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SOL PLAATJE MUNCIPALITY
WATER LOSS MANAGEMENT STUDY

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EXECUTIVE SUMMARY

This report details the findings of a study of water loss at the Sol Plaatje Municipality's water supply and distribution system. The study was commissioned by Mega Tech Inc., a USAid procuring agent and is funded by USAid.

The report shows that the levels of Unaccounted for Water (UAW, which is the difference between the volume of water purchased and the volume of water sold) have reached unacceptably high levels (38%)over the last few years, resulting in unnecessary costs and revenue loss. The study is an attempt to identify all the various components of water loss, to quantify each component and to recommend steps that should be taken in order to reduce water loss. The study has addressed both physical water loss and administration loss.

The study shows that the major contributions to UAW are from ageing, inaccurate consumer meters, meter restrictors, unmetered standpipes, too many interim accounts, frequent bursts and leaks, treatment losses and long delays in meter repairs/replacement. Although it is impossible to calculate the magnitude of each contribution to UAW, the study shows that roughly half the UAW is due to administration loss and half due to physical loss.

The report makes several recommendations for the implementation of a water loss management plan, that ranges from small to large scale action. A target UAW of 15% has been suggested in the report, and the municipality will need to spend in the region of R5million a year in order to achieve that target over a five year period. The resultant savings that will be made from the reduced water loss will more than cover the cost of implementing the water loss management plan, and has a payback period of five years (or less, depending on the growth of UAW if left to continue)

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ABBREVIATIONS

AADD	Average annual daily demand (annual demand ÷ 365 days)
FMS	Financial management system
GIS	Geographical information system
kℓ	1000 litres
Mamsl	Meters above mean sea level
Mℓ	1 000 000 litres
MTI	MegaTech (Inc)
PRV	Pressure reducing valve
SCADA	Supervisory control and data acquisition
SPM	Sol Plaatje Municipality
TWL	Top water level (of reservoir)
UAW	Unaccounted for water

1. INTRODUCTION

Ninham Shand were appointed by Mega-Tech, Inc. on 13 February to carry out a water loss management study for Sol Plaatje Municipality (SPM). Mega-Tech, Inc. (MTI) provides administrative, management, and logistical support to USAID/South Africa's Housing and Urban Development Team. MTI also serves as a USAID procuring agent and acts in this capacity for the purposes of this study. This study is funded by USAID.

The objective of this study is to develop a plan of action for optimising metering and monitoring systems related to water management, to reduce water losses, increase revenues, and reduce costs of supply, particularly energy costs. The study area is the City of Kimberley and its immediate surrounds. Other communities under Sol Plaatje Municipality jurisdiction that fall outside of Kimberley are not included in this study.

2. BACKGROUND

The water supply for Sol Plaatje is abstracted from the Vaal River at Riverton, a point approximately 24 kilometres from Kimberley. This water is abstracted via low lift pumps and metered for the purpose of payment to the Department of Water Affairs and Forestry. The Water is purified at Riverton and then pumped via high lift pumps either directly into the reticulation or to the Newton reservoir complex in Kimberley. The water leaving Riverton is metered. All main reservoir intakes are sited at the bottom of the reservoirs and the pipelines thus serve as delivery lines during pumping periods and gravity fed delivery lines during periods when no pumping is taking place.

The water reticulation in Sol Plaatje has developed incrementally over the last century with the result that many areas are fed by a number of small diameter pipes making the delimitation of district metering areas problematic. The result of this situation is that unaccounted for water is based on the difference between the water abstracted at Riverton and the water sold through consumer meters. While this situation was not ideal, until approximately 2 years ago the level of unaccounted for water was fairly stable at approximately 10 – 13%. This level has now risen to approximately 35% and represents a substantial financial loss to the municipality. This unaccounted for water arises in the context of approximately 45 000 households supplied by approximately 850 km of water reticulation pipelines.

The problem is exacerbated by there being no direct link between the financial management system (FMS) and the geographical information system (GIS), with the result that it is difficult to monitor consumption levels geographically. Without district water meters and links between the FMS and GIS it is currently not even possible to determine with any certainty whether the bulk of the unaccounted for water results from anomalies within the FMS or is as a result of physical water loss.

In addition, the link between energy consumption and water pumping is inadequately measured and monitored. Baseline information on pump performance and consumption will be required to efficiently operate the existing pumps and minimize energy charges. Currently, no metering scheme exists at the Newton Reservoir and an incomplete system is in place at the Riverton complex.

3. WATER BALANCE

In order to determine the extent of water loss, it is necessary to carry out a water balance, a comparison between the volume of water purchased and the volume of water sold to consumers.

3.1 WATER PURCHASED AND WATER SOLD

The volume of water purchased is the volume of water abstracted from the Vaal River at Riverton. This volume is metered for the purposes of payment to the Department of Water Affairs and Forestry. The volume of water purchased during the last five complete financial years is shown in Table 1 below.

The volume of water sold to consumers is recorded by the consumer water meters that are read by the Treasury Department. The volume of water sold during the last five complete financial years is shown in Table 1 below.

Table 1 : Water supplied and water sold statistics

	Financial Year				
	1997/98	1998/99	1999/00	2000/01	2001/02
Volume Abstracted	22,504,763 kl	22,164,654 kl	21,586,868 kl	22,970,286 kl	22,549,435 kl
Volume Pumped	20,254,287 kl	19,818,228 kl	18,481,695 kl	20,258,814 kl	21,366,809 kl
Total Volume Sold	16,444,539 kl	17,569,517 kl	15,929,477 kl	15,613,795 kl	13,949,266 kl
No. of meters	34 823	36 351	36 818	42 813	43 382
Population	212 257	212 000	232 430	232 430	232 430
Water expenses	R39 510 824	R45 994 926	R39 409 692	R42 839 395	R42 614 935
Water sales	R36 419 261	R46 083 933	R39 318 353	R42 839 395	R42 931 167
AADD	55 491 kℓ/d	54 297 kℓ/d	50 635 kℓ/d	55 504 kℓ/d	58 539 kℓ/d

3.2 UNACCOUNTED FOR WATER (UAW)

Unaccounted for water (UAW) is defined in SABS 0306:1999 as “the difference between the measured volume of water put into the supply and distribution system and the total volume of water measured to authorised consumers whose fixed property address appears on the official list of the water services authority”. In simpler terms, it is the difference between the volume of water treated (pumped) by the Municipality and the volume of water sold to consumers. This definition excludes the process losses at the Water Treatment Works, however we believe that these losses should be included in this study as they are unusually high and variable. Care will be taken to exclude process losses when comparing Kimberley’s UAW to other authorities’ UAW.

For the purpose of this study, UAW will therefore consist of the following :

Physical loss of water

- Process losses at the water treatment works
- Leakage from bulk supply mains
- Losses from the reticulation, i.e. bursts and leaks
- Losses from reservoirs, i.e. leaks, overflows and flushing
- Reticulation scouring or flushing
- Fire fighting use that is not metered
- Authorised unmeasured use (municipal use)
- Unmetered connections (communal standpipes)
- Illegal connections and theft

Administration or apparent loss

- Meter inaccuracy (bulk and consumer meters)

- Meter reading error (by meter reader, whether accidental or deliberate)
- Data capture error (of meter books by Treasury Department clerks)
- Incorrect interim estimates and adjustments
- Missing or erroneous accounts (on Treasury database)
- Administration error (by Engineering or Treasury Dept)

The most popular expression of UAW is a percentage of the volume of water entering the supply and distribution system (or in the case of this study, the volume of water purchased). This unit is considered simplistic by some, as it can be misleading if the volume of water purchased changes significantly while the UAW remains constant. However percentage is readily understood and easy to use for comparison purposes, therefore this report will quote UAW in percentage as well as the actual volume of UAW.

UAW over the last five financial years is shown in Table 2 as follows:

Table 2 : UAW and its components

Loss	Financial Year				
	1997/98	1998/99	1999/00	2000/01	2001/02
Volume Purchased	22,504,763 kl	22,164,654 kl	21,586,868 kl	22,970,286 kl	22,549,435 kl
Volume Pumped	20,254,287 kl	19,818,228 kl	18,481,695 kl	20,258,814 kl	21,366,809 kl
Actual sales (kℓ)	16,444,539 kl	17,569,517 kl	15,929,477 kl	15,613,795 kl	13,949.266 kl
UAW	6,060,224 kl	4,595,137 kl	5,657,391 kl	7,356,491 kl	8,600,169 kl
% UAW	26.9%	20.7%	26.2%	32.0%	38.1%
Distribution losses	3,809,748 kl	2,248,711 kl	2,552,218 kl	4,645,019 kl	7,417,543 kl
% Distribution losses	18.8%	11.3%	13.8%	22.9%	34.7%
Treatment losses	2,250,476 kl	2,346,426 kl	3,105,173 kl	2,711,472 kl	1,182,626 kl
% Treatment losses	10.0%	10.6%	14.4%	11.8%	5.2%

The information in Table 2 above is also shown graphically in Figure 1 at the back of this report. Figure 1 shows more clearly that the treatment losses have steadily reduced over the last five financial years to approximately 5% of the volume of water purchased. Since the total UAW has steadily risen over the last five financial years, it means that the distribution losses have almost tripled in the last three years, which is more cause for concern.

Table 2 shows that distribution losses have reached 7 417 543 kℓ/year or 35% of the volume of water pumped. UAW has been rising steadily over the last four financial years and is set to continue rising if nothing is done to reduce it. 35% is considered to be an excessively high loss. By comparison, Figure 2 at the back of this report shows the estimated UAW for various countries as presented in the WRC report to the International Water Supply Association in 1989. Admittedly this information is somewhat dated, however it is expected that these country's UAW would have reduced since 1989 due to the international focus that UAW and water loss management has received in the last decade. However, Figure 2 does illustrate that Kimberley's UAW compares relatively poorly with international averages.

UAW represents a substantial cost to SPM in terms of unnecessary water supply costs and loss of revenue. It is accepted that there is no water supply system that can be entirely loss free therefore in practice there will always be UAW. It is therefore necessary to set a target UAW which provides an equilibrium between the loss of revenue and the cost of reducing UAW. SABS 0306 : 1999 suggests a target between 8 – 15% and in the case of SPM it is assumed that an achievable target is 15% of water purchased. In that case, the theoretical cost of excess UAW during the last five financial years is estimated as follows:

Table 3 : Theoretical cost of excess UAW

	Financial Year				
	1997/98	1998/99	1999/00	2000/01	2001/02
Volume Purchased	22,504,763 kl	22,164,654 kl	21,586,868 kl	22,970,286 kl	22,549,435 kl
Target UAW (15%)	3,375,714 kl	3,324,698 kl	3,238,030 kl	3,445,543 kl	3,382,415 kl
Target sales at 15% UAW	19,129,049 kl	18,839,956 kl	18,348,838 kl	19,524,743 kl	19,167,020 kl
Actual sales (kℓ)	16,444,539 kl	17,569,517 kl	15,929,477 kl	15,613,795 kl	13,949,266 kl
Theoretical loss	2,684,510 kl	1,270,439 kl	2,419,361 kl	3,910,948 kl	5,217,754 kl
Actual sales (R)	R 36,419,261	R 46,083,933	R 39,318,353	R 42,839,395	R 43,146,009
Average selling price	R 2.21	R 2.62	R 2.47	R 2.74	R 3.09
Theoretical cost of excess UAW	R 5,945,308	R 3,332,295	R 5,971,651	R 10,730,425	R 16,138,860

The calculations above represent the worst case cost scenario since they use the average selling price (actual sales divided by units sold) to calculate the theoretical cost of excess UAW. In fact the excess UAW is made up of both physical loss and administration loss. The cost to SPM of 1kl of water that is lost by physical loss e.g. a burst pipe, is the cost of water supplied i.e. R3.63 whereas the cost to SPM of 1kl of water that is lost by administration losses e.g meter inaccuracy, is the cost at selling price i.e. say R4.43. The contribution to excess UAW of physical loss and administration loss is unknown therefore the theoretical cost of excess UAW cannot be calculated accurately.

3.3 WATER CONSUMPTION GROUPS

The volume of water sold during the last five financial years has been broken down into the various consumer groups and this is shown in Table 4 below and in Figure 3 at the back of the report.

Table 4 : Water sales by consumer group

	Financial Year				
	1997/98	1998/99	1999/00	2000/01	2001/02
Domestic	10,627,567 kl	10,771,836 kl	10,491,284 kl	10,884,410 kl	9,449,843 kl
Flats	75,059 kl	105,105 kl	107,850 kl	112,978 kl	126,742 kl
Parks & Schools	1,245,664 kl	1,598,070 kl	1,154,045 kl	1,203,036 kl	1,200,320 kl
Charities & Churches	242,629 kl	204,160 kl	243,772 kl	217,053 kl	218,160 kl
Commercial	4,146,990 kl	3,586,197 kl	2,624,186 kl	2,065,948 kl	1,843,894 kl
Industrial	106,630 kl	1,304,149 kl	1,308,340 kl	1,130,370 kl	1,110,307 kl
Total Volume Sold	16,444,539 kl	17,569,517 kl	15,929,477 kl	15,613,795 kl	13,949,266 kl

There are three interesting points to notice from these records:

- There is a steady(21%) decline in the volume of water sold during the last four financial years, in spite of a constant volume of water supplied. This suggests that administration losses are significantly responsible for the high UAW since the decline in sales is not met with a corresponding decline in purchases.

- There is a steady and rather dramatic (55%) decline in the volume of water sold to the commercial group during the last five financial years. This suggests that administration losses are a significant part of the UAW in this category since decline in water sales has not been met with a corresponding exodus of business from Kimberley during this period. There have been some notable business closures, including the abattoir, SA Bottling, SA Breweries to name a few large water consumers, however this is not expected to have had such a large impact on commercial water demand. Furthermore, it is rather unlikely that business has reduced its water consumption to this extent during the last five years, and more unlikely that the decline is a result of the theft of water, therefore it can be concluded that the decline is a result of administration losses.

- Domestic consumption is by far the largest consumer group and industrial consumption is a relatively small consumer group. Domestic consumption remained more or less constant during the first four years followed by a fairly dramatic decrease in 2001/02. This is totally opposite to a gradual year on year increase that could be expected.

It is clear from the information presented above that water sales are dropping in spite of an increasing water demand. This scenario results in an increasing UAW which must be addressed. The objective is to determine the components of UAW and how to address the causes of these components.

4. INFRASTRUCTURE

4.1 WATER TREATMENT WORKS

The Riverton complex comprises a water treatment works to purify raw water abstracted from the Vaal River under a permit issued by the Department of Water Affairs and Forestry. Water is abstracted from the river by low lift pumps in two intake towers in the Vaal River. It is then treated at the treatment works which has a capacity of 163 Ml/day. The treatment process comprises conventional flocculation, sedimentation, filtration and disinfection. Treated water is stored in three balancing reservoirs with a combined capacity of 31.0 Ml. The individual capacities of these reservoirs is 2.0 Ml, 9.0 Ml and 20.0 Ml respectively. Treated water is then pumped to Kimberley by high lift pumps that are housed in two adjacent pump stations. The pumps lift the water through a static head of 147m between Riverton and the Newton reservoir complex, applying a maximum pumping head of 216m.

Raw water is measured by four Krohne electromagnetic flow meters at the low lift pumps. Treated water is measured by two Krohne electromagnetic flow meters at the high lift pumps, one on each rising main. These meters are calibrated by the supplier every quarter. Calibration records are not kept by the operations staff. The flow meter readings are displayed on the operators control panel inside the water treatment works. This display can show instantaneous flow rate and totalised volume.

Process losses are currently 5.2% of volume of water purchased, however they have reached up to 14% in the last five years. 5% is considered to be a maximum process loss and this should be fixed as the target loss.

The treatment process has not been assessed in any detail in this study, but the historical process losses suggest that there are potential savings to be made by reducing process losses.

Recommendation : *Meter calibration certificates should be kept on file.* *A detailed study of the water treatment process should be carried out to assess the scope of reducing treatment losses to a minimum.*

4.2 ZONE METERS

4.2.1 Water supply districts and zones

SABS 0306:1999 defines a zone as “a separately isolatable section of a subdistrict, usually not exceeding 2000 residential properties or their equivalent, and in which quantities of water entering and leaving can be measured”. It defines a subdistrict as “ a separately isolatable section of a district that comprises one or more zones in which quantities of water entering and leaving can be measured, but that probably does not exceed about 10,000 residential properties or their equivalent”.

According to these definitions, Roodepan, Kimdustria, Homevale and Galashewe are considered to be discrete zones where the zone meters can be used to carry out water balance and leak detection. The balance of the reticulation i.e. central Kimberley is relatively flat land that has been extended incrementally during the growth of the City, resulting in a large network of small diameter reticulation mains rather than discrete zones that are fed by trunk mains. Such a network layout is not easily isolated into discrete zones or districts.

A cursory inspection of the water reticulation drawings shows that the reticulation could be divided into approximately eleven zones, based purely on the layout of the reticulation. These zones would have to be checked by detailed network analysis with an updated, verified and calibrated WADISO model. The possible zone demarcation is shown in Drawing 10757 PE002.

There are six water meters at Riverton as described above. In Kimberley there are ten district meters. There is one at Roodepan, two at Kimdustria, two at Homevale, three at Galashewe and two at the Newton reservoir complex. There are no district meters in the city centre area. These meters are not read regularly and are not used for the logging of flow and pressure. Some of these meters are out of commission due to vandalism or other damage, and none of them have been calibrated since installation in 1998. Consequently there is no baseline minimum night flow analysis, leak detection, water balance or water audit data for these zones.

Recommendation :
The water reticulation should be divided into the proposed discrete zones, to be checked by specific WADISO modelling, and zone meters should be installed at the entrance to those newly established zones.
The existing zone meters should be repaired and re-calibrated as appropriate.

4.2.2 Water auditing

SABS 0306:1999 defines a water audit as "a procedure to account for the water entering an area through a meter and the cumulative consumptions within the area, taking into account the distribution layout and the nature of the area".

Water auditing is an essential part of water loss management. It is a water balancing and accounting exercise that provides management with the information required to make informed decisions on how to reduce water loss, if carried out in accordance with SABS guidelines.

SPM can begin the water auditing process when discrete zones have been demarcated, zone meters installed and baseline data obtained from the logging of these zone meters for a period of at least three months. Water auditing can only be carried out accurately when the GIS and FMS are properly linked, so that the consumption in each zone can be measured from the spatial presentation of the FMS data.

Recommendation :
Water auditing procedures should be initiated in accordance with SABS 0306 : 1999 for existing zones and new zones as they are established.

4.3 CONSUMER METERS

The SPM's preferred choice of consumer meter is the Elster Kent PSM (brass) or KSM (plastic) meter in the small diameters and the Meinecke large diameter meters. Castle meters were also used in previous years yet they are no longer installed now.

