2(b)** respectively.

**Table 5.7.2.2(a) : Cost Estimate of Civil Works for Scenario 2 :System Excluding Matla and Kriel**

ITEM	DESCRIPTION	UNIT	QUANTITY	AMOUNT(R)
<b>1</b>	<b>Site clearance :</b>			
1.1	Clear & grub strip 3m wide	m	9,500	37,525
1.2	Remove & grub trees :			
1.2.1	Over 1m up to 2m	no	5	6,398
1.2.2	Over 1m up to 3m	no	0	-
1.3	Take down existing fences	km	0	-
1.4	Temporary works : traffic & maintenance	sum	3	5,000
1.5	Excavations to exposed existing services	m <sup>3</sup>	0	5,000
1.6	Replace beacons & pegs	sum	0	10,000
<b>2</b>	<b>Excavate for pipe trenches :</b>			
2.1	Excavations for pipes over 300mm diameter to the following depth intervals :			
2.1.1	0.0 m to 1.0 m	m	475	17,575
2.1.2	1.0 m to 2.0 m	m	8,075	484,500
2.1.3	2.0 m to 3.0 m	m	950	95,000
2.1.4	3.0 m to 4.0 m	m	0	-
2.2	Extra over for :			
2.2.1	Intermediate material	m <sup>3</sup>	1,929	25,071
2.2.2	Hard rock material	m <sup>3</sup>	3,857	462,840
2.2.3	Boulders Class A	m <sup>3</sup>	174	10,447
2.2.4	Boulders Class B	m <sup>3</sup>	174	10,447
2.2.5	Excavate unsuitable material	m <sup>3</sup>	348	17,412
2.3	Backfill materials from :			
2.3.1	Borrow pits	m <sup>3</sup>	146	2,628
2.3.2	Commercial/off-site sources	m <sup>3</sup>	146	7,301
2.2.3	Compaction in road reserves	m	45	9,000
2.3.4	Truck haul over 1km	m <sup>3</sup> km	730	1,825
2.3.5	Shoring of trenches	m	0	-
2.3.6	Forming underdrain	m	0	-
2.3.7	Extra for 2.3.6 lining underdrain	m	0	-
2.3.8	Extra for 2.3.6 drainage pipes	m	0	-
2.4	Miscellaneous allowances for :			
2.4.1	Repairs to road or rail crossings	no	10	4,000
2.4.2	Inconvenience to cross existing fences, etc.	no	30	12,000

ITEM	DESCRIPTION	UNIT	QUANTITY	AMOUNT(R)
2.4.3	Care to cross existing pipes, etc.	no	10	6,000
2.4.4	Care to adjoining trenches	m	5	5,000
<b>3</b>	<b>Pipework</b>			
3.1	Pipework : Supply, transport, lay, install, test			
3.1.1	560mm diameter - HDPE	m	9,500	6,517,000
3.2	Pipe Specials	sum	325,850	325,850
<b>4</b>	<b>Cleaning Eyes</b>			
4.1	Cleaning eyes	no	48	114,000
<b>5</b>	<b>Bedding</b>			
5.1	From trench excavation			
5.1.1	Selected granular material	m <sup>3</sup>	5,253	168,100
5.1.2	Selected fill material	m <sup>3</sup>	1,984	63,475
5.2	By Importing material			
5.2.1	Selected granular material	m <sup>3</sup>	584	40,274
5.2.2	Selected fill material	m <sup>3</sup>	220	15,208
<b>6</b>	<b>Pump Station</b>			
6.1	Pump station civil/building cost including sump cost	sum	1	150,000
<b>7</b>	<b>Valves</b>			
7.1	Air release valves	sum	15	87,692
7.2	Non-return valves	sum	2	2,000
	<b>NET TOTAL COST</b>			<b>R 8,718,567</b>
	<b>ADD : 15 % for P &amp; G'S</b>			<b>1,307,785</b>
	<b>SUB TOTAL</b>			<b>R 10,026,352</b>
	<b>Add : 25 % for contingencies</b>			<b>2,506,588</b>
	<b>Add : 15 % for engineering and project management</b>			<b>1,503,953</b>
	<b>SUB TOTAL</b>			<b>R 14,036,893</b>
	<b>Add : 10 % for cost price adjustment</b>			<b>1,403,689</b>
	<b>TOTAL CIVIL COST (excl. VAT)</b>			<b>R 15,440,583</b>