4.3.1 Meter age

The installation date of all consumer meters have been extracted from the Treasury database. The Treasury database has been cross checked with the Water Works database of consumer meters by taking a random sample of twenty meters and comparing the meter number and address. In all cases there was a match of address but in ten (50%) cases the meter number was different. This shows that there is a significant discrepancy between the electronic Treasury database and the manual card system used at Water Works. The Treasury database is widely regarded as the most complete and up to date inventory therefore this database has been used for the analysis of water meter age. This does not imply that the Treasury database is in fact complete and up to date.

A total of 39,382 water meters are entered on the treasury database. This figure does not however agree with the statistics represented in Table 1. This discrepancy needs to be accounted for by the Treasury Department. Water meter information was included on the Treasury database for the first time in early 1993 and the installation date of all existing water meters was entered as 1 January 1993. This means that all water meters on the Treasury database that show an installation date of 1 January 1993, are ten years of age, or older.

The age distribution of water meters is shown in Table 5 below:

Table 5 : Water meter age distribution

Year installed	Age (years)	No. of meters	Percentage (%)
- 1993	10 years and older	22,974	58.3 %
1994 - 1998	5 – 10 years	12,592	32.0 %
1999 - 2003	0 – 5 years	3,816	9.7 %
Total		39,382	100 %

The most economical time to replace a water meter is when the cost of replacing the meter equals the cost of maintaining the meter (maintenance cost and loss of revenue due to inaccuracy). The service life of a meter is dependent on the quality, class and rate of decline of accuracy of the meter.

Two hypothetical scenarios have been analysed for the purposes of estimating the optimum meter replacement age. These two scenarios, a low income group domestic consumption and a middle/high income group domestic consumption, are shown in Figure 4 at the back of this report. The scenarios are based on the following assumptions :

- Meter replacement cost is R340-00 per meter (average of 15mm and 20mm meters)
- Water consumption in the case of low income groups is 10 kl per month at an equivalent tariff of R2.20/kl
- Water consumption in the case of middle and high income groups is 50 kl per month at an equivalent tariff of R4.66/kl
- Meter accuracy declines on a hypothetical compounding basis at 20% per annum after 3 years of accurate measurement within a 2% tolerance

The conclusions that can be drawn from this analysis are :

- The optimum meter replacement age is heavily dependent on water tariff and the volume passing through the meter, the higher the tariff and volume, the shorter the life of the meter.
- It is also dependent on meter replacement cost and anticipated error, but to a lesser extent than the above two variables.
- The meter replacement cost reduces exponentially with time and the optimum meter replacement age, according to meter age alone, is ten years as the cost of meter replacement reduces at an insignificant rate after ten years.
- The theoretical optimum meter replacement age is shorter for high volume consumers and longer for low volume consumers.
- The optimum meter replacement age is seven years for high volume consumers and fourteen years for low volume consumers. Seven years is a very short life for a water meter and we do not propose such regular meter replacement. A more realistic meter replacement age is ten years for high volume consumers and fourteen years for low volume consumers.

Based on the above analysis, it can be concluded that 58% of the water meters in Kimberley are in need of replacement. These meters have exceeded the optimum replacement age and are most likely responsible for significant loss of revenue.

Recommendation :
The discrepancy between the number of consumer meters on the FMS and the number of meters on statistics must be verified by the Treasury Department.
A routine water meter replacement programme should be implemented to replace old meters. Refer to item 4.3.6

4.3.2 Meter restrictors

It is SPM's policy that defaulting account holders are penalised by the insertion of a 1.5mm restrictor into the water meter. The restrictor reduces the flow through the meter to a trickle flow that offers a "lifeline" water supply. This supply is inconvenient and is expected to encourage the consumer to pay the outstanding account. There is no evidence to indicate whether defaulting consumers do settle their accounts after the restrictor has been installed.

A total of 9776 such restrictors are installed at present. SPM have found that approximately 3000 of the restricted meters have stopped recording as a result of the installation of these restrictors. SPM have also found that when the restrictors are removed, approximately 80% of these meters record the low flows properly again. It should be noted that the ability of a water meter to measure low flows declines from the date of installation, therefore it can be expected that low flows through old water meters with a restrictor will escape measurement.

The theoretical volume of water that escapes measurement in these cases is estimated by assuming that each household consumes 10 kℓ/month, in which case the total volume of water loss is 360 000 kℓ/year (3000 erven x 10 kℓ/erf/month x 12 months/year).

SPM are considering the use of larger diameter restrictors as they have received complaints from defaulting consumers that their water supply is inadequate. Larger restrictors will allow more flow through the meter, and this flow will more than likely also escape measurement. In our opinion, larger restrictors will allow enough flow to defeat the object of using restrictors and will lead to more water loss.

The problem with restrictors is twofold: firstly the restrictors easily become blocked, necessitating regular maintenance and replacement of meters unnecessarily. Secondly the restrictors often lead to loss of revenue as the meter allows water to pass through it without recording the flow.

Recommendation :
Council should review the policy of meter restrictors and how effective they are at encouraging defaulting consumers to pay their accounts.
Council should also consider removing the restrictors and using alternative means of dealing with defaulters such as cutting off electricity, or in the case of indigent defaulters, charging a flat tariff.

4.3.3 Meter sizing

Large water consumers typically require large diameter meters that can measure the larger volumes of water. Such consumers will include commercial, industrial, institutional or multiple domestic consumers (flats, townhouses).

At present these meters are sized according to the size of the water main/connection rather than the anticipated flow rate through the meter. The ability of the larger diameter meters to measure low flows is limited, and the volume of water escaping measurement at low flows increases with meter size. Consequently, if the meter is oversized, as tends to be the case when sizing the meter according to the size of the water main, then the volume of water escaping measurement at low flows is increased further.

A sample of 20 large diameter meters were chosen at random and the size of the meter was compared with the consumers average consumption. All 20 meters were either one or two sizes too large according to the meter specifications and the average flow rates. Fire flow has not been taken into account in this assessment and will play a role at consumers with a high fire risk. However it can be concluded that the majority of large diameter meters are oversized and that this will lead to loss of revenue as the low flows will escape measurement. Unfortunately, the volume of water escaping measurement by oversized meters cannot be reliably estimated.

In order to avoid this problem, large diameter meters should be sized according to the anticipated flow rates through the meter. The flow rates to be considered when sizing these meters are the starting flow, minimum flow, recommended continuous flow and the maximum (fire) flow. The anticipated flow rate can be based on municipal experience, fire requirements and the estimating procedures set out in SABS 0252-1:1994 Water supply and drainage for buildings.

If the range of flow is too wide to be accurately measured by a large diameter meter, it is preferable to use a combination meter which is a meter unit comprising both a large diameter and a small diameter meter. A combination meter can accurately measure the low flows as well as the higher flows. Combination meters should be used in applications such as large office complexes, schools or any consumer that will have a wide-ranging consumption from say a single toilet flush through to large-scale irrigation or wet industry processes.

Recommendation
Large diameter meters at new installations should be sized according to the procedure mentioned above. The size of all existing large diameter meters should be checked against the consumption pattern and the average measured consumption of the consumer. Those meters that are oversized should be replaced with correctly sized meters or with combination meters, as appropriate.

4.3.4 Meter accuracy

A sample of 96 consumer meters were randomly selected and tested at SPM's test bench in Kimberley (the test bench is not part of an accredited measuring facility but it is considered to be accurate and the results can be regarded as reliable. Two tests were performed on each meter, a slow test for which a controlled volume of water was passed through the meter at a flow rate of 0.4 l/min and a fast test, for which a controlled volume of water was passed through the meter at a flow rate of 19 l/min. The purpose of conducting both tests was to assess the performance of the meter under both low flow and normal (typical) flow conditions and to assess the difference in performance at the two flow rates. Time did not permit more meters to be tested, however the results of these tests can be regarded as representative of all consumer meters.

The results of the meter tests are summarised in Table 6 below and the results of each test are tabulated in Appendix 1 :

Table 6 : Summary of meter test results

	Slow test		Fast test	
	No. of meters	% of total	No. of meters	% of total
No. of meters tested	96	-	70	-
No. of stuck meters (zero flow measured)	37	39%	10	14%
No. of meters within 2% tolerance	9	9%	33	47%
No. of meters outside 2% tolerance	50	52%	27	39%
Ave % error of meters outside tolerance (excl. stuck meters)	-	-20%	-	+1%

The results of the tests show that a large percentage of water meters are either stuck i.e. they do not register any flow through the meter and also that a large percentage of meters are outside an acceptable 2% tolerance. The combined effect of these two findings is that meter condition and inaccuracy leads to UAW and revenue loss.

Other conclusions that can be drawn from these test results are :

- Meter inaccuracies are both positive and negative which results in some inaccuracies cancelling each other out. The large majority of inaccuracies are negative, leading to a negative water balance and loss of revenue.
- Meter error is largest at the low flow rate than at the high flow rate.

If the results of these tests are assumed to be representative of all meters, and if it is assumed that 10% of water supplied is consumed at low flow rates (based on ABB Kent research), then the theoretical loss of water due to meter error is estimated as follows:

Stuck meters	14% of water supplied	equals 14% of water supplied
Meters stuck at low flow only	25% of 10% of water supplied	equals 3% of water supplied
Under reading meters	20% of 10% of water supplied	equals 2% of water supplied
Over reading meters	1% of water supplied	equals (1%) of water supplied
Total loss due to meter error		18% of water supplied

Admittedly this is not an accurate calculation as it is based on percentages and on a small sample of data, yet it does illustrate the potential magnitude of the losses due to meter inaccuracy. If the assumed low flow rate is reduced to 5% (conservative) of water supplied, then the water loss due to meter error would reduce to 15% of water supplied. It can therefore be concluded that meter inaccuracy is responsible for losses between 15 – 18% of water supplied, which represents approximately 45% of UAW.

Recommendation :
Further testing should be carried out to verify the results of these tests before embarking on the meter replacement programme, as proposed in item 4.3.6.

4.3.5 Water quality

Copies of chemical analyses of treated water samples taken during the last year are attached in Appendix 2. According to these analyses, the parameter of most concern with respect to water loss is the $CaCO_3$ precipitation potential. Based on these analyses, the water is aggressive, and is likely to dissolve calcium from cementitious pipes and cause corrosion of steel pipes and fittings. This deduction corresponds with the burst problems encountered in the water reticulation.

Based on the average $CaCO_3$ precipitation potential at the Newton reservoir complex (-15mg $CaCO_3$ /l), each Megalitre of water has the "potential" to dissolve 6 kg of calcium from the cementitious pipes and reservoirs. Although it is unlikely that all 6kg will be dissolved, the effect of this water is to weaken the pipes with time.

This situation could be addressed by installing a stabilization process at the water treatment works which would involve either lime and carbon dioxide dosing, lime dosing only or calcium carbonate contact. The choice of stabilization process requires a more thorough analysis. The stabilization process can prevent further weakening of pipes but it cannot repair the damage already done thus far.

The water quality parameter that affects the condition and accuracy of water meters is suspended solids. The suspended solids of these chemical analyses show that the treated water is relatively free of solids at the sampling points. The aggressive water will result in loose rust particles in the water reticulation and the high incidence of bursts will also lead to suspended solids entering the reticulation.

The effect of suspended solid particles on the meter is to

- Partially or completely block the meter, especially in the case of the meters with restrictors, as the restrictors trap solid particles easily. This requires unnecessary maintenance or replacement of the meter.

- Accelerate wear on the meter and therefore reduce its accuracy and shorten its life.

Recommendation :
A more detailed analysis of the water treatment process should be carried out to determine the best process required to stabilize the aggressive water.

4.3.6 Meter replacement programme

SPM Water Works department are responsible for meter replacement. The typical installation begins with an instruction from the Treasury Department to install/repair meters. These instructions normally arise from a consumer complaint, a new installation or from a Treasury exception report. There is no formal meter replacement programme that aims to replace water meters on a routine programme.

Item 4.3.1 shows that the optimum meter replacement age is ten to fourteen years. A meter replacement programme should therefore be implemented on a routine basis to ensure that meters are replaced before they exceed the optimum replacement age. Due to the large number of meters that need to be replaced, it would be necessary to implement the meter replacement programme in two phases as follows:

- Phase one : a high intensity meter replacement programme to replace all meters that are older than ten or fourteen years respectively. This phase should be carried out on a project basis over a five to six year period by independent contractors.

- Phase two : a lower intensity replacement programme that is designed to replace meters when they reach the optimum replacement age. This phase should be carried out on an ongoing basis by SPM Water Works department.

An important requirement of the meter replacement programme is to replace the oldest meters first. The highest priority will therefore be the large diameter meters, followed by the commercial consumer meters, followed by the high and middle income group domestic meters followed by the low income group domestic meters.

Recommendation :
A two phase meter replacement programme should be implemented in such a manner that ensures that meters are not in service longer than the optimum meter replacement age.

4.4 RESERVOIRS

Kimberley has two water storage facilities in the water reticulation, namely the Newton reservoir complex in Kimberley and the Roodepan water tower in Roodepan.

- Newton reservoir complex
  The Newton reservoir complex is situated at the highest point in Kimberley. The reservoir complex comprises four ground level reservoirs with a combined capacity of 261.5 Ml at a common top water level of 1247 mamsl and an elevated water tower with a capacity of 452 kl and a top water level of 1267.5 mamsl. The respective individual capacities of the four reservoirs are 23.0 Ml, 45.5 Ml, 91.0 Ml and 102.0 Ml. The small capacity of the elevated water tower means that its capacity is not regarded as storage but merely as a balancing reservoir for the purposes of providing adequate pressure in the high level zone.

At the current AADD of 58.5 Ml/day, the storage capacity of 261.5 Ml is equivalent to approximately 4.5 days storage, which is more than adequate.

There are three low lift pump-stations at the reservoir complex that pump water from the ground level reservoirs up to the water tower and also directly into the reticulation.

- Roodepan
  There is an elevated water tower with a capacity of 750 kl and a top water level of 1183.9 mamsl at Roodepan. This water tower is fed from Riverton when the Riverton pumps are switched on, or by gravity feed from the Newton reservoir complex when the Riverton pumps are switched off.

4.4.1 Reservoir cleaning and inspection

One reservoir is cleaned each year, which means that each reservoir is cleaned every five years. When a reservoir is cleaned, the water level in the reservoir is first drawn down to approximately 1.0m depth. The remaining water is then pumped/scoured to waste via the stormwater drainage system. The reservoir roof, walls and floor are cleaned and then inspected by a SPM structural engineer for structural integrity. Although these inspections are essential, it is unlikely that they would reveal minor cracks that would lead to water loss. Routine maintenance is also carried out when the reservoir is empty.

4.4.2 Reservoir losses

Reservoir losses occur as a result of flushing (as above), overfilling and leakage from a reservoir.

SPM staff report that there have been very few overflows from reservoirs and could recall only one occasion of overflowing at the Roodepan water tower that was due to a faulty inlet valve, which was repaired successfully.

The Newton reservoir overflow system is a bellmouth arrangement situated inside the reservoir. The overflow pipe is connected to the scour outlet pipe that leads to the stormwater drainage system. It is possible that overflows occur, since overflowing water will go unnoticed, particularly due to the manual operating rule. However, this is regarded as unlikely as the water level in the reservoirs is monitored hourly by staff who are on duty 24 hours per day. Nevertheless, it is possible that in the low demand, winter months that a combination of events could lead to overfilling.

SPM staff also reported that they are not aware of any leaks from reservoirs, either now or in the past. It was reported that staff at the reservoir complex inspect the valve chambers and the ground surrounding the reservoirs for signs of leakage. However, leaks in reservoirs are common yet seldom visible, especially when there are no reservoir under-drain inspection chambers as is the case here.

The valve chambers were inspected during our visit to the reservoir complex. The shallow chambers were dry but there was water lying at the bottom of one of the deep chambers. It could not be determined whether this was groundwater, rainwater or leakage water. It is unlikely to be groundwater at that level and it is also unlikely to be rainwater as there had been no rain and other chambers were dry. Therefore it is most likely to be leakage water, either from the reservoirs or from the pipes.

<u>Recommendation:</u>
Deep (foundation level) inspection chambers should be excavated around the reservoirs and these chambers should be regularly monitored for leakage from the reservoirs.

Drop tests (precise measurement of water level with sealed inlet and outlet over a fixed time period) should be carried out on each of the four storage reservoirs at the Newton reservoir complex at least once a quarter. The reservoir leakage results of these drop tests should be recorded as a quantity per day and as a percentage of storage.

Reservoir levels should be monitored electronically and incorporated in the proposed telemetry and SCADA system.

4.4.3 Reservoir configuration

At the Newton reservoir complex, there are nine pumps situated in three pump stations that pump treated water into the water tower and directly into the reticulation.

It is not ideal to pump directly to a reticulation because the pump start/stop condition can lead to pressure surges that could in turn lead to pipe bursts. Pressure reducing valves are installed on the discharge pipes from the Newton pumps to the reticulation.

<u>Recommendation</u> :
The pressure reducing valves should be checked and monitored by data logger on a regular basis to establish whether pressure surges are occurring in the reticulation as a result of pump start/stop condition.

4.5 DISTRIBUTION PIPELINES

4.5.1 Burst and leak repairs

The procedure for the reporting and dealing with bursts and leaks is as follows. The public reports bursts to the Municipality and the call is diverted to the Water Works office, which is open from 7:00am to 4:45pm. They have an office hours telephone number and there is also a 24hr emergency telephone number. There used to be a toll free number but this was discontinued when staffing arrangements changed and because the toll free number was abused.

The report is logged by hand in a book and it is then passed on by radio message to the next available maintenance team. Complaints are prioritized so that bursts receive earlier attention than minor complaints such as a leaking meter. The maintenance team then goes out to repair the burst. The maintenance team does not report back to Water Works to close out a complaint. However, a backup check that bursts are dealt with, is the number of complaints received for one event, i.e. if the burst isn't repaired timeously the municipality receives many complaints for the same event.

The target response time is 1hour during working hours and 1.5 hours after hours. The target repair time is a maximum of 6hours. Legislation requires the repair of leaks within 48 hours.

There is no consumer education campaign to encourage the public to report bursts and leaks.

The maintenance of pipes and the repair of bursts and leakage is reactive. Proactive leak detection is not carried out at present. As a result there is no data to show the volume of leakage losses. This means that it is not possible to calculate the baseline specific loss rates in terms of kl/hour/km or kl/connection etc.