**Table 5.7.2.2(b) : Cost Estimate of Mechanical Equipment for Scenario 2 : System Excluding Matla and Kriel**

ITEM	DESCRIPTION	UNIT	QUANTITY	AMOUNT(R)
<b>1</b>	<b>Pumps</b>			
1.1	600 L/sec at 100 meters head	no	2	1,300,000
	<b>NET TOTAL COST</b>			<b>1,300,000</b>
	<b>Add : 25 % for contingencies</b>			<b>325,000</b>
	<b>Add : 15 % for engineering and project management</b>			<b>195,000</b>
	<b>SUB TOTAL</b>			<b>1,820,000</b>
	<b>Add : 10 % for cost price adjustment</b>			<b>182,000</b>
	<b>TOTAL MECHANICAL EQUIPMENT (excl. VAT)</b>			<b>R 2,002,000</b>

The routine operating and maintenance costs associated with Scenario 2 : System excluding Matla and Kriel are summarised in **Table 5.7.2.2(c)**

**Table 5.7.2.2(c) : Estimated Annual Operating and Maintenance Cost for Scenario 2 : System Excluding Matla and Kriel**

ITEM	DESCRIPTION	UNIT	AMOUNT(R)
	<b>Annual maintenance costs</b>		
1	Civil structures and pipes	% of capital cost	77,203
2	Mechanical equipment	% of capital cost	80,080
3	Electrical installations	% of capital cost	3,003
	<b>Annual operating costs</b>		
4	Pumping electrical power		
4.1	Electricity consumption	R/kWhr	455,520
4.2	Peak demand	R/kVA	11,968
	<b>Annual operating and maintenance cost</b>		<b>R 627,774</b>

### 5.7.3 Middelburg

The civil construction and mechanical equipment capital cost estimates for the Middelburg system are summarised in **Tables 5.7.3(a)** and **5.7.3(b)** respectively.

**Table 5.7.3(a) : Cost Estimate of Civil Works for the Middelburg System**

ITEM	DESCRIPTION	UNIT	QUANTITY	AMOUNT(R)
<b>1</b>	<b>Site clearance :</b>			
1.1	Clear & grub strip 3m wide	m	17,500	69,125
1.2	Remove & grub trees :			
1.2.1	Over 1m up to 2m	no	9	11,786
1.2.2	Over 1m up to 3m	no	0	-
1.3	Take down existing fences	km	0	-
1.4	Temporary works : traffic & maintenance	sum	-	5,000
1.5	Excavations to exposed existing services	m <sup>3</sup>	0	5,000
1.6	Replace beacons & pegs	sum	-	10,000
<b>2</b>	<b>Excavate for pipe trenches :</b>			
2.1	Excavations for pipes over 300mm diameter to the following depth intervals :			
2.1.1	0.0 m to 1.0 m	m	875	32,375
2.1.2	1.0 m to 2.0 m	m	14,875	892,500
2.1.3	2.0 m to 3.0 m	m	1,750	175,000
2.1.4	3.0 m to 4.0 m	m	0	-
2.2	Extra over for :			
2.2.1	Intermediate material	m <sup>3</sup>	3,553	46,183
2.2.2	Hard rock material	m <sup>3</sup>	7,105	852,600
2.2.3	Boulders Class A	m <sup>3</sup>	321	19,244
2.2.4	Boulders Class B	m <sup>3</sup>	321	19,244
2.2.5	Excavate unsuitable material	m <sup>3</sup>	642	32,074
2.3	Backfill materials from :			