The only data available to measure the effect of bursts and to draw comparisons with guideleines are the number of bursts. The number of bursts during the last three years is presented in Appendix 3. These details are summarized in Table 7 below:

Table 7 : Summary of burst frequency during the last three years

Year	PIPE MATERIAL AND SIZE											
	AC		STEEL		uPVC		HDPe		UNDEFINED		R. MAIN	TOTAL
	S	L	S	L	S	L	S	L	S	L		
2000	813	0	81	118	35	-	39	-	29	4	15	1134
2001	442	3	39	96	18	-	48	-	45	6	17	714
2002	344	11	14	51	3	-	31	-	7	4	1	466
TOTAL	1599	14	134	245	56	-	118	-	81	14	33	2314

S = Small diameter pipes = up to and including 150mm diameter
L = Large diameter pipes = larger than 150mm

Table 7 shows that the significant majority of bursts occur on small diameter AC mains and the least bursts occur on uPVC mains. The most interesting observation is the decline in the number of bursts over the last three years, which is in contrast to the increase in UAW over the last three years. Although the frequency of bursts is no measure of the volume of water loss, this would suggest one of three possibilities :

- Physical water loss by bursts have not increased over the last three years.
- Water Works are attending to fewer bursts than before for whatsoever reasons
- Record keeping of the maintenance database is deteriorating.

We expect that it is a result of the second and third items as there is no other evidence to suggest that the condition of the network and therefore the burst situation has improved. It must be noted that this data is derived from handwritten records. SPM believe that there has not been a reduction in burst over the last three years, which means that these records are not reliable. This underlines the need for an electronic maintenance database.

Typical burst frequencies for a water supply system are:

- Trunk mains
  - Good : 0.015 – 0.020 per km per year
  - Below average : 0.06 – 0.07 per km per year

- Distribution mains
  - Good : 0.10 – 0.15 per km per year
  - Average : 0.20 – 0.35 per km per year
  - Poor : 0.40 – 0.55 per km per year

The total length of distribution mains, according to the WADISO model is 675 km. There were 465 bursts on the distribution mains in 2002, which equates to a burst frequency of 0.69 per km per year, which is poor in terms of the above guideline. This frequency is for the entire distribution and will therefore be higher in zones that have higher burst frequencies.

A summary of the maintenance book is shown in Table 8 below. This summary shows that the number of leaks has increased over the last three years in contrast to the number of bursts. This confirms the view that the physical water loss by bursts has not decreased over the last three years.

Table 8 : Summary of maintenance activities

Year	Repairs					Replacement		
	Network Leaks	Meters	Leaking communication pipes	Valves	Public Standpipes	Meters	Meter boxes	Valves
2000	2527	3637	1710	141	96	315	186	145
2001	3295	4540	1850	130	89	451	262	70
2002	4449	2859	625	110	62	409	259	39
TOTAL	10271	11036	4185	381	247	1175	707	254

Another interesting observation is the decline in the number of meter repairs over the last three years. There is no evidence to suggest that there are less meters requiring maintenance, on the contrary there are more. This shows that the maintenance teams are concentrating on network leaks, to the detriment of water meters.

Recommendation :
The efficiency of the maintenance teams should be investigated more closely and if required additional teams should be provided, or a bonus incentive scheme should be introduced to improve efficiency, as appropriate.

4.5.2 Factors affecting the number of bursts and leaks

There are various factors that affect the number of bursts and the volume of water leaking from the reticulation, such as:

- Water pressure, the higher the pressure the more water is lost from a burst/leak
- Pressure surges, sudden pressure surges will lead to damage of pipes.
- Soil type. Clays are subject to movement as the moisture in the soil varies. This movement can crack rigid pipes. Leaks are not easily seen in course, gravely soils. The soil profile of the Kimberley area is extremely variable with expansive clays in most of Roodepan, Homevale, Homelight and Homestead, a mixture of clays, collapsible sands and rock in Galashewe, and a mixture of lime and intact dolerites in Kimberley.
- Traffic vibrations induced by heavy vehicles can cause movement and cracking of rigid pipes
- Pipe material and age
- Water quality, aggressive water can have the effects mentioned in item 4.3.6
- The quality of bedding material and the standard of workmanship when laying and maintaining the pipe.

There is no evidence to suggest which of the above factors have the most effect on bursts and leaks in Kimberley.

4.5.3 Factors affecting the burst response time

There are a number of factors that affect the response time to bursts.

- The fact that not all zones are monitored by zone meters, the Kimberley City zone is too large, and that none of the existing zone meters are logged by data loggers means that there is no way of pro-actively identifying the occurrence of a burst. This increases the duration between the occurrence of, and the reporting of the burst. It will also result in smaller invisible bursts and leaks going undetected.

- The absence of a complete GIS showing the layout of the water reticulation, the position of valves and hydrants, and other underground services prolongs the response time between the complaint and the time that the water pipe is isolated and drained. This leads to time wastage while staff search for valves to isolate the burst and/or time wastage during the repair of damage to another service. The waste of time has an obvious impact on water loss, but the fact that valves are not easily found sometimes means that unnecessarily large areas of the reticulation need to be isolated in order to isolate the burst. This means that there is a more widespread disruption to consumers and it also means there is more water loss as a larger area of the reticulation must be scoured. Furthermore, such cases lead to additional water loss due to scouring the larger area of the reticulation after the repair to expel air and dirt.

- The absence of a GIS terminal at the Water Works office that can be used to identify the position of services immediately after the complaint is received.

- The limited number of maintenance teams leads to long delays in the response to lower priority complaints.

Recommendation :
Additional zone meters should be installed and should be logged on a regular basis to identify bursts.
The GIS must be completed and a terminal should be provided at the Water Works office.

4.5.4 Maintenance database

Maintenance of the water distribution system is recorded in a book by hand as mentioned above. These records are summarised monthly for management reports. This method is prone to several types of administration error e.g. incorrect spelling of street names, incorrect job description, to name a few. As such the maintenance database is extremely inaccessible therefore it is not a useful management tool for the monitoring of the maintenance service.

Recommendation :
An electronic database programme should be written by software developers specifically for SPM Water Works. This programme must be a Windows driven programme with a link to the GIS. Data should be entered by selecting check boxes or multiple choice selections. Entering of data by typing text should be kept to an absolute minimum. The database should have a list of street names, fault type, pipe diameter, pipe material, automatic time, date and age of complaint etc. The programme must run reports that summarise the contents of the database easily and clearly. It must be possible to generate a report in a format that can be used by the GIS to display summarized complaint details graphically on a plan of the water reticulation. This programme must be accessible to management via the network at all times.

SPM are in the process of implementing the Tasker programme. This programme should be tested for the abovementioned functionality and if not suitable it should be customised to meet these requirements.

4.5.5 Leak detection

As mentioned previously, the high level zone in Kimberley is not easily divided into discrete zones for water balancing and leak detection purposes. Furthermore there are not enough water meters at the Newton reservoir complex to measure all the flow leaving the reservoirs. A simple method of establishing the minimum night flow would be to fill the reservoirs during the day, isolate all but one reservoir after the evening peak and to measure the water level precisely from 12:00am to 4:00am. This method is only feasible if drop tests and valve inspections have been carried out beforehand. This is merely a first order estimate of leakage losses and should not be used as a substitute for proper minimum night flow analysis in each zone.

> <u>*Recommendation*</u> *:*
> *Measure minimum night flows to establish worst leakage zones, carry out water audit, then start leak detection with leak detection equipment.*

4.5.6 Pipe replacement programme

The Kimberley water reticulation consists of asbestos cement, steel, cast iron, uPVC, HDPE and cast iron pipes with ages varying up to 130 years old. Various problems are encountered with the older pipes such as the failure of the lead filled joints of the cast iron pipes, corrosion of the steel pipes and leaching of the cement from asbestos cement pipes, especially those that were not bitumen dipped.

Due to the large number of bursts and leaks, it is necessary to implement a systematic pipe replacement programme to replace those pipes that are more economical to replace than to continue repairing. It is difficult to determine the optimum time to replace a pipe in terms of age, number of bursts, material etc. A rule of thumb that is proposed for urban reticulation is to replace pipelines that burst more than once per year per km. The maintenance database does not provide this information clearly therefore three drawings of the city showing :

- Frequency of bursts by area (this drawing is based on the handwritten records which are incomplete. Approximately half of the burst records are shown on this drawing due to the mismatch of the maintenance data to the FMS)

- Pipe age (which is based on the historic growth of the City, assuming that the pipes were laid when the areas were developed and that the pipes have not been replaced since)

- Static water pressure

have been prepared to assist SPM identify the worst burst areas. Refer to Drawing 10757 PE003, 10757PE004 and 10757 PE007. These areas should be prioritised for routine pipe replacement. This drawing is intended to assist SPM start a pipe replacement programme now rather than wait until the zone meters have been calibrated/repaired/installed. It is not intended to replace the conventional leak detection process.

> <u>*Recommendation*</u>
> *A systematic pipe replacement programme should be implemented for the on-going replacement of those pipes that require regular maintenance and are responsible for the most water loss.*

4.5.7 Pressure management

At present pressure management is used in the form of :

- Pressure reducing valves (PRV) at the offtakes from the Riverton rising mains to the reticulation at a place known as Lang Bome (Galashewe) and Platfontein (Galashewe)

- A water tower at the offtake from the Riverton rising main to the reticulation at Roodepan

- A water tower at the Newton reservoir complex to increase pressure at the flat high level zone in Kimberley

These measures are essential to protect the reticulation from the high pressures in the rising main. SPM have encountered bursting problems in the reticulation when these PRVs have malfunctioned in the past.

The water reticulation was analysed by SPM/Africon Consulting Engineers with the use of a WADISO network analysis model. The static pressure and peak flow pressure conditions as determined from that model are shown in Drawings 10757 PE004 and 10757 PE005 at the back of this report. These drawings show that there is a significant variation between peak and static pressure conditions at some points in the reticulation, and that pressures are generally below 6.0 bar. There are however some areas where the static pressures are in excess of 8.0 bar, yet these are not high burst frequency areas.

Given the large number of bursts that occur in the aging reticulation and given the assumption that there will be a significant amount of undetected leakage, high pressures will lead to more water loss than low pressures. Hydraulic theory shows that the volume of water that escapes from a leak is dependent on the size and shape of an opening and the pressure in the main. It would therefore be beneficial to extend the scope of pressure management of the water reticulation.

Pressure management would take the form of the installation of PRVs at the entrance to discrete zones. The design of such a system is a detailed task that needs careful network analysis and the PRVs require careful sizing and location. This is beyond the scope of this study but it should be carried out as part of the water loss management programme.

Pressure reduction is advantageous for the following reasons:

- It has a significant impact on background leakage as high pressure leads to high leakage.
- It will lead to fewer bursts, where bursts are occurring as a result of high pressures
- There will be fewer interruptions of supply to consumers
- It will reduce water demand since plumbing leaks and legitimate consumption downstream of the consumer meter will reduce
- Cost savings will be realised when installing new pipes at lower pressure classes.

Recommendation :
A pressure management system should be designed to reduce pressures in the high pressure zones of the reticulation to a maximum of 6.0 bar.

4.5.8 Monitoring, measurement and control

The Riverton treatment works and the high lift pumps are operated manually. The high lift pumps are either operated at fixed times to coincide with off peak energy periods, or by telephonic instruction from the operators at the Newton reservoir complex, if for instance the water level in the Newton storage reservoirs is low. This operating rule will lead to inefficient energy consumption, particularly over weekends and public holidays. It will also lead to potential water loss e.g. accidental overfilling of the Newton reservoirs.

The pumps at the Newton reservoir and water tower are operated manually. The level in the water tower is observed by a float gauge. When the level drops too low the operator manually starts the pumps and when it rises too high he stops the pumps. There are three sets of pumps that pump to the water tower. The small pumps pump to the water tower 24 hours per day. When the level in the water tower drops below a certain level, the operator switches the larger pumps on. If the demand is still too high then the operator switches the third set of pumps on. There is also a float switch with a siren alarm to report a high level and low level condition.

In our opinion, the manual operation of such a large number of important pumps is prone to failure, results in inefficient energy consumption and leads to possible water loss. The automatic control of the water supply system will undoubtedly lead to more efficient control, reduced maintenance and downtime and an increased surety of supply.

We suggest that an independent telemetry and SCADA communications system should be installed to monitor and control the water supply system. We understand that the SPM electrical supply is monitored by a telemetry system, but would suggest that the water supply telemetry system be kept separate from that system. The system should comprise :

- A central station at the Riverton and Newton complexes that include
  - SCADA software
  - PC and printer
  - Cell phone paging

- An out-station at the Riverton complex that includes
  - ultrasonic level measurement of the balancing reservoirs at the water treatment works
  - all low lift pumps and all high lift pumps
  - raw water flow meters and treated water flow meters

- An out-station at the Newton reservoir complex that includes
  - ultrasonic level measurement of the main reservoirs
  - ultrasonic level measurement of the water tower
  - all low lift pumps
  - all flow meters

- An out-station at selected PRVs and zone meters

The purpose of the telemetry system would be to automate the water supply system by starting/stopping pumps according to a combination of water level in the reservoirs/water tower, off-peak energy periods, manual operation during peak periods and manual intervention in the case of emergency. Other advantages of a telemetry and SCADA system are improved reporting statistics, immediate fault reporting and alarms, better control of operations staff, to name a few.

Recommendation :
Install a telemetry and SCADA system to automatically monitor and control the bulk water supply system as detailed above.

4.6 BULK SUPPLY PIPELINES

The bulk water supply pipelines comprise the following components:

- Two parallel pipelines of 900mm and 600mmm diameter respectively that convey water a distance of 13.5 km from the Riverton complex to a place known as Midstation which lies to the north of Roodepan;

- From Midstation the pipelines split into two separate routes to the Newton reservoir complex as follows:
  - Two parallel 600mm diameter pipelines that run through the northern suburbs of Kimberley to the Newton reservoir complex
  - A 965mm diameter pipeline which follows the western perimeter of Kimberley to a place known as Carters Ridge. From here the pipeline splits into two parallel pipelines of 600mm and 750mm diameter which link up to the Newton reservoir complex

- A 450mm diameter take off from the two 600mm pipelines near Midstation to the Roodepan water tower.

4.6.1 Leak detection

SPM inspect the route of the bulk water supply pipelines on a weekly basis. This is a visual inpection for signs of water, green patches of grass/reeds or sunken ground and an inspection of air valve chambers for signs of leakage. This method is satisfactory for large leaks and bursts because the high pressures in the pipeline will more than likely lead to the abovementioned symptoms. However, while this is a necessary inspection that should continue, it is not entirely reliable as it wont detect the smaller leaks. These inspections should therefore be supplemented with a more scientific method of leak detection.

The simplest way to do this would be to pump against closed valves on the off-takes to Roodepan and Galashewe and the inlet valves at the Newton reservoir complex. The flow rate should then be measured at the treated water flow meters at the Riverton complex. (The feasibility and safety of this method must be checked beforehand) Alternatively, if this method is problematic in terms of pressure and pipe pressure classes, the inlet valves at one of the reservoirs at the Newton complex could be kept open while the others are closed. Precise measurement of the water level in the reservoir could then be used to calculate the volume entering the reservoir during the test period. Comparison of the volume pumped and the volume entering the reservoir will identify any leakage from the rising main. This method is only feasible if reservoir drop tests and valve inspections have been carried out beforehand.

If a leak is detected, the length of rising main under investigation should be shortened by closing valves at various points along the length of the pipeline in order to isolate the lengths where the leak/s exist. It will be necessary to inspect and refurbish the valves beforehand to ensure that they are drop tight before carrying out these tests.

The leak/s will need to be located by direct sounding of fittings (cheapest equipment but least reliable) or with leak-noise correlators (expensive equipment but more reliable). Such tests should be carried out on a regular, say weekly basis, and the results reported and kept on file.

Recommendation :
Routine visual inspections of the bulk supply pipelines should continue on a weekly basis.
A leak detection exercise should be carried out on a routine basis to reduce water loss on the bulk supply pipelines according to one of the procedures set out above.

5. UNMEASURED USE

5.1 AUTHORIZED UNMEASURED USE

This is water consumption that is used for legitimate purposes but is not measured.

5.1.1 Fire fighting

Water consumed for fire fighting purposes is not measured and will therefore be responsible for some of the UAW. Mr Riaan Van Rensburg, Deputy Fire Chief of Kimberley Fire Department was interviewed to determine the water consumption for fire fighting. He explained that there are four types of water consumption by the Fire Department, namely :

- Physical fire fighting : Water consumption for physical fire fighting is not measured but is estimated by means of measuring the pumping hours and correlating this to the flow rate of the pump and the volume of water in the tank.

- Training : Training exercises are carried out at the Department and in the field where water is obtained from fire hydrants. This consumption is not recorded.

- Fire hydrant inspections : The Fire Department carries out routine inspections of fire hydrants to determine their condition and to carry out any repairs that may be required. During these inspections a certain volume of water is wasted. This consumption is not recorded but is estimated to be approximately 20 kl per month

- Water supply by tanker : The Fire Department occasionally supplies water for domestic purposes to residents that are affected by water shortages due to bursts or other conditions. Water for this purpose is obtained from fire hydrants and this consumption is not recorded. The volume of water consumed in this way is negligible.

The estimated water consumption for fire fighting purposes is approximately 1500 kℓ/year, made up as follows:

Physical fire fighting		55 kl/month
Training (assumed to be the same as fire fighting)		55 kl/month
Fire hydrant inspections (10 hyd /day * 100 l/hyd * 20 day/month)		20 kl/month
Total		130 kl/month
	Or	1,500 kl/year

This is a negligible volume of water when compared to the volume of UAW, therefore no remedial actions with respect to fire fighting are necessary.

Mr van Rensburg reported that the condition of fire hydrants is generally good and that there are seldom cases of vandalism on fire hydrants. It can therefore be expected that the theft of water from fire hydrants is negligible.

5.1.2 Scouring of mains

There are some dead ends in the reticulation, but generally it is a well-looped network. As a result, there is hardly ever a need to flush mains to expel stagnant water. On one or two occasions in the past it has been necessary to do this but it was found that certain valves that should have been open were in fact closed, leading to stagnation. These valves have been opened now.

After bursts that involve the replacement of a section of pipe (or other work that allows dirt to enter the pipeline) the mains are vented at the nearest fire hydrants to expel air and dirt. Venting is carried out for between 30 and 45 minutes depending on how much air and dirt has entered the reticulation.

5.1.3 Municipal use

Municipal use includes uses such as street washing/wetting, irrigation of parks etc. All parks under irrigation by the municipality are metered. Road medians and flower gardens that are under irrigation are also metered. Water supplies at sewage pump stations and the sewage treatment works are metered.

All municipal consumption is reportedly metered and is recorded on the financial system. Departmental usage is treated as an income for the water service and an expenditure to the various departments. Municipal accounts are not submitted to Department supervisors therefore there is no direct control over water consumption.

There is a strong possibility that some of these meters are not read. This was confirmed by a spot check of two meters at Queenspark, where one meter was damaged and the other meter could not be found by the meter reader. The meter at the Karen Muir swimming bath was stuck. It is also possible that costs are debited to incorrect votes.

Recommendation :
Municipal accounts should be submitted to Department supervisors.
SPM should identify damaged municipal meters and those municipal meters that are not being read.