ITEM	DESCRIPTION	UNIT	QUANTITY	AMOUNT(R)
2.3.1	Borrow pits	m <sup>3</sup>	269	4,842
2.3.2	Commercial/off-site sources	m <sup>3</sup>	269	13,449
2.2.3	Compaction in road reserves	m	45	9,000
2.3.4	Truck haul over 1km	m <sup>3</sup> km	1,345	3,362
2.3.5	Shoring of trenches	m	0	-
2.3.6	Forming underdrain	m	0	-
2.3.7	Extra for 2.3.6 lining underdrain	m	0	-
2.3.8	Extra for 2.3.6 drainage pipes	m	0	-
2.4	Miscellaneous allowances for :			
2.4.1	Repairs to road or rail crossings	no	10	4,000
2.4.2	Inconvenience to cross existing fences, etc.	no	30	12,000
2.4.3	Care to cross existing pipes, etc.	no	10	6,000
2.4.4	Care to adjoining trenches	m	5	5,000
<b>3</b>	<b>Pipework</b>			
3.1	Pipework : Supply, transport, lay, install, test			
3.1.1	600 diamter - HDPE	m	17,500	12,005,000
3.2	Pipe Specials	sum	600,250	600,250
<b>4</b>	<b>Cleaning Eyes</b>			
4.1	Cleaning eyes	no	88	210,000
<b>5</b>	<b>Bedding</b>			
5.1	From trench excavation			
5.1.1	Selected granular material	m <sup>3</sup>	9,677	309,658
5.1.2	Selected fill material	m <sup>3</sup>	3,654	116,928
5.2	By Importing material			
5.2.1	Selected granular material	m <sup>3</sup>	1,075	74,189
5.2.2	Selected fill material	m <sup>3</sup>	406	28,014
<b>6</b>	<b>Pump Station</b>			
6.1	Pump station civil/building cost including sump cost	sum	1	150,000
<b>7</b>	<b>Valves</b>			
7.1	Air release valves	sum	27	161,538
7.2	Non-return valves	sum	2	2,000
	<b>NET TOTAL COST</b>			<b>R 15,885,361</b>
	<b>Add : 15 % for P &amp; G'S</b>			<b>2,382,804</b>
	<b>SUB TOTAL</b>			<b>R 18,268,165</b>
	<b>Add : 25 % for contingencies</b>			<b>4,567,041</b>
	<b>Add : 15 % for engineering and project management</b>			<b>2,740,225</b>
	<b>SUB TOTAL</b>			<b>R 25,575,431</b>
	<b>Add : 10 % for cost price adjustment</b>			<b>2,557,543</b>
	<b>TOTAL CIVIL COST (excl. VAT)</b>			<b>R 28,132,974</b>

**Table 5.7.3(b) : Cost Estimate of Mechanical Equipment for the Middelburg System.**

ITEM	DESCRIPTION	UNIT	QUANTITY	AMOUNT(R)
<b>1</b>	<b>Pumps</b>			
1.1	460 L/sec at 98 meters head	no	2	1,300,000
	<b>NET TOTAL COST</b>			<b>1,300,000</b>
	<b>Add : 25 % for contingencies</b>			<b>325,000</b>
	<b>Add : 15 % for engineering and project management</b>			<b>195,000</b>
	<b>SUB TOTAL</b>			<b>1,820,000</b>
	<b>Add : 10 % for cost price adjustment</b>			<b>182,000</b>
	<b>TOTAL MECHANICAL EQUIPMENT (excl. VAT)</b>			<b>R 2,002,000</b>

The routine operating and maintenance costs associated with the Middelburg distribution network system is summarised in **Table 5.7.3(c)**

**Table 5.7.3(c) : Estimated Annual Operating and Maintenance Cost for the Middelburg System**

ITEM	DESCRIPTION	UNIT	AMOUNT(R)
	<b>Annual maintenance costs</b>		
1	Civil structures and pipes	% of capital cost	140,665
2	Mechanical equipment	% of capital cost	80,080
3	Electrical installations	% of capital cost	3,003
	<b>Annual operating costs</b>		
4	Pumping electrical power		
4.1	Electricity consumption	R/kWhr	455,520
4.2	Peak demand	R/kVA	11,968
	<b>Annual operating and maintenance cost</b>		<b>R 691,236</b>

#### 5.7.4 Cost Summary

**Table 5.7.4** gives a summary of the costs associated with the distribution pipelines.

**Table 5.7.4 : Cost Summary of Distribution Pipelines**

	Civil Costs	Mechanical Costs	Total Capital Costs	Annual Operating and Maintenance Cost
Klipspruit	R 10,283,531	R 2,002,000	R 12,285,531	R 601,989
Witbank				
• Scenario 1	R 19,756,231	R 2,926,000	R 22,682,231	R 863,006
• Scenario 2	R 15,440,583	R 2,002,000	R 17,442,583	R 627,774
Middelburg	R 28,132,974	R 2,002,000	R 30,134,974	R 691,236

## 5.8 CONCLUDING COMMENTS

The collection, treatment and beneficial use of excess mine water will not only in general improve water quality, but will also supplement the local water resources in the catchment. This report indicated that there exists several potential urban and industrial uses for the treated mine water and for the use of mine water for irrigation. Application of the treated mine water to supplement cooling water supply to power stations can also be considered, but this will require a high level of treatment. A summary of the current and future water demands of the various water use sectors investigated is summarised in **Table 5.8.1**.