5.1.4 Unmetered connections

Unmetered connections include :

- Erven that are connected to the water reticulation but do not have a water meter,
- Erven that are connected to the water reticulation that do have a water meter that is not read,
- Erven that are not connected to the water reticulation and are supplied by standpipes.

In the case of new housing developments, particularly low cost housing projects, the new water connection can sometimes take several months to appear on the Treasury database and therefore on the meter reading route. The consumer receives free water during this period. Although this doesn't happen very often, SPM should make every attempt to ensure that this period is kept to a minimum.

There are an estimated 1000 households in the SANTA center, Zone 2 and the Chris Hani buffer area that have metered water connections that are not read. These meters are not read since there is no cadastral plan (SG plan) of the area and therefore these accounts are not captured on the Treasury database. Since these meters are not read they are not accounted for in the water balance. If it is assumed that each household consumes 10 kl/month then the total consumption from these un-read connections is 120,000 kl/year (1,000 erven x 10 kl/erf/month x 12 months/year) which is approximately 1.5% of the UAW in 2001/02.

There are 75 standpipes in service at present, of which only 25 are metered. The 50 unmetered standpipes are not accounted for in the water balance. If it is assumed that each standpipe supplies say 50 erven, then 2500 erven are supplied by standpipes. If it is further assumed that each household consumes 10 kl/month then the total consumption from unmetered standpipes is 300,000 kl/year (2,500 erven x 10 kl/erf/month x 12 months/year) which is approximately 3.5% of the UAW in 2001/02.

It must also be noted that standpipes are generally responsible for significant water loss as consumers do not normally use the facility responsibly. The tap can often be left open for long periods, resulting in unnecessary water loss. These consumers are not billed as it is assumed that they use less than the 6kl free basic water allowance, and they are not charged for availability.

Recommendation :
The period between connection of a water supply and registration on the meter route must be kept to a minimum, especially in the case of low cost housing projects.
Unmetered connections must be kept to an absolute minimum
All metered connections must be read
All standpipes should be metered and read, and standpipe taps should be replaced with automatic shut-off valves.

5.2 UNAUTHORIZED UNMEASURED USE

This is water consumption that is used for illegitimate purposes and is not measured.

5.2.1 Illegal connections

There is no system or procedure in place to check for illegal connections. Illegal connections are usually reported to SPM by members of the public. SPM staff have reported two cases of illegal connections that have been discovered in the last ten years and in both cases the connection was removed and the authorities were notified of the offence.

Illegal connections typically occur in informal settlements and squatter areas where there is no formal water supply, and in high income areas where water consumption is high.

5.2.2 Theft

Theft of water can occur in the form of physical theft such as illegal connections or the abuse of fire appliances, and meter tampering.

There is no information to suggest that theft of water is taking place, however it can be expected that there is an element of theft that should be taken into account in the water balance and water audit.

Recommendation:
Carry out routine inspections of consumers in all income groups (low income group with restrictors or in informal settlements, and middle/high income group with swimming pools and garden irrigation systems) The erf connection between the main and the meter should be exposed on unpaved verges and inspected for signs of meter bypassing or illegal connection.

6. GEOGRAPHICAL INFORMATION SYSTEM (GIS)

The GIS part of the study was handled by GIMS (Pty) Ltd a geo-spatial company specializing in GIS software, support, services and applications.

6.1 OBJECTIVES

The following objectives were set for the investigation of the GIS:

- Investigate and gather information and data within the existing GIS and Treasury systems and assess the current status of data availability, correctness and integration of both systems. This would be achieved via various meetings with the respective role players and conducting an on-site visit.

- Report and tabulate findings and suggest a solution to overcome the current (alleged) inadequate integration between GIS and the Treasury system.

- Suggest a solution framework of 'repair and build' to establish a working GIS that becomes a reliable and consistent source of information to decision makers, managers and casual users.

6.2 GIS AND FINANCIAL SYSTEM

Information was collected by telephone discussions and at an on-site meeting with the following Departments :

- Treasury (Beryl Englebrecht)
- GIS (Rob Gibson)
- Water Billing (Roelien Faaber)

Mr Gibson described the current data types, attempts to link the cadastral data with treasury records and the systems in place. It was immediately apparent that there is no formal key (or field) with which the GIS and Treasury system can communicate, although with some manipulation of the erf ID fields in both systems some degree of matching is possible.

The financial system in use at present is Munnex, which is a Windows based programme that supports a modest relational database. It was designed internally by a municipal employee and has undergone numerous enhancements to support the growing demands of SPM. It would appear that it is inadequate in terms of open systems integration with the GIS. SPM is currently in the process of replacing Munnex with a commercial programme.

The extract of records for GIS use is a manual exercise. This data is stored in a text file that may not necessarily preserve the integrity of data types and format. (It was not verified whether other table types are supported). It would also appear that the data extraction is sporadic, indicating (and verified) that there is no active GIS usage by users on the SPM network, at this time.

Evidence indicates that there was significant GIS interest and usage 10 years ago. A number of GIS have been used since 1987, namely REGIS, AutoDesk World and Geomedia. SPM make use of Geomedia at present. Assuming that the various (older and almost defunct) GIS licences that were purchased had been used, and by looking at the numerous themes of data, there would have been a substantial GIS, or CAD staff complement at that time.

The GIS Manager is the only person involved in GIS development, therefore considering the lack of resources he endures, he has accomplished a significant volume of data provision and service delivery. It is also very clear that the GIS division is considerably understaffed, which will be addressed later in this report.

6.3 DATA AND CADASTRE

Themes of data that are more freely available and of importance are:

- Erf/farm spatial/'cadastre' (Surveyor General approved properties)
- Water network
- Wards
- Contours
- Informal settlements
- Storm water

Most of this data is incomplete and requires updating. As SPM does not have a policy whereby each division is responsible for the upkeep of their own data, it would appear that the GIS manager has been responsible for this task.

An incomplete layer of the water network exists and can be overlaid onto the erf layer to determine which properties may/may not have water connections (a broad brush approach well suited to GIS analysis). There is no valve data on the water network and the position of the water meters is not available.

The term cadastre is often used incorrectly in the context of GIS. A cadastre is a managed database of both spatial and Deeds records. SPM's 'cadastral' database is more accurately described as a Surveyor General approved noting sheet layer. It is neither spatially accurate nor complete, the former not as important as the latter as it really only serves as a base map via which attributed data from the Treasury and Deeds Office can be linked, and therefore enhancing its value.

It is also incomplete due to the rapid subdivision (controlled or informal) of land that has not been documented in the GIS or the Surveyor General's Office.

6.4 GIS TABLE vs TREASURY TABLE

Data sourced from the Surveyor General contains a spatial field that describes each property with a 21-character ID key. This ID key contains enough information to describe the Magisterial District, Allotment code, Erf number and Portion.

The Treasury database does not have such a key, and this is a fundamental problem. The primary table of the Treasury database links to secondary tables, so that once the suburb code and erf ID are combined, it should result in a derived key that will match with similar fields in the GIS table. However, there are approximately 43000 accounts in the Treasury database and only about 70 - 80% of these can be linked to the GIS in this manner.

The primary Treasury database field sub links to very important secondary tables such as water meter readings, zones, street number and names, owners and suburbs as an example.

As we are interested in water consumption data, this process of linking is essential and it would be preferable for this process to be automatic and processed every evening prior to GIS use the next day. Such a process can be scripted (programmed) quite easily.

7. FINANCIAL MANAGEMENT

The financial management system was investigated by the accountant on the study team, Mr Henry Riekert of Kimberley. He has collected information by several interviews with the Assistant City Treasurer, the Control Accountant, staff of the Control Accountant, EDP personnel, the GIS Manager, meter readers and the LED official.

Financial statements and budgets were inspected, meters were inspected in the field and Treasury Department systems and procedures were observed in-situ.

7.1 INCOME AND EXPENDITURE

The actual income/expenditure for the water service for 1997/98 to 2001/02 and the budgeted income/expenditure for 2002/3 is summarized in Table 9 as follows:

Table 9 : Income and expenditure for the water service

	1997/98	1998/00	1999/00	2000/01	2001/02	2002/03 Budget
Actual Income	36,419,261	46,083,933	39,318,358	42,839,395	42,614,935	56,261,893
Actual Expenditure	39,510,824	45,994,926	39,409,692	42,839,395	42,931,167	55,707,344
Surplus (Deficit)	(3,091,563)	89,007	(91,333)	-	(316,232)	554,549

7.2 FINANCIAL MANAGEMENT SYSTEM (FMS)

7.2.1 Account applications

A new account application is entered onto the FMS as follows. The applicant completes an application form and submits it to the Treasury Department which is then forwarded to the Engineering Department for approval. If the connection is approved on technical grounds, then the application can proceed. When the deposit has been paid an instruction is sent to the Engineering Department for registration and the installation of the water connection. The account is then entered on the meter route list and the Treasury database.

In the case of the transfer of an existing property, a final reading is taken and a final account rendered. The new occupant then applies for the water service in the same way as for a new account.

7.2.2 Water tariff

Water tariffs are paid by each consumer according to the volume of consumption and an availability charge is only applicable to unimproved stands.

The current water tariffs are shown in Table 10 below.

Table 10 : Water tariffs 2002/2003

	Tariff
Schools, Sport fields and Parks	R 3-86
Charities / Churches	R 3-67
Business – Commercial	R 6-46
Business – Industrial	R 5-26
Residential (0 – 6 kℓ)	R 0-00
Residential (7 - 20 kℓ)	R 5-45
Residential (21 – 40 kℓ)	R 5-32
Residential (41 – 60 kℓ)	R 5-57
Residential (more than 60 kℓ)	R 5-83
Flats (0 – 6 kℓ)	R 0-00
Flats (7 - 20 kℓ)	R 5-45
Flats (21- 40 kℓ)	R 5-32
Flats (more than 40 kℓ)	R 5-83
Builder's Water	R 7-35
Rural Consumers : as above plus	4%

Recommendation :
The water tariffs should be restructured to increase with increased consumption. SPM should also determine their maximum desirable consumption by residential consumers and apply significantly higher tariffs for consumption in excess of that limit, ie. the tariffs for consumption in excess of that limit should increase more steeply than they do at present.

7.2.3 Database

The water service information is captured onto the FMS. The Treasury database is supervised by the Control Accountant.

The following database records exist.

- Water Base Record:
  - Property number (1)
  - Account number
  - Service Record (2)
  - Tariff Code (3)
  - Other data

- Water Service Record:
  - Debtors account number (2)
  - Service Record (2)
  - Property number (1)
  - Balances
  - Other data

- Water meter record:
  This database is linked with the other data but a separate database is maintained. The records are as follows:
  - Property number (1)
  - Base Record
  - Meter no 1
  - Meter no 2
  - Other data

- Tariff Record
  Tariff Code (3)
  Tariff Data
- Accounting transactions
  Debtors account number (2)
  Type transaction
  Transaction reference number
  Other data

The figures in brackets denote a linkage to each other.

Water charges are calculated when the meter readings have been entered and transferred to the meter records of the Treasury database. The meter records are then used to calculate the monthly consumption which is multiplied by the relevant tariff/s.

The levies are calculated by self generating journals. Water income is credited with the total amount and the debtors control account is debited with the same amount.

The FMS is used to send out the accounts and information regarding payments. Statistics are also produced by the financial system reports.

7.3 METER READING

Meters are read monthly. There are 5 meter reading areas with a total of 189 routes. There are 22 meter readers (eleven teams of two) and one supervisor. The meter readers are rotated to avoid collusion or fraud. The meter readers are on a bonus system that provides an incentive for meter readers to read more meters.

A route list has been prepared for each route. The list consists of a route number, address, account number, meter number and a place to insert the present reading. Meter readers record the reading by handwriting the reading in a book. Some consumers read their meters themselves if, for example the meter is difficult to read due to closed gates, etc. These readings are submitted to the Treasury Department on a prescribed form.

Books 48, 49 and 51 are the routes for the industrial area, the Army and the farms respectively. These books are not rotated as these meters are not adjacent to streets and would be difficult to find if the meter reader is not familiar with the route. This is a potential reason for the reduction in commercial sector consumption and should be investigated further by the Treasury Department.

Approximately 1000 households in the SANTA Centre, Zone 2 and Chris Hani Buffer Area have metered water connections, but are not on the FMS. The meters are therefore not read and these consumers receive free water. According to the Treasury Officials, there is no cadastral plan of these informal townships therefore there are no records to be entered on the FMS.

There are approximately 1200 large diameter consumer meters. It is suspected that many of these meters are not read, according to the exception reports. Twenty of these meters were inspected and six were found to be damaged. The loss of revenue resulting from damaged meters cannot be estimated but is expected to be significant as these are large consumers.

The Treasury Department identifies damaged meters by running exception reports, and then sends an instruction to repair/replace the meter to Water Works. These meters are often repaired/replaced long after the instruction is sent, sometimes up to six months later. The reason for the long delay is that the Water Works deals with burst complaints as a higher priority than meters. However the end result is that interim accounts are submitted.

We also suspect that there will be damaged large diameter meters that are not identified by the exception reports, as there are cases where the meter readers do not know where the meter is situated and meters haven't been read for several months.

<u>Recommendation</u> :

The meter books should be replaced with electronic hand held terminals (HHT). Studies have indicated that time savings of 15% in meter reading, 40% in supervision and 50% in data capture could be achieved through the use of HHT. The incidence of meter reading errors is dramatically reduced and errors from data capturing are eliminated entirely.

The meters in Santa Centre, Zone 2 and Chris Hani buffer should be captured onto the FMS and the meters should be read.

Verify meter readings on routes that are not rotated on a regular basdis by means of spot checks.

The delay in repair/replacement of faulty/damaged meters must be reduced and a reporting system should be established to control this delay.

An additional four (two teams of two) more meter readers should be provided. See item 8.3

The delay in repair/replacement of faulty/damaged meters must be reduced and a reporting system should be established to control this delay.

7.4 BILLING

When the meter readers have completed the routes, the meter reader books are then captured into the FMS.

A major exception report is run on the meter readings. This report produces the following indicators:

- Nil consumption
- High 3 times previous
- Low 3 times previous
- Flip meters (These are meters which have clocked over to zero)
- Changed meters

After the major exception report is run, a minor exception report is produced. This report includes the items on the major exception report as well as:

- Meter not read
- Zero usage
- Not all meters read
- No meter for reading.

First and Final meter readings are captured. An error report (excessive usages) is run, and then a test run of about 100 accounts is processed. The test run is checked for errors.

The final run is processed and accounts are then sent out. 22 000 accounts are delivered by post and the rest are delivered by hand by temporary staff. A staff member in the office of the Control-Accountant is responsible for these deliveries. There is no control over the accounts sent out by post, however evidence suggests that accounts do reach the account holders.

The following journals are run after the accounts have been processed and sent out.

- An adjustment journal
  The Water Clerk does the adjustment of the previous months accounts. The Chief Clerk must approve the adjustment of accounts older than one month.

- Water leakages
  These are water leaks on the consumer's property that are repaired by Water Works. When the leak has been repaired, the following three months consumption is averaged and this average is compared with consumption prior to the leak repair. The estimated water loss is calculated and 50% of the loss is written off the consumer's account. This write off is financial only, the volume of water loss is not taken into account. This journal must be approved by the Chief Clerk.

7.4.1 Interim accounts

Interim accounts are accounts than are estimated if a meter reading is unavailable for whatever reason. They are an unavoidable part of any Municipal billing system, yet in the case of SPM they appear to be a problem because so many interim accounts are sent out.

If the meter cannot be read, the Treasury Department estimates the account value in Rands, based on previous months data. The water consumption is not estimated. When the meter is eventually read, an adjustment is made on the FMS to correct any erroneous estimating. The problems with this method are as follows :

- The water consumption is not estimated, therefore at financial year end the water balance is distorted.

- If the meter is replaced, the volume of consumption is "lost" and therefore distorts the water balance.

Appendix 4 shows the statistics of interim accounts for the last four months. Unfortunately the format of reporting changed in November 2002, therefore previous data is not available. The report in Appendix 4 is summarized in Table 11 below.

Table 11 : Summary of interim accounts

	Feb 2003	Jan 2003	Dec 2002	Nov 2002
No. of meters read	16 915	12 516	19 617	20 559
No. of interim accounts	5 880	10 196	3 590	2 201
Total	22 795	22 712	23 207	22 800
Percentage of interim accounts to Total	26	45	15	10

If the highest and lowest percentages are eliminated, the average percentage of interim accounts is 20%. Since water consumption is not estimated, it means that 20% of water consumption for the last month of the financial year will be left out of the water balance and the consumption from those meters that are replaced will also be left out of the water balance. In theory there should be a balance of water consumption at the financial year end from the previous financial year end, however, given the erratic fluctuation of the number of interim accounts each month, it is more than likely that there will be a significant difference.

Two complaints about interim accounts were received from consumers during the interviews with Treasury staff.

The meters in Galeshewe and some other areas are not read regularly and this increases the number of interim accounts. This is due to the monthly due dates.

The following conditions lead to legitimate interim accounts:

1. Covered
2. Premises locked
3. Gates locked
4. Filled with water
5. Meter stuck
6. Leak in water box
7. Meter not registering
8. Faulty meter
9. Missing digits
10. Disconnected
11. Not in use
12. Meter box
13. Car parked on meter
14. Meter not located
15. Meter upside down
16. Dogs
17. Bees in box
18. Changed meter
19. Changed counter

A reason that often leads to interim accounts is item 1, the fact that meters are hidden by sand, particularly after windy or rainy weather. The meter reader is unable to find the meter therefore an interim account is generated. Options to deal with this problem include meter markers, entering the meter position on the GIS and installing above ground meter boxes (expensive).

<u>Recommendation</u> :
The number of interim accounts must be reduced by :

- *Providing more meter reading teams*
- *Faulty water meters must be repaired/replaced within one month or at the most two months.*
- *Other common reasons for the use of interim accounts should be established and addressed.*
- *Making the meters easier to find.*

7.4.2 Meter fault reporting

As mentioned previously, exception reports are run on the FMS to identify faulty meter readings and meters. Meter readers also identify faulty meters during the meter reading routes.

Faulty meters are reported on a prescribed form to Water Works for inspection and repair. However, the number of interim accounts that are six months and older (2.5% of all meters) indicates that Water Works are unable to give prompt attention to these meters due to their heavy workload dealing with bursts. There is currently no electronic system for the follow-up of problems reported to Water Works.

This problem is also encountered with the installation of restrictors. Water Works used to install restrictors on behalf of the Treasury Department, but due to the long delays the Treasury Department opted to use independent contractors instead. Water Works have reported that this leads to problems as the restrictors are not always installed correctly and they are often called out to repair the installation.

Recommendation : *SPM should conduct an efficiency survey of the Water Works to establish how to increase efficiency and whether to provide additional maintenance teams at Water Works to repair water meters promptly and to install/remove restrictors.* *The proposed electronic maintenance database programme must have the facility to record meter fault reports/complaints and it must be possible to track the handling of complaints.* *The Treasury Department should transfer the function of restrictor installations to Water Works.*

8. RESOURCE MANAGEMENT

The following comments are made on the resources that are involved in the water supply system.

8.1 ENGINEERING

8.1.1 Water loss management unit

Due to the significant scope of the water loss problem, the high cost of water loss and the long time that will be taken to reduce UAW to acceptable levels, we believe that a water loss management unit must be established in SPM.

At first, this unit would comprise a water loss manager and a junior technician. At a later date, when the unit embarks on proactive leak detection, up to six water service hands will be required. The water loss manager should preferably be a civil engineering technician with at least 10 years experience in the water industry and the junior technician should preferably be a civil engineering technician with a minimum two years experience in the water industry.

The water loss management unit should report directly to the City Engineer, and would be responsible for the establishment and implementation of a detailed water loss management plan which is based on this study. The primary objective of the unit will be to reduce water loss to acceptable levels in as short a period as possible, and thereafter to maintain those water loss levels. The secondary objective of the unit would be to establish and implement a water conservation/water demand management strategy.

Specifically the unit will be responsible for implementing zone measurement, implementing a telemetry and SCADA system, establishing leakage benchmarks, implementing the meter replacement programme, implementing the pipe replacement programme, water auditing and reporting, amongst others.

8.1.2 Water Works

Due to the high number of bursts in the water reticulation, the Water Works maintenance teams are unable to deal with lower priority complaints and meter maintenance timeously. This often leads to long delays in minor leak repairs and the replacement of stuck meters, which can lead to significant loss of revenue.

We therefore believe that the efficiency of the Water Works needs to be examined more closely, and if necessary additional teams should be provided, or a bonus incentive scheme should be introduced to improve efficiency, as appropriate. Additional teams are preferable because the water loss management unit will require experienced water service hands at a later date. The intention would be that the additional teams are recruited by Water Works now and are later transferred to the water loss management unit when bursts are under better control. The need for maintenance teams should reduce as the need for staff in the water loss management unit increases.

We also believe that Water Works should take over the function of installing and maintaining meter restrictors in order to place the responsibility for meter maintenance in one department. This can be achieved by using the additional teams mentioned above.

8.2 GIS

The GIS has an important role to play in water loss management and the reduction of UAW. At present the GIS section is understaffed and is in need of additional technical staff. The backlog in data on the GIS and the relationship between the GIS and the financial system need to be addressed urgently, therefore we believe it is more appropriate to use consultants for this purpose.

When the GIS has been updated as recommended, there will be a need to constantly update, maintain and improve the GIS. We believe that an additional technical person who reports to the City Engineer, will be required to perform this function under the supervision of the GIS Manager.

8.3 TREASURY

The meter reading function appears to be problematic as there are so many interim accounts, which result in a loss of revenue. We believe that the efficiency of the meter reading function must be examined more closely and should be improved by introducing :

- A more effective bonus incentive scheme than is currently used
- Replacing the handwritten meter book with the hand held terminal
- By recruiting up to eight additional meter readers.

9. ELECTRICAL EQUIPMENT AT RIVERTON AND NEWTON

One of the objectives of this study is to assess the electrical installations that form part of the water supply system. In particular, the efficiency of the electrical equipment and the consumption of energy must be assessed, as well as the measurement of energy consumption. Methods of improving efficiency and reducing energy consumption without affecting the capacity of the water supply system must be recommended.

This part of the study is not directly associated with water loss, but rather with cost saving. It is therefore situated in Appendix 5. The report was prepared by Mr Koos Kritzinger, professional electrical engineer based in Bloemfontein.

10. DISCUSSION

The findings of this study confirm SPM concerns that the volume of UAW has reached unacceptable levels which are set to continue or even increase if appropriate action is not taken. The severity of this finding is underlined by the fact that the distribution losses have more than tripled over the last four financial years. SPM have previously attempted to establish the cause of the high UAW, to no avail.

It must be acknowledged that water loss management is a strategy or management process that is implemented on a continuous, on-going basis to achieve the specified objectives. It is not a single objective and does not have one or two simple solutions. Water loss is not a problem that can be solved in a single attempt or project but is rather a continuous process.

Because UAW levels have been acceptable in the past, SPM have dealt with water loss management in a reactive manner. This means that steps have not been taken to measure leakage losses on the various components of the water supply system. As such there is no baseline data that can be used to assess the causes of water loss accurately. In the absence of such data, this study has assessed the data that is available and makes recommendations for the implementation of water loss management steps that will establish the baseline data. Water loss management decisions will have to be made at that stage.

The report does however make an attempt to indicate the components of water loss by rough estimates. The components that have been estimated are shown in Table 12 as follows:

Table 12 : Estimated components of UAW

Component of UAW	Estimated loss (kl/year)
Administration loss	
❑ Meter error	3 600 000 kl/year
❑ Meter restrictors	360 000 kl/year
❑ Unmetered connections	120 000 kl/year
❑ Unmetered standpipes	300 000 kl/year
❑ Interim accounts (2% of water sales at year end)	280 000 kl/year
❑ Interim accounts (replaced meters)	no data
Physical loss	
❑ Water treatment process loss	1 200 000 kl/year
❑ Leakage, bursts, reservoir overflow	no data
TOTAL UAW	**8 600 000 kl/year**

The figures in the above table are merely a rough indication of the order of magnitude of the various components, provided here for the sake of comparison, and should by no means be regarded as accurate. Note that there will be partial duplication of the interim accounts and meter error and meter restrictor figures. It is unfortunate that there is no data on leakage and bursts, but it is interesting to note that administration loss is a substantial contributor to UAW, in spite of the high frequency of bursts and leaks.

This suggests that there is as much merit in dealing with the administration losses as the physical losses. In fact it is preferable (from a financial viewpoint) all other things being equal, to address loss of revenue as a higher priority than physical loss because the cost of revenue loss is higher than the cost of physical loss. In other words, the cost to SPM of 1kl of water that is lost by physical loss e.g. a burst pipe, is the cost of water supplied i.e. R3.63 whereas the cost to SPM of 1kl of water that is lost by administration losses, e.g. meter error, is the cost at selling price i.e. say R4.43.

The study has shown that the most important factors that need to be addressed include:

- The large number of ageing consumer meters that are stuck and have large errors.
- Zone meters need to be installed and data logging of these meters must be carried out to establish leak loss and burst data for each zone. This information must then be used to implement a proactive leak repair programme.

- The GIS must be updated and completed to:

    - Show the positions of water pipelines, valves and other underground services to assist the maintenance teams reduce the complaint response time.

    - Show the positions of the consumer meters to assist meter readers find hidden meters.

    - Show other services and database information so that the GIS is used as reliable management tool and can be compared with the FMS.

- The high number of interim accounts, which must be reduced and the fact that the water consumption is not estimated for interim accounts.

- The long delays in maintenance of faulty meters must be reduced .

- The efficiency of meter reading and data capture must be improved.

- The manual operation rule that is used to operate the water supply system must be replaced with an automatic telemetry and SCADA system.

The present cost of UAW in excess of 15% is approximately R16.1 million, and it has been rising by approximately R5.0 million per year for the last two years. If water loss management is not successfully implemented, and if the cost of UAW remains constant (conservative as it is set to increase based on the historical trend), a total of R80 million (R16 million x 5) would be lost during the next five years, due to UAW levels in excess of 15%. It is therefore clear that urgent steps must be taken to prevent this situation.

Every water supply system will have UAW therefore the water supply authority must define a target UAW that is the most cost effective level , when balancing the cost of water loss management and the cost of water loss. SABS 0306:1999 suggests a target UAW of between 8-15%, however in the case of SPM we suggest that a first order level would be 15% and this level should be achieved within a five year programme. SPM must adjust this target as appropriate.

SPM will also need to determine how much to spend on water loss management each year. In order to prepare a first order estimate of the cost of water loss management, we have assumed that R5 million (10% of current water expenses) will be spent each year for five years. This expenditure would amount to R25 million during the next five years. When compared to the potential loss of R80 million, this cost represents a return on investment of 1% for the initial five year period and approximately 60% thereafter.

We believe that a water loss management unit should be established to manage water loss to a level of 15% or better, over a period of five years. In our opinion the scope of work involved and the responsibility is too great to be absorbed by the existing staff.

11. WATER CONSERVATION AND WATER DEMAND MANAGEMENT

Water loss management is a fundamental component of water conservation and water demand management. It is correct to address water loss management first in the case of SPM’s water supply, as the water loss is high. However, the water loss management plan should be extended to a water conservation and water demand management strategy at a later date, when the implementation of the water loss management plan is in progress.

Measures that should be included in the water conservation / water demand management strategy include:

- Consumer education
- Media campaigns
- School education and awareness programmes
- Retrofitting water wasting appliances
- Implementing restrictions on the time of day during which consumers can irrigate lawns
- Re-use of treated effluent
- Re-use of grey water
- More aggressive stepped water tariffs designed to encourage consumers to use less water
- Informative billing that provides the consumer with his water consumption statistics

12. RECOMMENDATIONS

The following recommendations are summarised from the report. They are not presented in order of priority, but in the order in which they are dealt with in the report.

12.1 ENGINEERING

12.1.1 Water treatment works

Meter calibration certificates should be kept on file.

A detailed study of the water treatment process should be carried out to assess the scope for reducing the treatment losses to a minimum.

A more detailed analysis of the effect of water quality on cementitious and steel pipes and fittings and the stabilization process required to address the aggressive water should be carried out.

12.1.2 Zone meters

The water reticulation should be divided into the proposed discrete zones, and these zones must be checked by specific WADISO modelling, after the model has been updated, verified and calibrated. Zone meters must be installed at the entrance to the newly established zones. Existing bulk water meters must then be repaired/recalibrated and minimum night flows must be measured to establish the worst leakage zones. A leak detection programme must then be implemented to proactively locate leaks and repair them.

Water auditing procedures must be initiated in accordance with SABS 0306:1999.

12.1.3 Consumer meters

A two phase water meter replacement programme should be implemented to replace old meters. This should be implemented after the results of the meter testing have been verified by further testing.

Council should review the policy of meter restrictors and how effective they are at encouraging defaulting consumers to pay their accounts. Council should consider alternative means of dealing with defaulters, such as cutting off electricity or in the case of indigent defaulters, charging a flat tariff.

Large diameter meters at new installations should be sized according to the procedures mentioned in the report. The size of all large diameter meters should be checked against the anticipated consumption pattern and the average measured consumption of the consumer. Those meters that are oversized should be replaced with correctly sized meters or with combination meters, as appropriate.

12.1.4 Reservoirs

Deep (foundation level) inspection chambers should be excavated around the reservoirs and these chambers should be regularly monitored for leakage from the reservoirs.

Drop tests (precise measurement of water level with sealed inlet and outlet over a fixed time period) should be carried out on each of the four storage reservoirs at the Newton reservoir complex at least once a quarter. The reservoir leakage results of these drop tests should be recorded as a quantity per day and as a percentage of storage.

Reservoir levels should be monitored electronically and incorporated in the proposed telemetry and SCADA system.

The pressure reducing valves downstream of the pumps at the Newton reservoir complex should be monitored by data loggers on a regular basis to establish whether there are pressure surges in the reticulation as a result of pump start/stop condition.

12.1.5 Maintenance

An electronic database programme should be written by software developers specifically for SPM Water Works to record maintenance complaints. This programme must be a Windows driven programme with a link to the GIS. Data should be entered by selecting check boxes or multiple choice selections. Entering of data by typing text should be kept to an absolute minimum. The database should have a list of street names, fault type, pipe diameter, pipe material, automatic time, date and age of complaint etc. The programme must run reports that summarise the contents of the database easily and clearly. It must be possible to generate a report in a format that can be used by the GIS to display summarized complaint details graphically on a plan of the water reticulation. This programme must be accessible to management via the network at all times.

A computer terminal which is connected to the network should be provided at the Water Works office, so that they have access to the GIS and the water reticulation in electronic format, and so that management has access to the maintenance database.

A systematic pipe replacement programme should be implemented for the on-going replacement of those pipes that require the most maintenance and are responsible for the most water loss.

12.1.6 Monitoring and control

A pressure management system should be designed to reduce pressures in the high pressure zones of the reticulation to a maximum of 6.0 bar.

A telemetry and SCADA system should be installed to automatically monitor and control the bulk water supply system.

12.1.7 Leak detection

The routine visual inspections of the bulk supply pipelines should be continued on a weekly basis.

A leak detection and leak location exercise should be carried out on a routine basis to reduce water loss on the bulk supply pipelines according to one of the procedures set out in the report.

12.1.8 Controlling unmeasured use

Unmetered connections must be kept to an absolute minimum

All metered connections must be read

Municipal accounts should be provided to Department supervisors and they should take responsibility for water consumption in their department

All standpipes should be metered and read and standpipe taps should be replaced with automatic shut-off valves.

Carry out routine inspections for signs of meter bypassing or illegal connection.

12.2 GIS

The recommended actions for the improvement of the GIS include the following:

12.2.1 Phase one (fast track approach)

- Obtain the best available erf/farm digital map without necessarily updating it and verifying its accuracy. Use a generalized dataset and develop a working base to add treasury data.
- Build a new field in the SG table to contain the link to the Treasury system
- Build a new field in the primary Treasury system table to contain the link to the GIS
- Link the Treasury system to the GIS and establish which erven have water consumption data
- Verify and overlay the pipe network to the SG layer and establish which erven have water connections
- Compare with water consumption data
- Update or develop if missing, the GIS database with existing services including roads, stormwater drainage, electricity, Telkom, water and sewerage. In other words all underground services.

Consultants would need to be engaged to assist the GIS department with this phase.

Phase one is short term and should result in some derived maps that at least highlight problem areas. In addition to the base GIS data, the consultant should combine the results of any fieldwork in the form of sketches, any hard copy plans/drawings, any numeric water data collected, any attribute data relating to water mains, valves, reservoirs and digitize these on the base GIS maps.

As much relevant mapping data as possible should be obtained from external sources. This would include orthophotos which could be sourced from Telkom, census data from Statistics South Africa, road networks and general infrastructure from MapStudio.

All this data can be used as input into a model that should derive some map data that will assist the water loss management plan.

12.2.2 Phase two (ongoing approach)

- Rebuild the spatial cadastre layer by checking all parcels in the Surveyor Generals' Office and updating this layer.
- Link these data with those within the Treasury system tables
- Establish metering zones and districts
- Establish which erven have more than one consumer (flats, commercial) and aggregate these values. (Check/verify with zone map. i.e. residential zone types, commercial, industrial etc.)
- Calculate water consumption per district
- Summarise water consumption and compare with bulk supply figures

- Identify exception outliers with respect to:

    - No Data (via consumption),
    - No Data (via missing consumption records)
    - Low or High consumption.

- Produce a surface map of water consumption (or lack of).

Consultants should be appointed to assist the GIS department with this phase.

ESRI technology should be used to analyse this data and in the long term, assist SPM with the implementation of a system which will include the sourcing and/or building of definitive data sets, procedures to automatically build attribute tables using the treasury system, train staff in the use of the GIS and set up procedures to deliver GIS data via the internal intranet using web technology.

12.3 TREASURY

12.3.1 Water tariff

The water tariff should be restructured to increase with increasing consumption. SPM should also determine their maximum desirable consumption by residential consumers and apply significantly higher tariff for consumption in excess of that limit.

12.3.2 Meter reading

The meter books should be replaced with electronic hand held terminals (HHT).

Verify meter readings on routes that are not rotated on a regular basis by means of spot checks.

An additional four meter readers should be provided

The meters in Santa Centre, Zone 2 and Chris Hani buffer should be captured onto the FMS and these meters should be read.

The delays in the repair/replacement of faulty water meters must be reduced to one month or at the most two months.

Common reasons for interim accounts should be established and addressed.

Meters must be made easier to find.

12.3.3 Meter fault reporting

SPM should conduct an efficiency survey of the Water Works to establish how to increase efficiency and whether to provide additional maintenance teams at Water Works to repair water meters promptly and to install/remove restrictors.

Treasury Department should transfer the function of restrictor installations to Water Works.

12.3.4 Consumer meters

The discrepancy between the number of consumer meters on the FMS and the number of meters on Statistics must be verified by the Treasury Department.

The standpipes must be replaced with an individual meter for each stand.

The GIS must show the location of meters.

All the Heads of Departments must make sure that all departmental usage is metered and correctly metered where practical. It includes the reporting of damaged meters.

A toll free telephone number should be provided to encourage the community to report the abuse of water or water meters.

12.4 ELECTRICAL

The following is a summary of the recommendations made by the electrical consultant in his report in Appendix 5.

- The implementation of a functional and effective communication system for the total water facility should be considered as a priority. This communication system should include a Telemetry system with SCADA software independent of any other systems in the municipal environment. The capacity and layout of such a communication system should be tailored in harmony with the outcome and findings in the principal report.

- The electricity metering system at Newton should be investigated and upgraded to get it on par with the metering of energy at the bulk supply point. Once this is done the management of pumping cycles should be monitored closely to further save on electricity costs.

- Depending on the outcome of the principal report a mentoring session is recommended to establish a master plan. This should include the defining of pumping requirements at each existing and new location and the resizing of pumps and motors where necessary.

- Following the establishment of a master plan and management strategy the introduction of cost saving mechanisms like Variable-Speed Drives and Soft-Starters on electric motors and PF Correction could be investigated effectively.

- Because of the present status of the communication systems available to the operational team it is eminent that further energy saving can only be achieved by implementing an enhanced management strategy with emphasis on cost saving procedures and effective control and monitoring protocols. This management strategy should include the training of staff and a management style that will create a total awareness and culture of energy saving. A sustainable audit function should form part of the management strategy to monitor targets on a continuous basis.

- As part of the envisaged management strategy mentioned above a complete survey of the mechanical status of pumps and equipment should be conducted. The survey should report on the condition of all pumps, electric motors and ancillary equipment and identify equipment due for replacement or major overhauls. SPM should involve WATERGY in this survey if they are available.

- The electricity metering system at Riverton should be investigated thoroughly. If not already in place a procedure of checking the meter reading exercise with Eskom should be implemented. This will ascertain the exact metering cycle, which is important for the analysing of metered data in an effort to establish trends and procedures for the saving of energy.

13. PLAN OF ACTION

The plan of action is a programme for the implementation of the recommendations made in this report. There will no doubt be modifications to the actions recommended in this report therefore the plan of action is prepared as a first order estimate of the programme of works. This plan of action will therefore need to be revised on a regular basis as the water loss management plan is implemented.

The cost estimates used for the plan of action exclude VAT, but they include engineering costs and contractor's preliminary and general costs where appropriate. All costs shown in the plan of action are 2003 costs with no allowance for escalation. Only those items with a financial implication are shown in the plan of action.