**Table 5.8.1 : Summary of Water Demands of The Different User Sectors**

Sector	Water Requirements			
	Current		Future	
	(1000 Mℓ/year)	(Mℓ/day)	(1000 Mℓ/year)	(Mℓ/day)
Irrigation	77	211	77	211
Stock Watering	6	16	7	19
Urban and Industrial	63	173	184	504
Mines	25	68	10	27
Power Stations	175	479	228	625
<b>Total</b>	<b>346</b>	<b>947</b>	<b>506</b>	<b>1,386</b>

The estimated current excess mine water of 44 Mℓ/day, increasing to an estimated 131 Mℓ/day by the year 2020 represents a substantial potential water resource in the catchment. Most of the increase in future water requirements, specifically for the urban and industrial growth will have to be imported to the catchment. The water use by the urban and industrial sector is expected to grow substantially over the next 20 years, requiring an estimated additional 330 Mℓ/day. The development of excess mine water as a supplementing water resource could be used as a minimum delay implementation of further inter-basin transfers of water to the Upper Olifants River Catchment.

Excess mine water could also be used to supply the future growth in water requirements for power generation. This requirement is expected to increase by 145 Mℓ/day, which is approximately the same as the estimated future amount of excess mine water. This application of the excess mine will however require a high level of treatment and associated high costs.

Irrigation application of the excess mine water also has potential. The demonstration project currently being executed indicates positive results in terms of technical feasibility and financial viability. The Department of Water Affairs and Forestry, however, does not currently foresee any further increase in irrigation water allocation in the catchment, specifically in view of the level to which the available water resources are already exploited in the Upper Olifants River catchment. The potential for re-allocation of irrigation water authorisation could possibly be investigated.

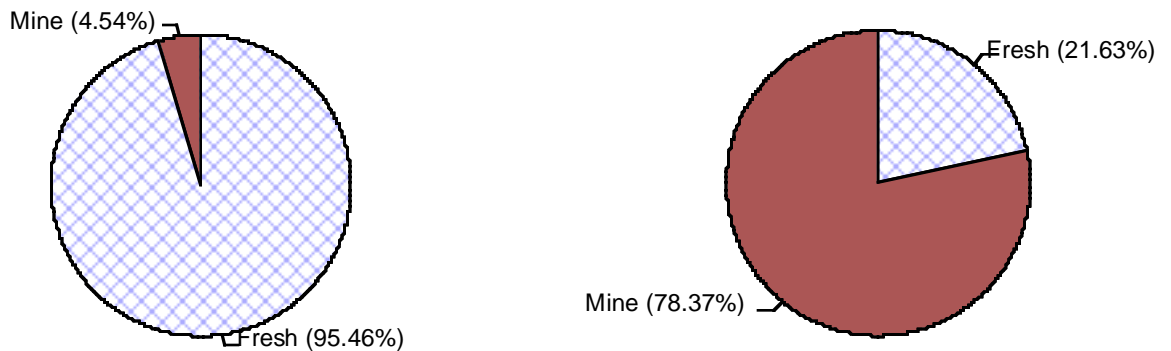
## CHAPTER 6.

### RECOMMENDED MINE WATER MANAGEMENT APPROACH IN THE UPPER OLIFANTS RIVER CATCHMENT

#### 6.1 WATER USAGE, QUANTITY, QUALITY, TREATMENT AND COLLECTION/DISTRIBUTION COST

Mine water discharged in the Upper Olifants River Catchment currently amounts to approximately 44 MP/d during an average hydrological year. This volume of excess mine water amounts to only 4,6% of the total water usage in the Upper Olifants River Catchment, but contributes 78% of the sulphate load. The following background is also of significance in the development of a management plan for the acid mine water problem in the Upper Olifants River Catchment:

- **Water usage in the Upper Olifants River Catchment** currently amounts to 947 MP/d (including the power stations), and will increase to an estimated 1 385 MP/d by 2020 (Table 6.1). The additional water demand by 2020 (438 MP/d) will have to be supplied by importation from neighbouring catchments, and more efficient utilisation of the local water resources, including excess mine water.
- **Excess mine water** currently amounts to 44 MP/d and will increase to an estimated 131 MP/d by 2020 (Table 6.2). The quality of mine water is generally poor with a sulphate concentration between 800 and 3 000 mg/P. It is not acceptable to discharge such poor quality excess mine water into high quality surface water. The current sulphate load of water in the Olifants River Catchment is estimated at 28,4 t/d (as  $\text{SO}_4$ ) ( $947 \text{ MP/d} \times 30 \text{ mg/P } \text{SO}_4$  ) 1 000 kg/t), which is small compared to the 102,9 t/d sulphate load in excess mine water ( $2\,337 \text{ mg/P } \text{SO}_4 \times 44 \text{ MP/d}$  ) 1 000 kg/t). The above-mentioned figures show that the relatively small volume of excess mine water is responsible for a major contribution of sulphate and other salts. Excess mine water in the Olifants River Catchment currently amounts, volume wise, to only 4,6% of the total water usage ( $44 \text{ MP/d} / 947 \text{ MP/d} \times 100$ ), but contributes 78,4% of the sulphate load ( $102,9 \text{ t/d} / (102,9 + 28,4) \text{ t/d} \times 100$ ) (Table 6.3 and Figure 6.1).



1.1 Volume (%)

1.2 Sulphate load (%)

**Figure 6.1 Comparison of water volumes and sulphate load of fresh water usage and excess mine water in the Upper Olifants River Catchment.**

Various levels of treatment are required to make excess mine water suitable for the following potential applications (acceptable sulphate concentration of treated water shown in brackets):

- irrigation (2 000 mg/P)
- coal processing plant (1 000 mg/P)
- general industrial use (500 mg/P)
- discharge to public streams (500 mg/P)
- potable use (200 mg/P)
- cooling water in power stations (30 to 50 mg/P)

Table 6.4 shows the capital and running cost associated with the treatment of mine water with various treatment processes. Should treated mine water need to be reused for any application except for irrigation (which should be utilised at the source), a collection system needs to be installed for transportation of the untreated mine water to a central treatment plant, as well as a distribution system for transportation of the treated water to the users. The cost of collection systems for the catchment is estimated at R192,9 million (Table 6.5) and that of a distribution system at R65,1 million (Table 6.6). The annual running cost for the collection and distribution systems is estimated at R3,1 million and R2,2 million respectively (Tables 6.5 and 6.6).

**Table 6.1** *Current and projected water usage in the Upper Olifants River Catchment.*

User	Water demand (MP/d)		
	Current	2020	Change
Irrigation	211	211	0
Stock watering	16	19	3
Urban and industrial	173	504	331
Mining	68	27	-41
Power stations*	479	625	146
Total (excluding power stations)	468	761	237
Total (including power stations)	947	1 385	483
Excess mine water	44	131	87

\* Supplied from water sources outside the Upper Olifants River Catchment.

**Table 6.2.** *Estimated volumes of excess mine water in the Upper Olifants River Catchment.*

Catchment/Power station	Volume (MP/d)	Quality		
		pH	Sulphate 95%	Magnesium 95%
<b>Middelburg Dam catchment</b>	<b>14,55</b>		<b>1524</b>	<b>88</b>
1. Arnot	4,4	8,5	2832	77
2. Eikeboom	0,46	8,6	75	41
3. Woestalleen	0,19	8,1	2069	280
4. Optimum	9,5	7,8	977	91
<b>Witbank Dam catchment</b>	<b>10,74</b>		<b>2498</b>	<b>287</b>

5. Douglas	0,66	7,8	1645	250
6. Goedehoop	0,56		2500	250
7. Greenside	0,65	8,7	3050	292
8. Kleinkopje and Landau	4,08	8,9	2604	304
9. Kroonfontein	0,09	8,5	1361	99
10. Middelburg South	0,02	7,6	2018	303
11. Middelburg North	0,58	3,8	2805	308
12. Rietspruit	1,41	8,5	2626	380
14. Tavistock	0,49	7,1	1520	148
15. Khutala	2,2		2500	250
<b>Kriel/Matla complex</b>	<b>9,12</b>		<b>563</b>	<b>47</b>
16. Kriel	1,99	8,4	729	99
17. Malta	5,67	8,9	485	32
13. Syferfontein	1,46	8,8	637	37
<b>Klipspruit catchment</b>	<b>9,62</b>		<b>5071</b>	<b>217</b>
18. Kromdraai	1,26		2600	50
19. South Witbank	2,47	2,8	4986	160
20. Middelburg Stream	0,61		2600	50
21. Old Tavistock	0,08		2600	50
22. Brugspruit High TDS	2,7	4,0	8203	435
23. Brugspruit Low TDS	2,5	3,3	3701	170
<b>Total</b>	<b>44,03</b>			

**Table 6.3. Comparison between water volumes and sulphate load of fresh water usage and excess mine water discharges in the Upper Olifants River Catchment.**

Parameter	Fresh water	Excess mine water	Total	Fresh water	Excess mine water
	MP/d	MP/d	MP/d	%	%
Volume (MP/d)	947	44,0	991	95,6	4,4
Sulphate concentration (mg/.P)	30	2337			
Sulphate load (t/d)	28,4	102,9	131,3	21,6	78,4

**Table6.4. Capital and running cost of various treatment processes (15 MP/d).**

Treatment process	SO <sub>4</sub> level in treated water	Capital cost (R million / MP/d)	Running cost (R/m ;)
Limestone neutralisation (incl. iron(II) oxidation)	2500	0,22	0,59
Lime neutralisation (pH 8)	1500	0,53	1,36
Limestone/lime treatment (pH 11) & gypsum crystallisation	1100	0,88	1,02
Lime treatment (pH 11.5) & gypsum crystallisation	1100	0,57	1,61
Advanced sulphate removal (including neutralization pre-treatment)	200	4,0 to 10,0	2,0 to 5,0

**Table 6.5. Cost of collection systems.**

<b>Sub-catchment</b>	<b>Capital cost (R)</b>	<b>Running cost (R)</b>
Middelburg Dam	32 000 000	410 000
Witbank Dam	52 400 000	745 000
Matla/Kriel/Syferfontein	90 900 000	1 525 000
Brugspruit	17 600 000	400 000
Total	192 900 000	3 080 000

**Table 6.6. Cost of distribution systems.**

<b>Sub-catchment</b>	<b>Capital cost (R)</b>	<b>Running cost (R)</b>
Middelburg Dam	30 134 974	691 236
Witbank Dam	17 442 583	627 774
Matla/Kriel/Syferfontein	5 239 648	236 232
Brugspruit	12 258 531	601 989
Total	65 075 736	2 156 231

## **6.2 MANAGEMENT OPTIONS**

The following two options, or a combination of thereof, can be considered for management of excess mine water in the Upper Olifants River Catchment:

- Collection and treatment of excess mine water to a quality suitable for several urban and industrial applications (Option A).
- Collection and treatment of mine water to a quality suitable for irrigation (Option B).

The estimated capital and running cost for the total Upper Olifants River Catchment for Option A amounts to R528.5 million and R55.7 million/a, respectively, compared with R68,2 million and R11,9 million for Option B (Table 6.7). It is recommended that Option B (pre-treatment/irrigation

combination) be investigated for implementation in the short to medium-term for the following reasons:

- \* Prevent pollution of surface water by not discharging potentially acidic and saline mine water to public streams.
- \* Treatment cost for irrigation application of the excess mine water is more affordable, as the Capital Expenditure is only 13% compared with Option A, and the running cost only 21% compared with Option A.
- \* The land required for irrigation of excess mine water (1891 ha in 2000) amounts to only 21% of what is already used for irrigation (9097 ha in 2000). In the catchment, indications are that gypsum-rich water can be used for irrigation, without affecting the suitability of soil for irrigation in the long-term.
- \* Irrigation could create job opportunities and stimulate the regional economy.

The long-term environmental impacts of the irrigation use of sulphate-rich mine water should be investigated and resolved to the satisfaction of all stakeholders, before proceeding with the catchment wide implementation of the scheme.