The expenditure on a pipe replacement programme is extremely difficult to assess at this stage since it is not clear what length or diameter or location of pipes will be replaced, until zone measurement is implemented. A preliminary estimate of R1.0 million per year has been assumed for the purposes of this plan of action. This figure is based on the average costs of replacing the existing pipelines. This budget would enable the replacement of approximately 3000m of pipeline per year, depending on pipe diameter, location, ground conditions, etc.

The expenditure on the water meter replacement programme is designed to spread out the cost of replacing the oldest meters over a full five year period so that when the initial five year programme is complete, the meters that are five years old now will need to be replaced. This will lead to the replacement of the same number (approximately 7100) of meters each year. The annual cost of this programme amounts to R2,5 million per year.

Table 13 overleaf is an outline programme for the implementation of the water loss management plan.

Table 13 : Plan of action

No	Recommendation	Total cost	Year					Each year thereafter
			2003/04	2004/05	2005/06	2006/07	2007/08	
1	**ENGINEERING**							
	Water treatment							
1.1	Water stabilization study	R 30,000	R 30,000					
1.2	Stabilisation process	R 100,000	R 100,000					
1.3	Treatment process loss study	R 15,000	R 15,000					
	Metering							
1.4	Identify metering zones	R 75,000	R 75,000					
1.5	Install and repair bulk meters	R 1,500,000	R 750,000	R 750,000				
1.6	Water meter replacement programme	R 13,000,000	R 1,000,000	R 2,000,000	R 2,500,000	R 2,500,000	R 2,500,000	R 2,500,000
	Reservoirs							
1.7	Reservoir inspection chambers	R 50,000	R 50,000					
1.8	Reservoir drop test	R 10,000	R 10,000					
	Monitoring and control							
1.9	Telemetry and SCADA system	R 300,000	R 300,000					
1.10	Pressure management system	R 440,000			R 400,000	R 20,000	R 20,000	R 20,000
	Maintenance							
1.11	Electronic database programme	R 20,000	R 20,000					
1.12	Pipe replacement	R 5,000,000	R 1,000,000	R 1,000,000	R 1,000,000	R 1,000,000	R 1,000,000	R 1,000,000
1.13	Leak detection on bulk pipelines	N/A	R 10,000	R 10,000	R 10,000	R 10,000	R 10,000	
2	**GIS**							
2.1	Phase one	R 250,000	R 250,000					
2.2	Phase two	R 100,000		R 100,000				
3	**TREASURY**							
3.1	Aquire HHT's	R 1,100,000	R 300,000	R 400,000	R 300,000			
3.2	Replace standpipes with metered conns	R 1,000,000				R 500,000	R 500,000	
4	**ELECTRICAL**							
4.1	Detailed study of equipment and meters	R 30,000	R 30,000					
4.2	Metering and control					R 100,000		
5	**RESOURCES**							
5.1	Water Loss Management Unit							
5.1.1	Staff	N/A	R 200,000	R 260,000	R 320,000	R 380,000	R 420,000	R 420,000
5.1.2	Vehicles	N/A	R 160,000		R 160,000		R 160,000	
5.1.3	Equipment	N/A	R 200,000	R 50,000	R 50,000	R 50,000	R 50,000	R 20,000
5.2	Maintenance teams	N/A	R 360,000	R 300,000	R 240,000	R 180,000	R 120,000	R 120,000
5.3	Additional meter readers	N/A	R 175,000	R 175,000	R 175,000	R 175,000	R 175,000	R 175,000
	TOTAL		R 5,035,000	R 5,045,000	R 5,155,000	R 4,915,000	R 4,955,000	R 4,255,000

14. CONCLUSION

This study has shown that the level of UAW in the SPM water supply system is unacceptably high, and steps must be taken to reduce the UAW. In the absence of baseline data it has been impossible to quantify, or estimate all the components of UAW, therefore estimates, empirical data and guidelines have been used to establish the main causes of the high UAW.

The findings of this study suggest that the largest contributors to the high UAW levels include ageing meters, meter restrictors, unmetered standpipes, too many interim accounts, frequent bursts and leaks, treatment losses and long delays in meter repairs/replacement. Although it is impossible to calculate the magnitude of each contribution to UAW, the study shows that roughly half the UAW is due to administration loss and half due to physical loss.

The situation in Kimberley is not unique, several cities and towns have similar and sometimes higher levels of UAW. However the financial implications of these losses are too high to ignore, therefore a water loss management plan should be implemented. The report gives a fairly detailed account of the current situation and the proposed plan of action for the implementation of the water loss management plan.

This plan will require the recruitment of additional staff, the establishment of a new water loss management unit, the purchase of equipment for the unit and many other costs. The study shows that the implementation of the water loss management programme will be financially viable in the medium (five years) term and will realise significant cost savings after the UAW levels have been reduced to acceptable levels.

In spite of ageing meters, ageing pipes and other causes of water loss, SPM can reduce their UAW significantly if the recommendations of this report are implemented, and if the water loss management plan is implemented in accordance with the guidelines set out in SABS 0306:1999.

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11 Africon, City of Kimberley water loss management report on phase II, December 1998

12 Africon, City of Kimberley water loss management report on phase III, June 1999

13 Sol Plaatje Municipality, Integrated development plan, October 2002

FIGURES

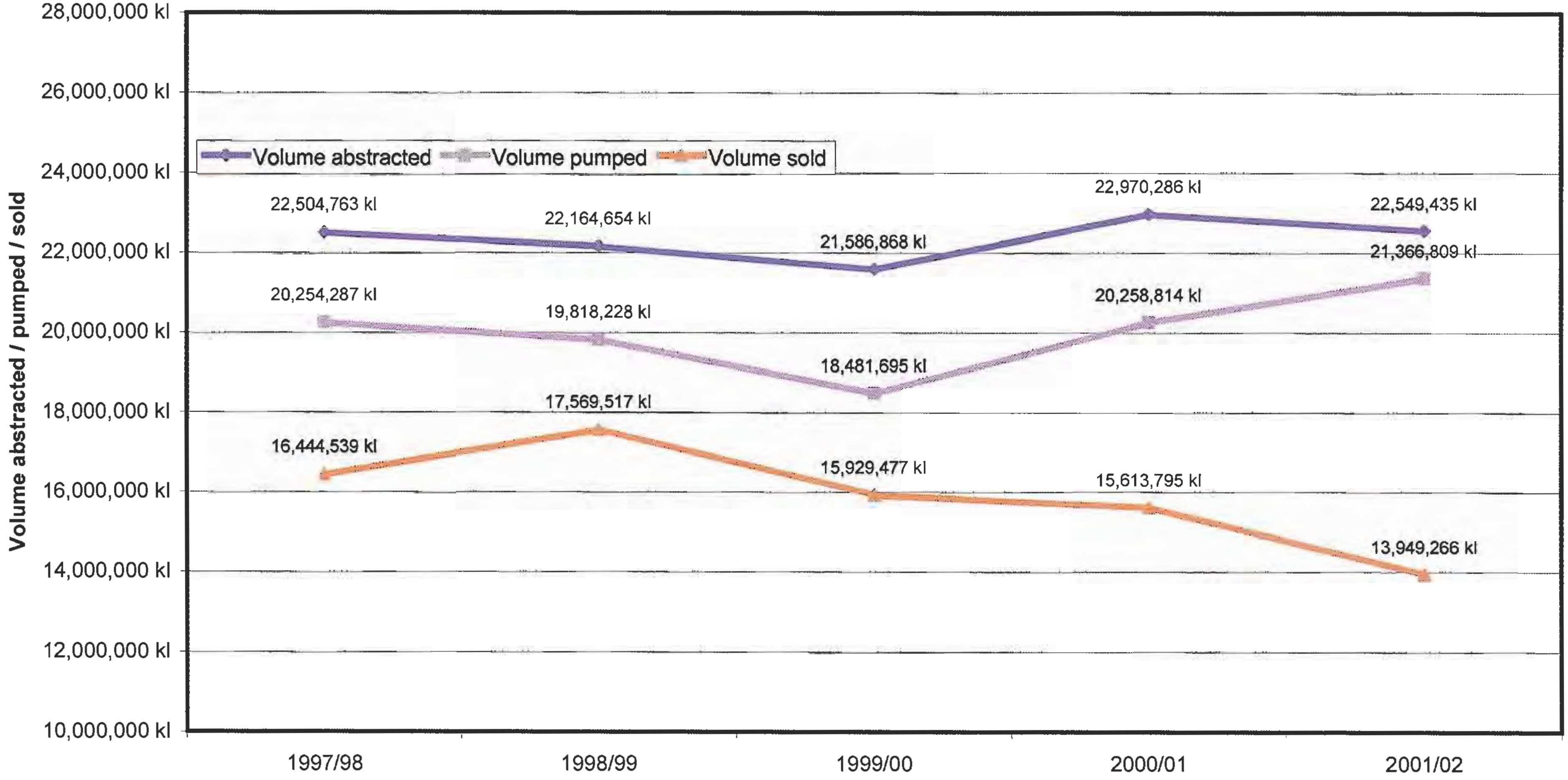


Figure 1 : Water balance per financial year

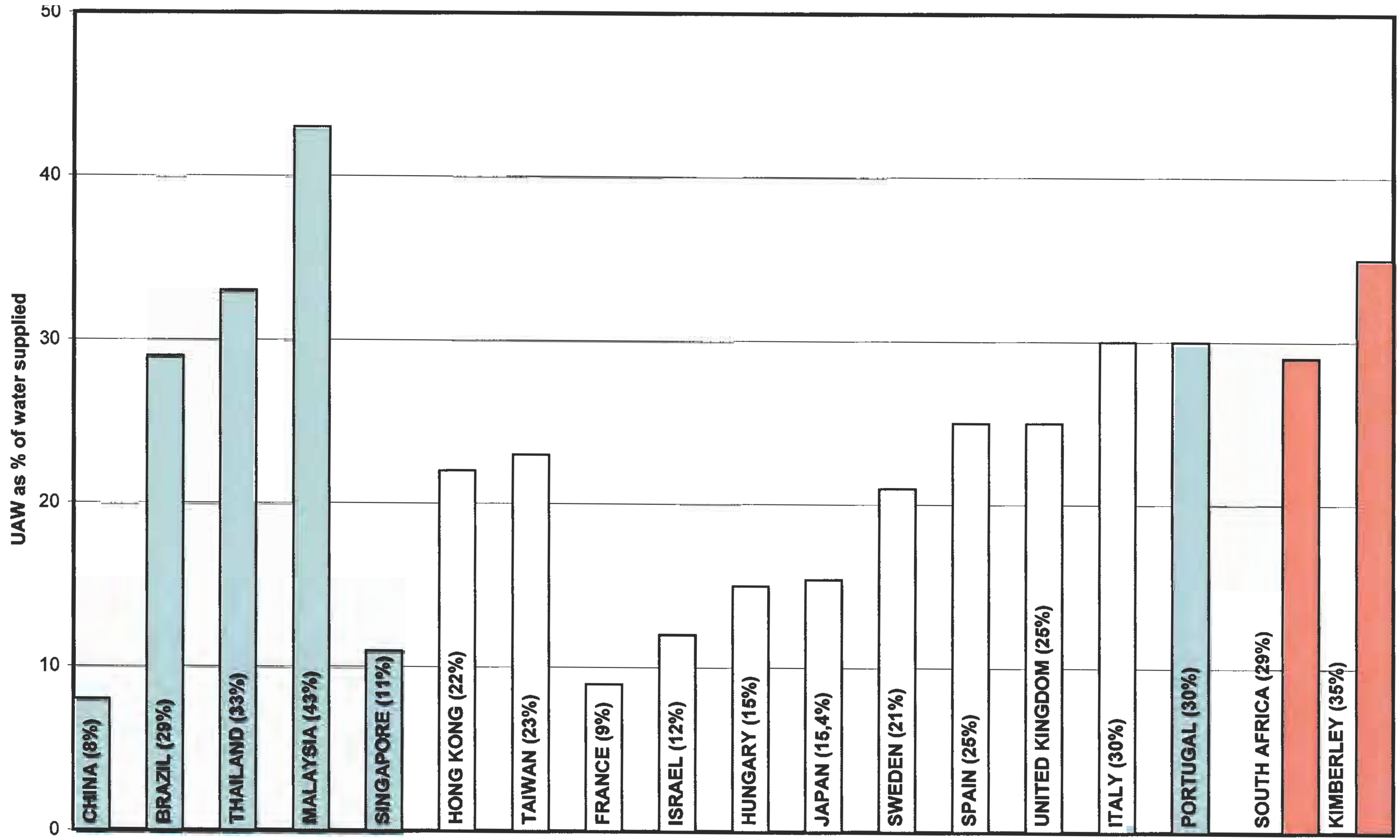


Figure 2 : Comparison of typical UAW around the world (WRC Report)

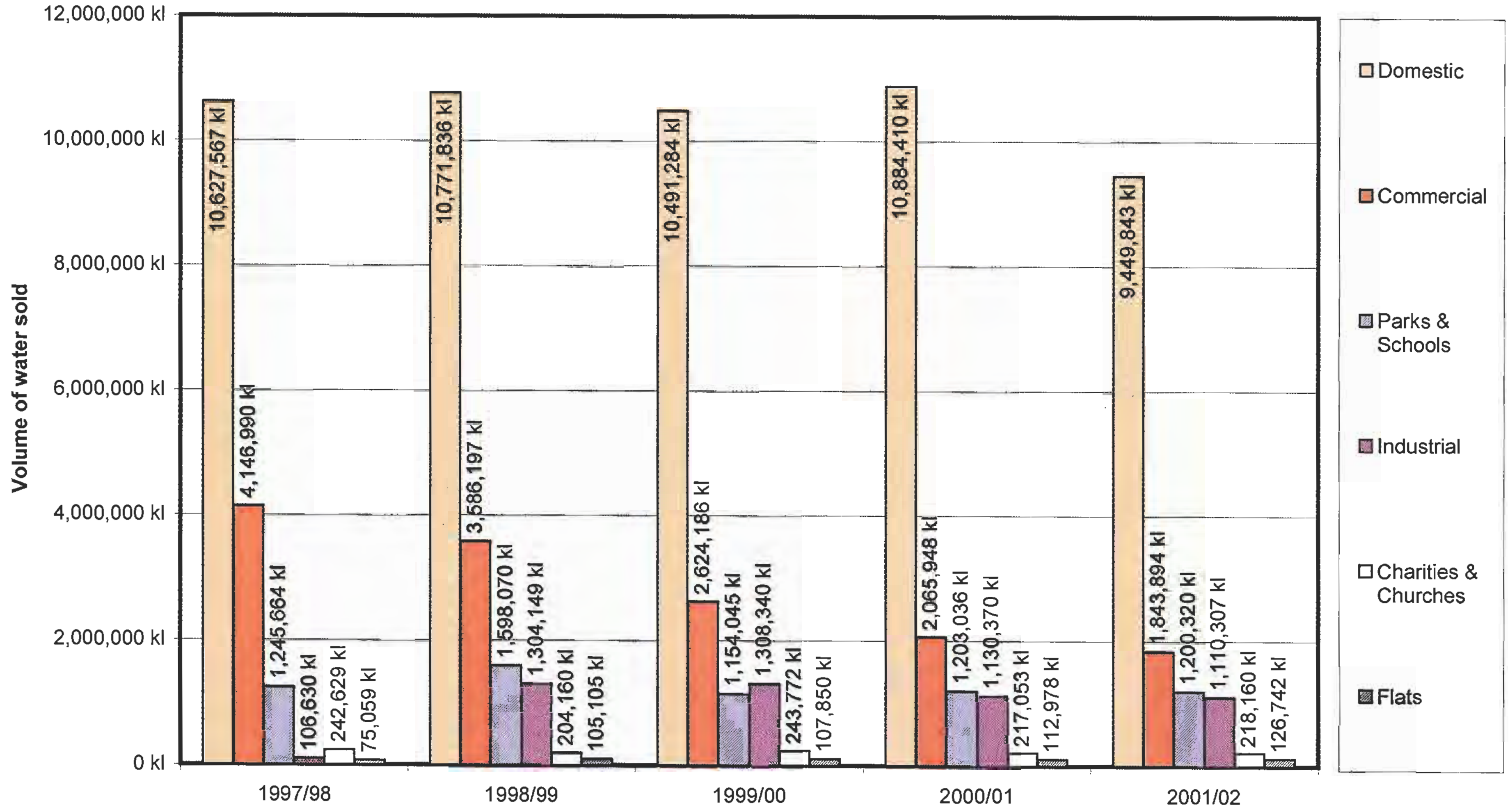
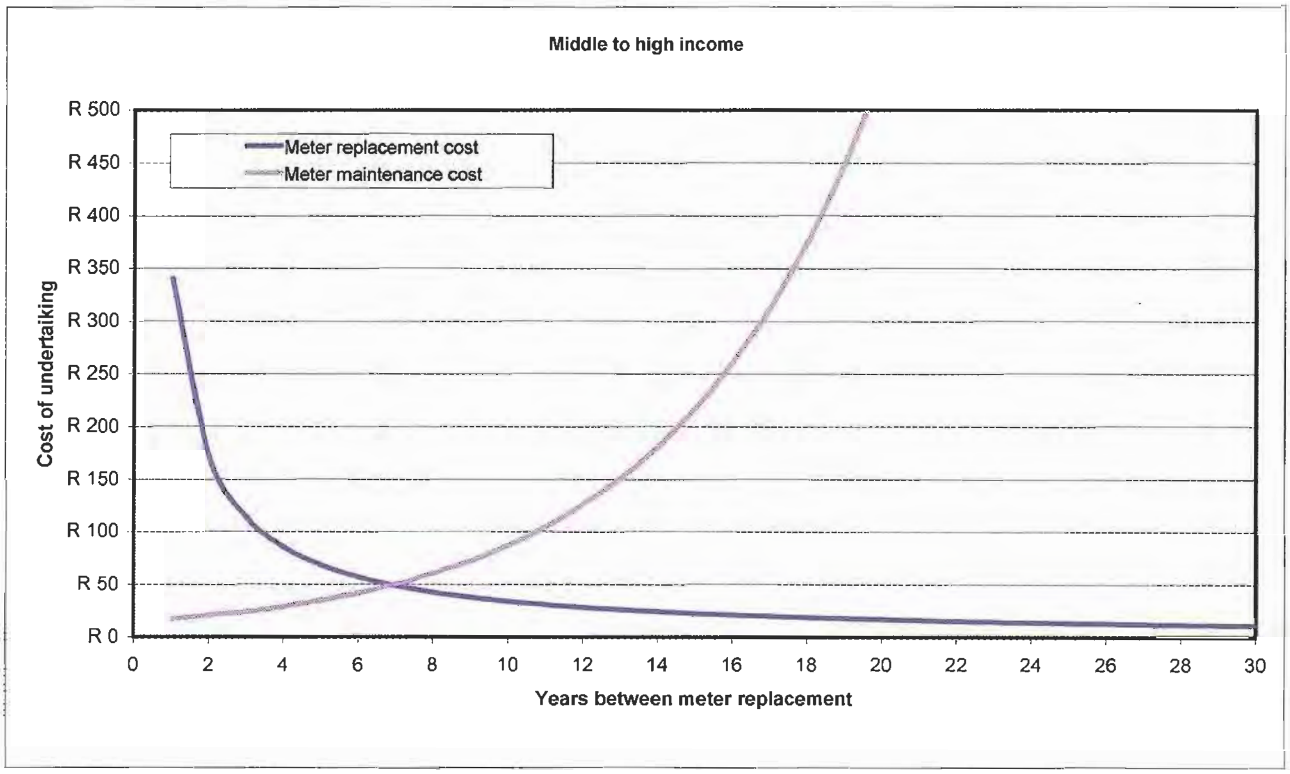


Figure 3 : Category sales per financial year



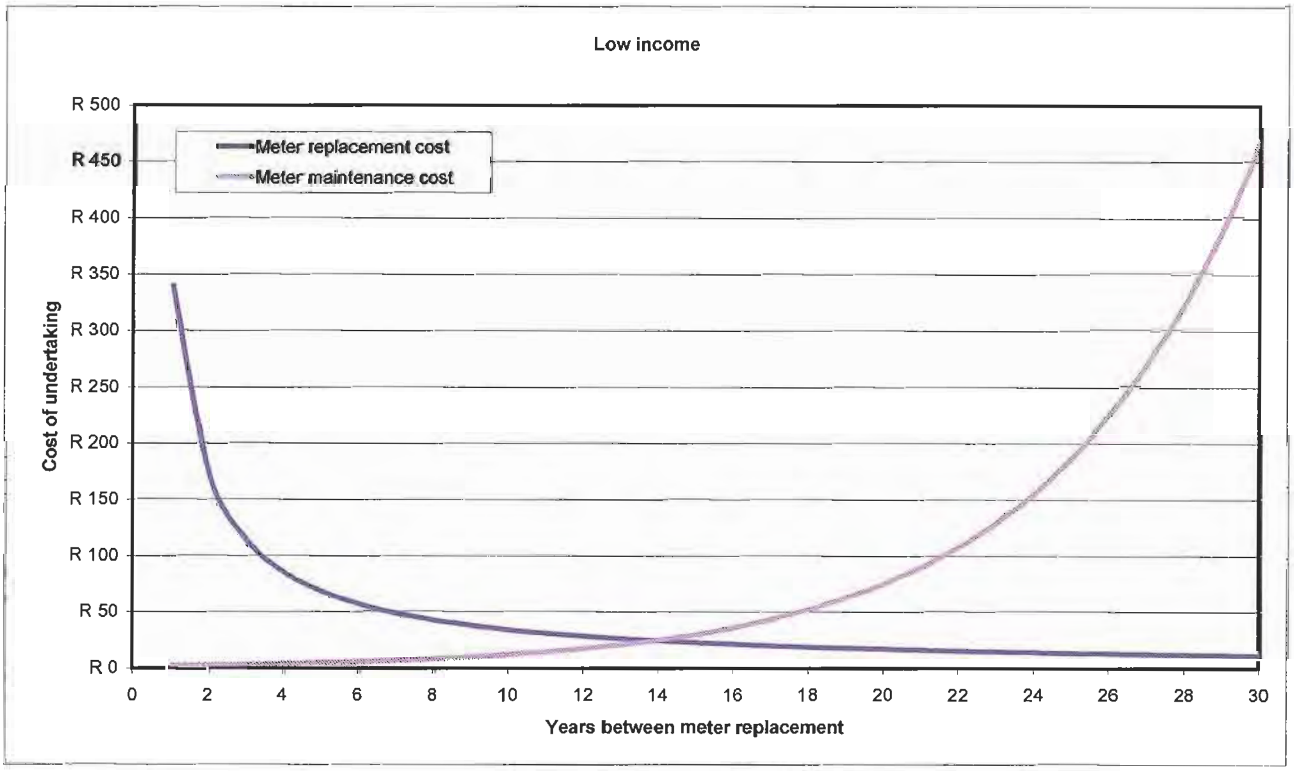
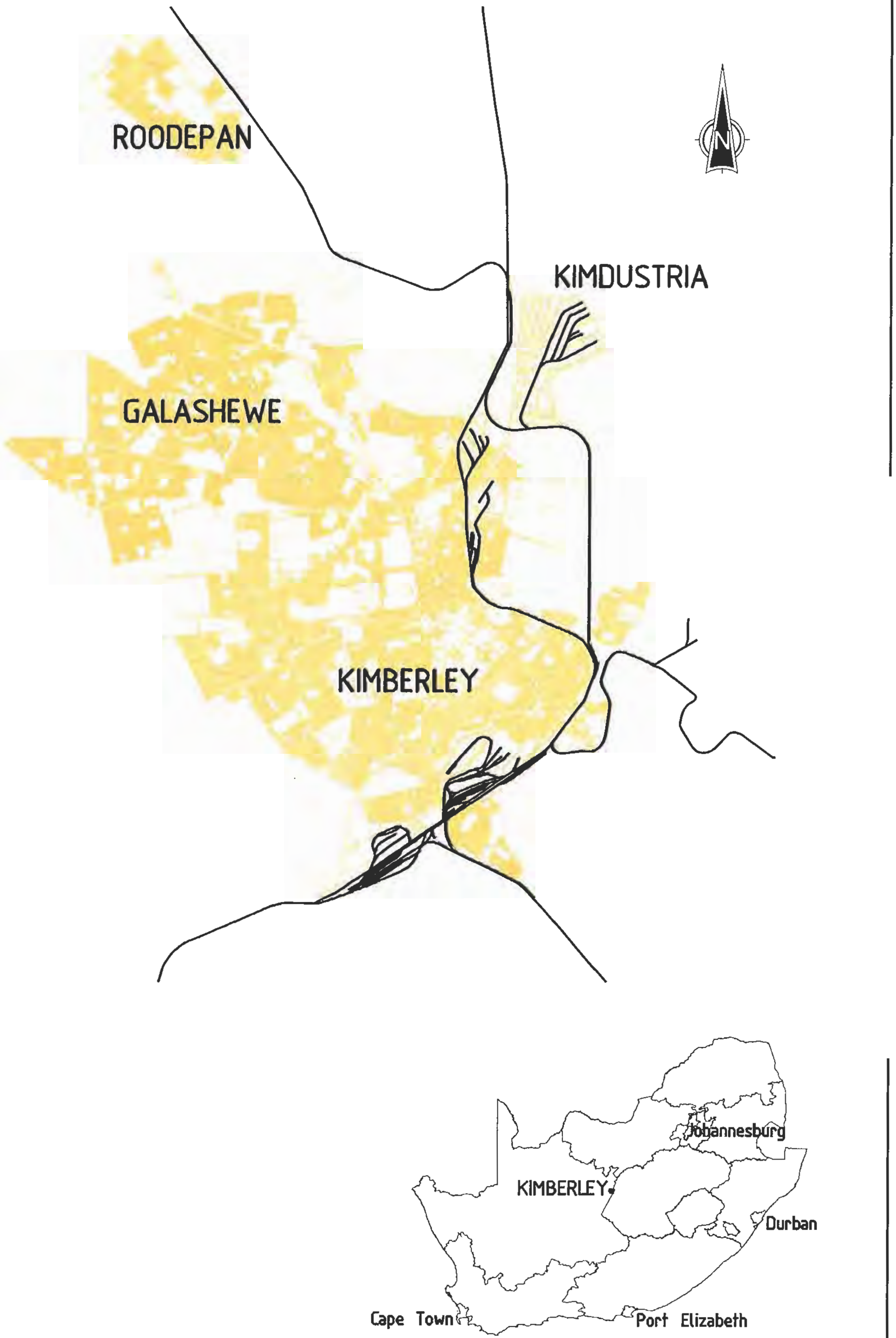


Figure 4 : Water meter replacement age

DRAWINGS



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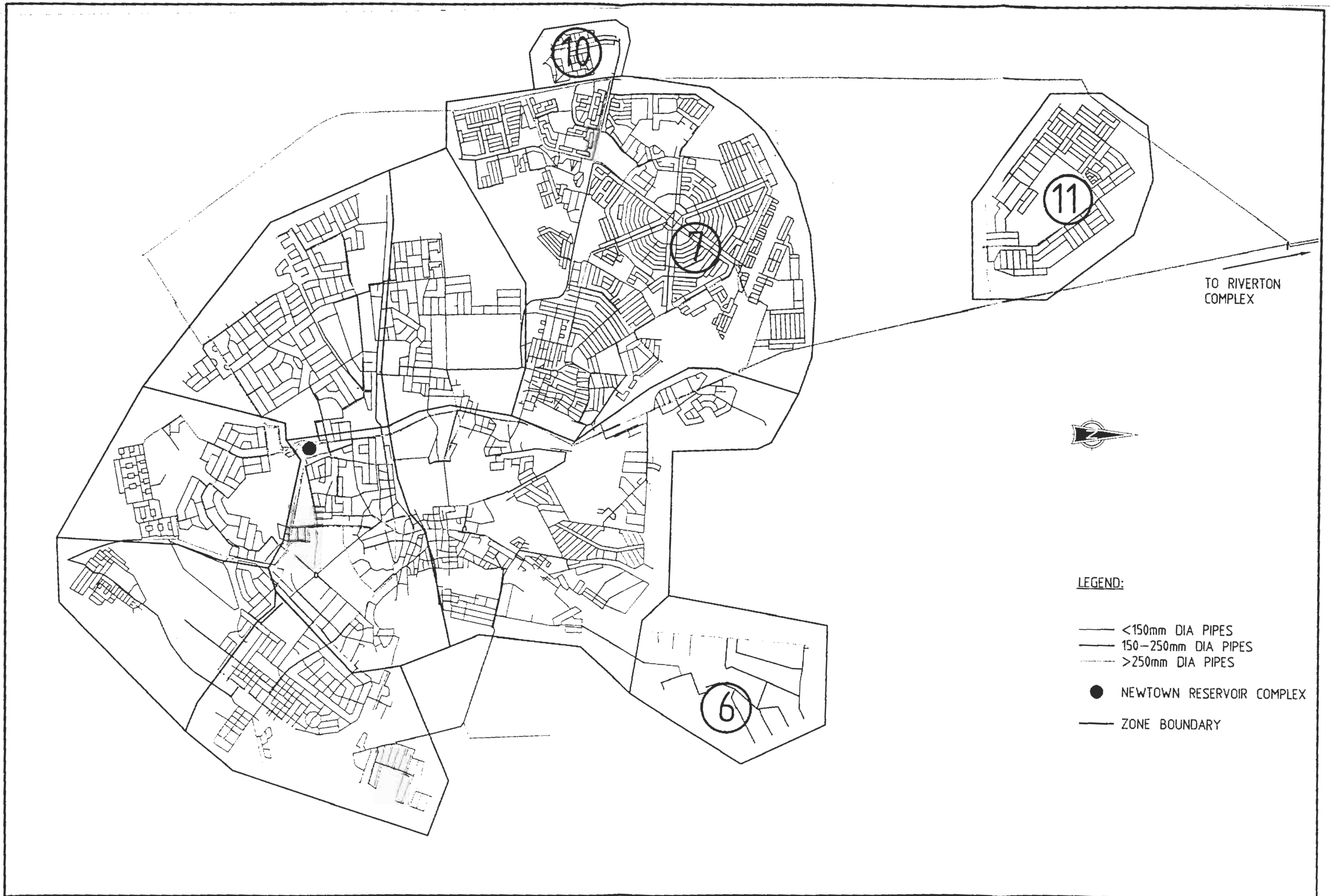
SOL PLAATJE MUNICIPALITY
KIMBERLEY WATER LOSS STUDY

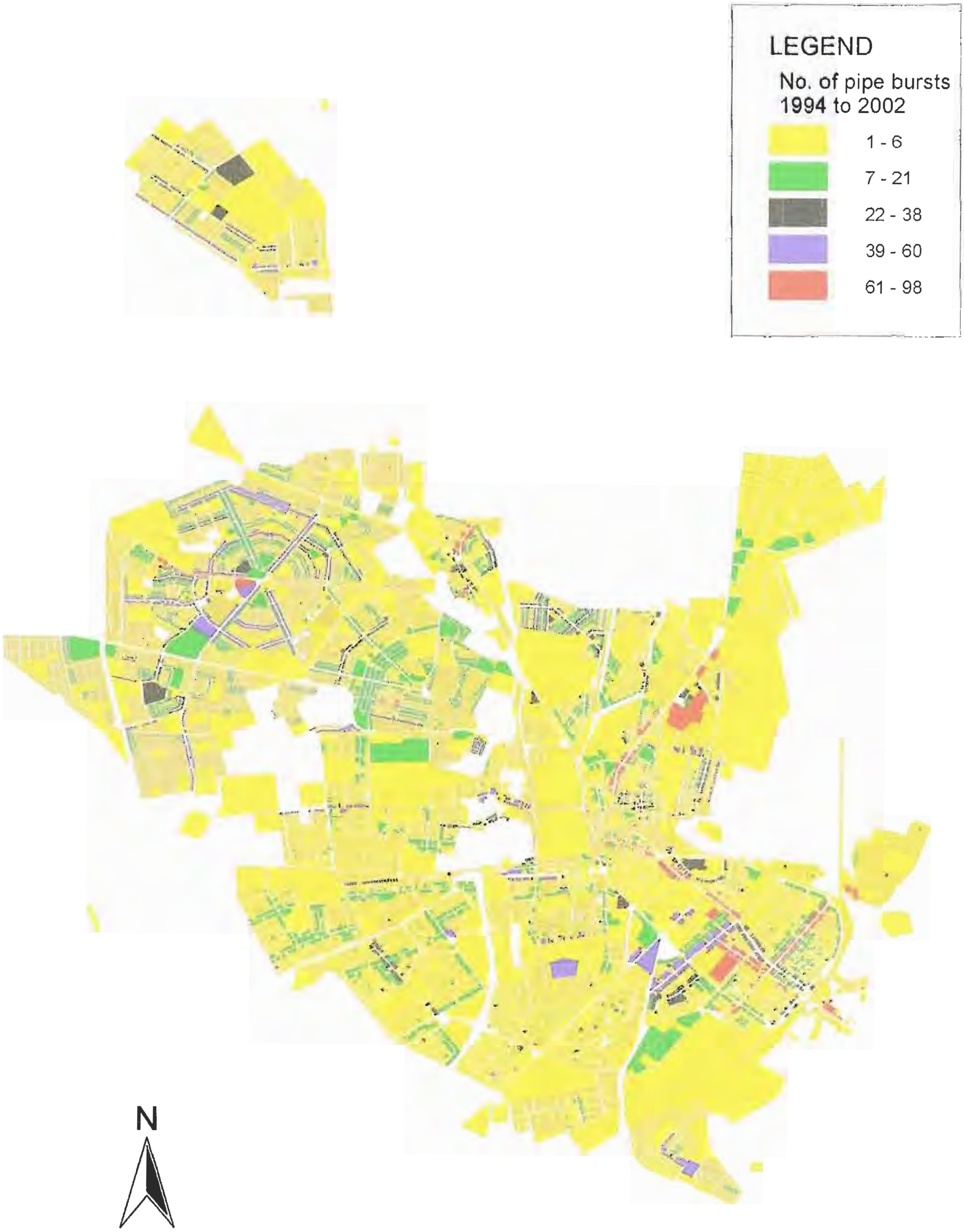
NINHAM SHAND
CONSULTING SERVICES
PORT ELIZABETH
FOUNDED IN 1908

LOCALITY PLAN

SCALE	DRG No	REV
1:100 000	10757 PE 001	A

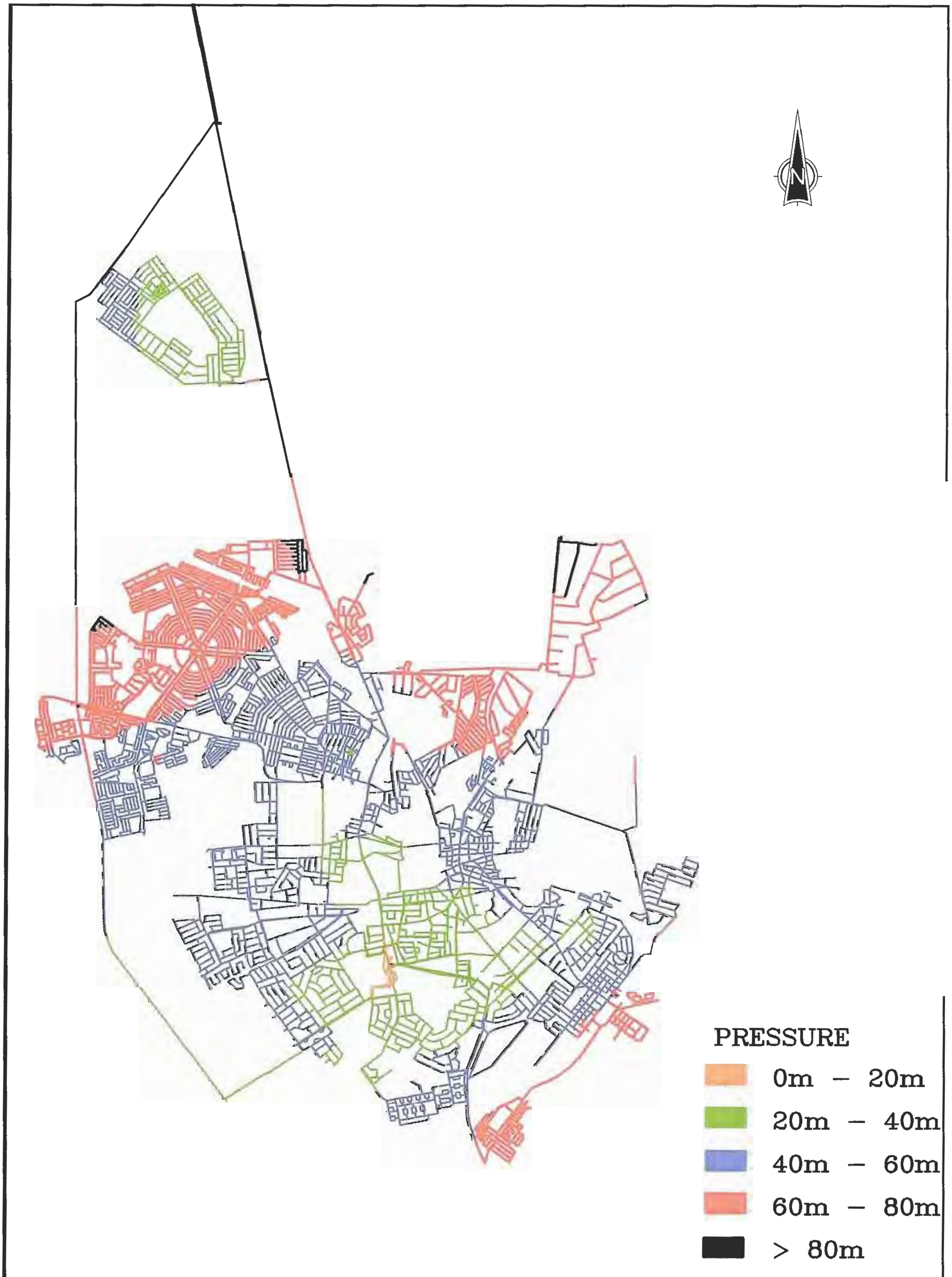


DRAWN GjH	DESIGNED GjH	PROJECT MANAGER	DATE	PROJECT DIRECTOR	DATE	FILE ZONES / PLOT SCALE 1=1	
NINHAM SHAND CONSULTING SERVICES PORT ELIZABETH		SOL PLAATJE MUNICIPALITY: KIMBERLEY WATER LOSS STUDY			SCALE	DRG No	REV
		POSSIBLE WATER SUPPLY ZONES			NTS	10757 PE 002	A