Option A, however, also holds merit, and should be reconsidered over the medium to long-term, along with the following developments:

- \* Reduction in the cost of advanced sulphate removal technologies. It is foreseen that, due to technological improvements to some of the technologies, cost could be reduced to levels similar to that of lime treatment within the next 10-20 years.
- \* Increased cost of imported fresh water. The cost of fresh water in the Upper Olifants River Catchment will increase over the next decade. This is due to the fact that the future increased demand for water in the catchment will have to be imported from neighbouring catchments at substantial cost.
- \* The cost of excess mine water collection may in future be substantially reduced, by utilisation of the natural underground drainage paths set up in the underground mine workings.

**Table 6.7. Comparison between Option A (complete treatment) and Option B (pre-treatment/irrigation combination) for the Upper Olifants River Catchment.**

Name	Volume ML/d	Quality			Cost						Irrigation band (day)	Irrigation Capital R/ha	CaO dose kg/m <sup>2</sup>		
		pH	Sulphate	Magnesium 96%	Acidity	Option A: (pre-treatment) SO <sub>4</sub> removal, SO <sub>4</sub> removed to 200 mg/L			Option B: (pre-treatment) SO <sub>4</sub> removal, SO <sub>4</sub> removed to 1500 mg/L						
						Capital (R)		Running (R/a)	Capital (R)					Running (R/a)	
						Pre-Int	SO <sub>4</sub>	Pre-Int	SO <sub>4</sub>	Irrigation				Lime/Cryst	Irrigation
<b>Treatment technologies</b>															
Middelburg Dam catchment	14,55	1 524	88												
1. Amot	4,4	2 832	77												
2. Ekkeboo	0,46	75	41												
3. Woestalleen	0,19	2 069	280												
4. Ophnu	0,5	977	91												
<b>Witbank Dam catchment</b>	<b>10,74</b>	<b>2 498</b>	<b>287</b>												
5. Douglas	0,86	1 645	250												
6. Goedehoop	0,56	2 500	250												
7. Greenside	0,95	3 050	292												
8. Kleinokpe & Landau	4,08	2 604	304												
9. Koornfontein	0,09	1 361	99												
10. Middelburg South	0,02	2 018	303												
11. Middelburg North	0,58	2 805	308												
12. Rietpruit	1,41	2 826	380												
14. Tavistock	0,49	1 520	148												
15. Khutala	2,2	2 500	250												
<b>Krui/Matla</b>	<b>9,12</b>	<b>563</b>	<b>47</b>												
16. Krui	1,99	729	99												
17. Matla	5,87	485	32												
13. Syferfontein	1,46	637	37												
<b>Klipspruit catchment</b>	<b>9,62</b>	<b>5 071</b>	<b>217</b>												
18. Krondraai	1,26	2 600	50												
19. South Witbank	2,47	4 986	160												
20. Middelburg Strea	0,61	2 600	50												
21. Old Tavistock	0,08	2 600	50												
22. Brugspruit High TDS	2,7	8 203	435												
23. Brugspruit Low TDS	2,5	3 701	170												
<b>Total</b>	<b>44,03</b>														
Total Capital cost (R)		27 687 752	242 875 019	10 322 956	40 177 375	24 758 402	43 464 410	1 607 065	10 322 956	1 607 065	10 322 956	1 890,70			
Total running cost (R/a)		27 700 000	242 900 000	10 300 000	50 500 000	24 800 000	43 500 000	1 600 000	10 300 000	1 600 000	11 690 000				
Total cost ratio			1,00		1,00		1,00		1,00		0,21				
<b>Collection systems:</b>															
Middelburg Da															
Witbank Da															
Matla/Krui/Syferfontein															
Brugspruit															
<b>Distribution systems:</b>															
MIDDELBURG Da															
Witbank Da															
Matla/Krui/Syferfontein															
Brugspruit															
Total capital cost (R)					528 596 000	1,00			88 223 000	0,13					
Capital cost ratio					1,00				0,13						
Total running cost (R/a)					55 700 000	1,00			11 690 000	0,21					

Notes:

Water application (mm/a)  
Water application ( ; d/ha)

Capital cost:

Irrigation (R/ha)

Lime neutralisation/gypsum crystallisation (R/(MP/d))

Total sulphate removal (R/(MP/d))

Scale factor

Running cost:

Irrigation (R/ ;

Lime neutralisation/gypsum crystallisation (R/ ; (excluding chemicals)

Total sulphate removal (R/ ;

850

2 328 767

12 000

0,80

0,10

0,32

0,32

2,50

0,32

2,50