DRAWN	DESIGNED	PROJECT MANAGER	PROJECT DIRECTOR	FILE PLOT SCALE

SOL PLAATJE MUNICIPALITY KIMBERLEY WATER LOSS STUDY	NINHAM SHAND CONSULTING SERVICES PORT ELIZABETH ©NINHAM SHAND (PTY) LTD 2003		
BURST FREQUENCY BY AREA	SCALE 1:75000	DRG No 10757 PE 003	REV A



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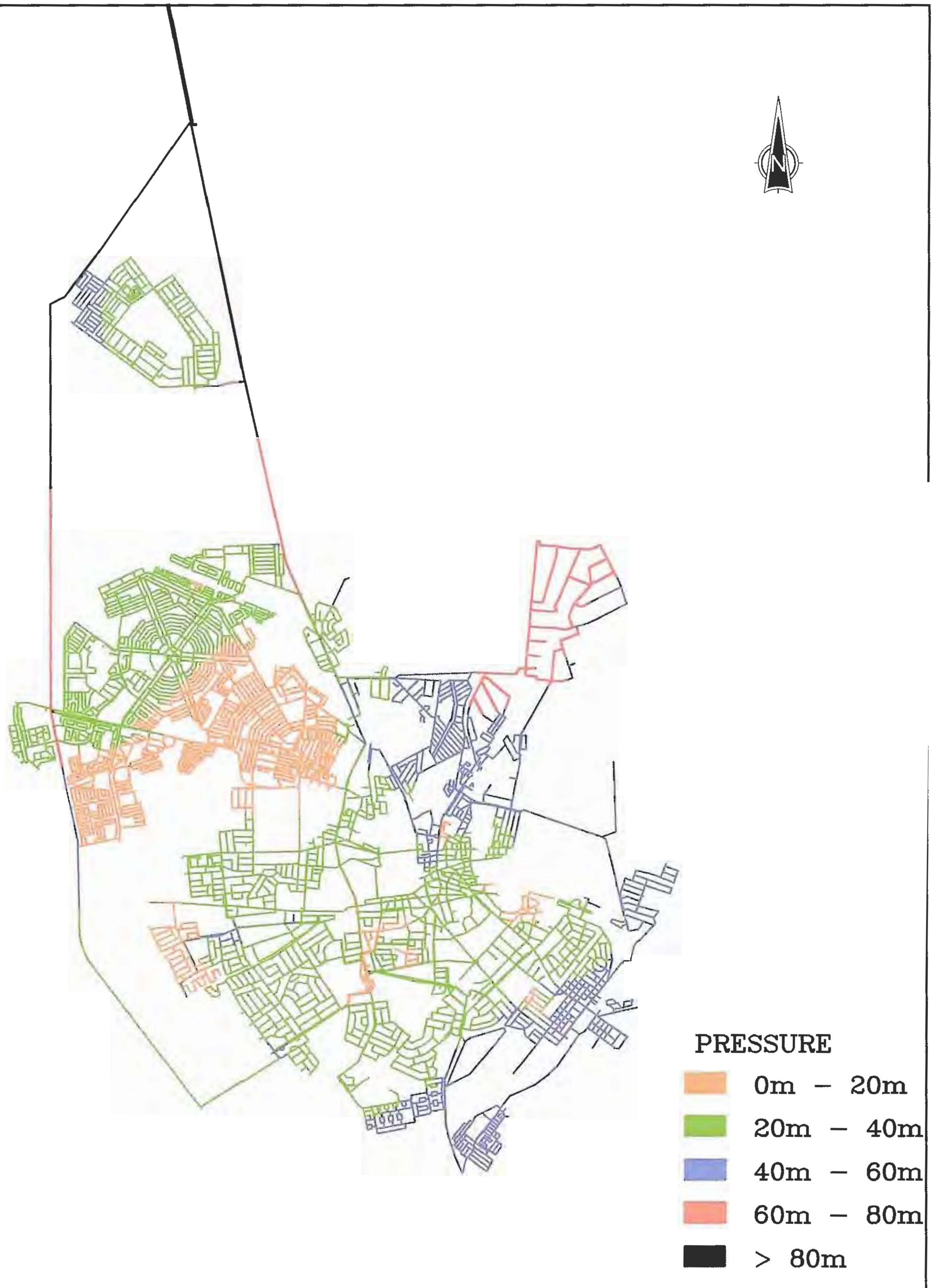
SOL PLAATJE MUNICIPALITY
KIMBERLEY WATER LOSS STUDY

NINHAM SHAND
CONSULTING SERVICES
PORT ELIZABETH

STATIC PRESSURE CONDITIONS

SCALE	DRG No	REV
NTS	10757 PE 004	A



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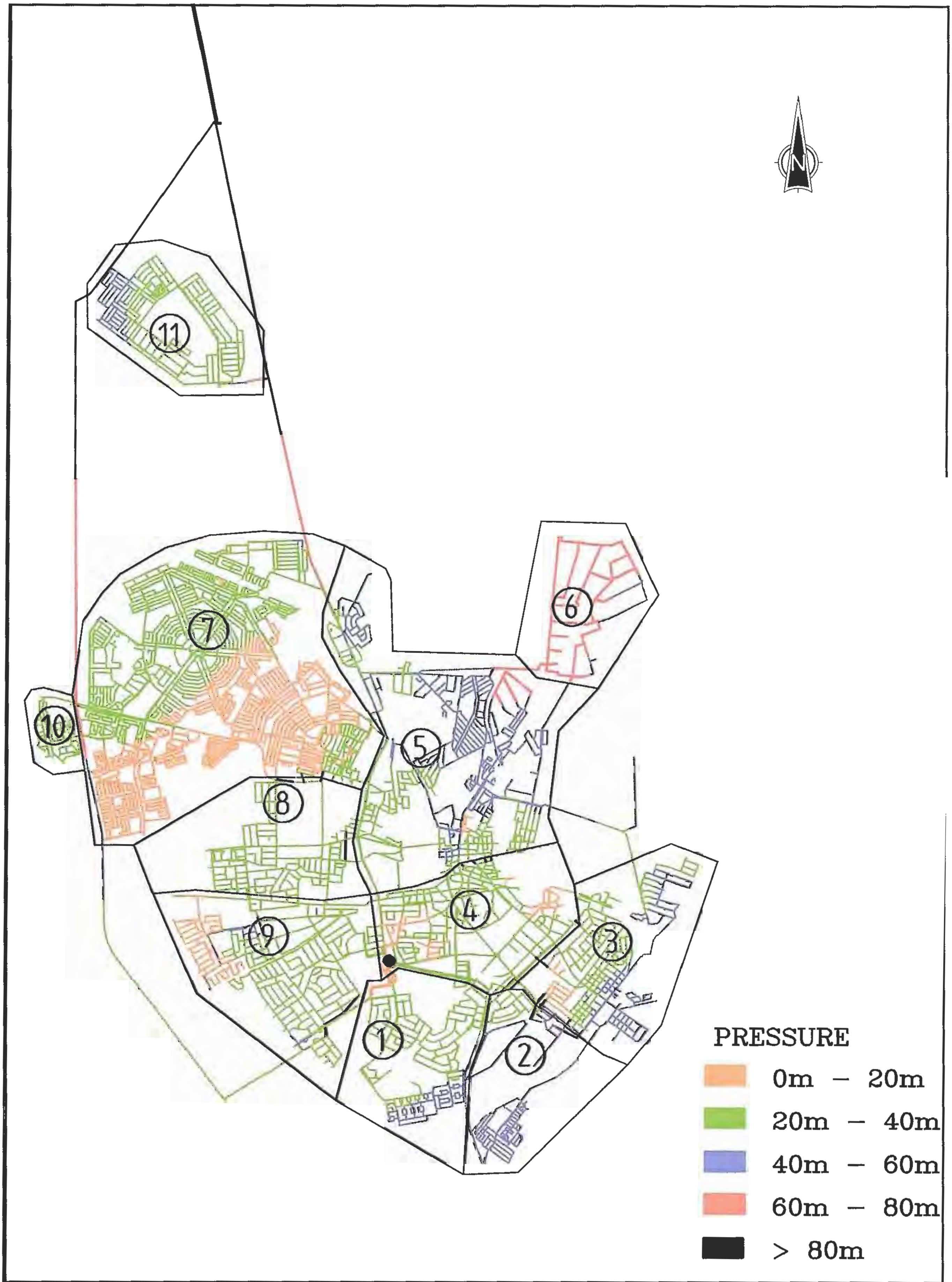
SOL PLAATJE MUNICIPALITY
KIMBERLEY WATER LOSS STUDY

NINHAM SHAND
CONSULTING SERVICES
PORT ELIZABETH

	SCALE	DRG No	REV
PEAK FLOW PRESSURE CONDITIONS – PRESENT NETWORK	NTS	10757 PE 005	A



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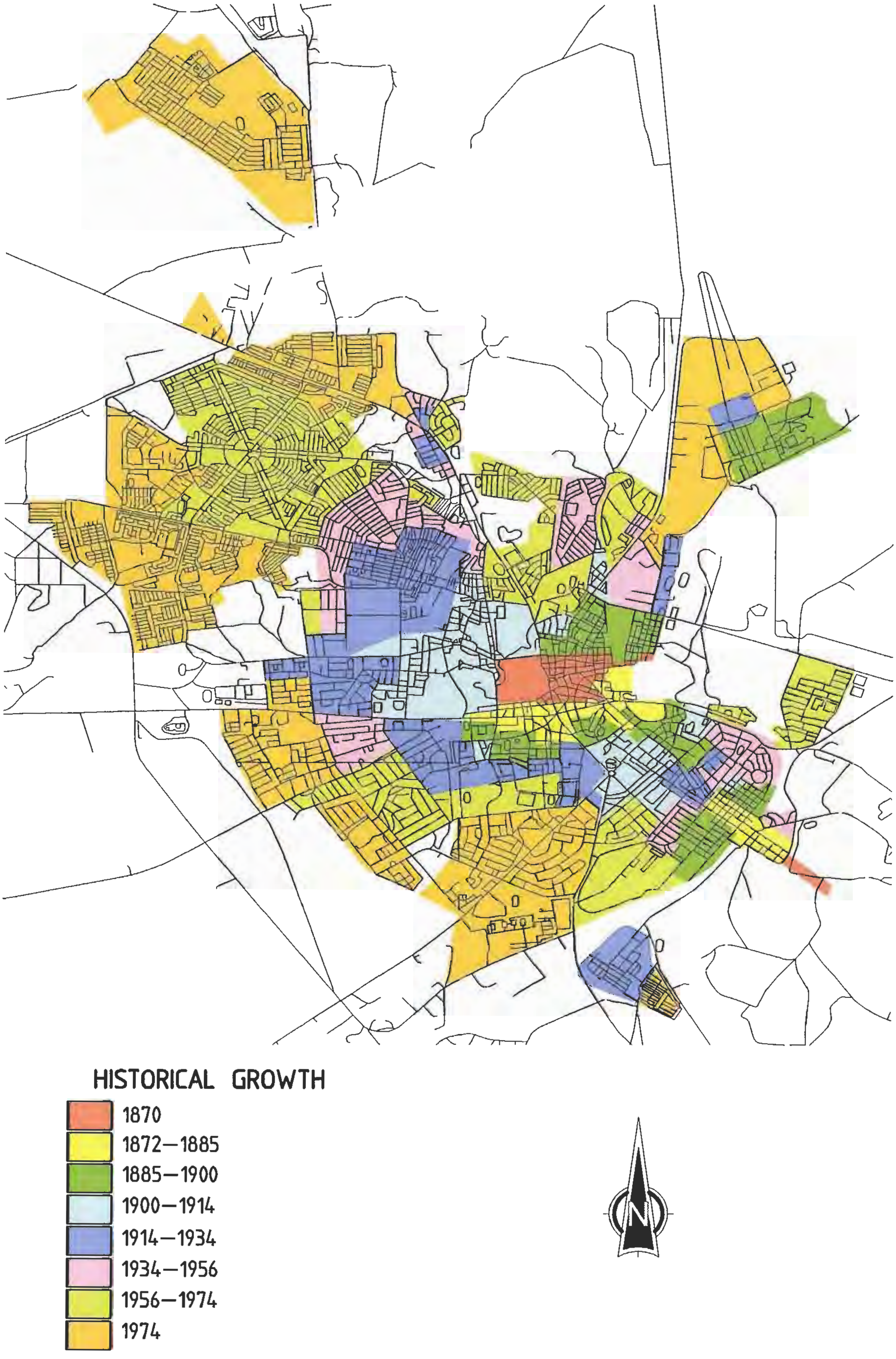
SOL PLAATJE MUNICIPALITY
KIMBERLY WATER LOSS STUDY

FOUNDED IN 1950
NINHAM SHAND
CONSULTING SERVICES
PORT ELIZABETH

PEAK FLOW CONDITIONS -
POSSIBLE WATER SUPPLY ZONES

SCALE	DRG No	REV
NTS	10757 PE 006	A



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SOL PLAATJE MUNICIPALITY
KIMBERLEY WATER LOSS STUDY

FOUNDED IN 1939 NINHAM SHAND CONSULTING SERVICES PORT ELIZABETH

HISTORICAL GROWTH OF KIMBERLEY

SCALE	DRG No	REV
NTS	10757 PE 007	A

APPENDICES

APPENDIX 1

WATER METER TEST RESULTS

No	Meter No	Slow test						Fast test					
		Vol	% error	Meters			% error outside tolarence	Vol	% error	Meters			% error outside tolarence
				Stuck	Inside tolarence	Outside tolarence				Stuck	Inside tolarence	Outside tolarence	
1	486981	116.10	16.1%	0	0	1	16.1%						
2	480379	69.60	-30.4%	0	0	1	-30.4%						
3	480307	5.60	-94.4%	0	0	1	-94.4%						
4	480305	102.20	2.2%	0	0	1	2.2%						
5	488179	92.60	-7.4%	0	0	1	-7.4%						
6	488787	91.20	-8.8%	0	0	1	-8.8%						
7	486981	54.50	9.0%	0	0	1	9.0%	11.40	-88.6%	0	0	1	-88.6%
8	480379	40.10	-19.8%	0	0	1	-19.8%	108.20	8.2%	0	0	1	8.2%
9	480307	0.00	-100.0%	1	0	0	0.0%	108.50	8.5%	0	0	1	8.5%
10	480305	47.50	-5.0%	0	0	1	-5.0%	100.60	0.6%	0	1	0	0.0%
11	488179	53.80	7.6%	0	0	1	7.6%	8.50	-91.5%	0	0	1	-91.5%
12	488787	150.70	201.4%	0	0	1	201.4%	109.00	9.0%	0	0	1	9.0%
13	480336	64.80	29.6%	0	0	1	29.6%	130.10	30.1%	0	0	1	30.1%
14	488753	59.20	18.4%	0	0	1	18.4%	122.80	22.8%	0	0	1	22.8%
15	488724	0.10	-99.8%	0	0	1	-99.8%	126.40	26.4%	0	0	1	26.4%
16	488221	0.10	-99.8%	0	0	1	-99.6%	130.80	30.8%	0	0	1	30.8%
17	463491	57.70	15.4%	0	0	1	15.4%	132.80	32.8%	0	0	1	32.8%
18	488740	8.40	-83.2%	0	0	1	-83.2%	121.40	21.4%	0	0	1	21.4%
19	940705027	50.30	0.6%	0	1	0	0.0%						
20	668893	5.00	-90.0%	0	0	1	-90.0%						
21	668876	0.00	-100.0%	1	0	0	0.0%						
22	668716	30.00	-40.0%	0	0	1	-40.0%						
23	668613	0.00	-100.0%	1	0	0	0.0%						
24	414088	0.00	-100.0%	1	0	0	0.0%						
25	668709	0.00	-100.0%	1	0	0	0.0%						
26	668786	0.00	-100.0%	1	0	0	0.0%						
27	668700	40.00	-20.0%	0	0	1	-20.0%						
28	94070312	49.60	-0.8%	0	1	0	0.0%						
29	668914	0.00	-100.0%	1	0	0	0.0%						
30	668670	0.00	-100.0%	1	0	0	0.0%						
31	668911	20.00	-60.0%	0	0	1	-60.0%						
32	668744	20.00	-60.0%	0	0	1	-60.0%						
33	668766	40.00	-20.0%	0	0	1	-20.0%						
34	668888	0.00	-100.0%	1	0	0	0.0%						
35	668771	20.00	-60.0%	0	0	1	-60.0%						
36	709782	50.00	0.0%	0	1	0	0.0%						
37	668735	0.00	-100.0%	1	0	0	0.0%	100.00	0.0%	0	1	0	0.0%
38	709787	20.00	-60.0%	0	0	1	-60.0%	120.00	20.0%	0	0	1	20.0%
39	668736	50.00	0.0%	0	1	0	0.0%	100.00	0.0%	0	1	0	0.0%
40	688591	0.00	-100.0%	1	0	0	0.0%	90.00	-10.0%	0	0	1	-10.0%
41	668897	20.00	-60.0%	0	0	1	-60.0%	100.00	0.0%	0	1	0	0.0%
42	668592	10.00	-80.0%	0	0	1	-80.0%	100.00	0.0%	0	1	0	0.0%
43	488170	54.80	9.6%	0	0	1	9.6%	99.50	-0.5%	0	1	0	0.0%
44	459944	47.70	-4.6%	0	0	1	-4.6%	109.90	9.9%	0	0	1	9.9%
45	480380	9.90	-80.2%	0	0	1	-80.2%	99.00	-1.0%	0	1	0	0.0%
46	488202	52.50	5.0%	0	0	1	5.0%	99.00	-1.0%	0	1	0	0.0%
47	480525	0.70	-98.6%	0	0	1	-98.6%	102.10	2.1%	0	0	1	2.1%
48	488784	62.60	25.2%	0	0	1	25.2%	99.10	-0.9%	0	1	0	0.0%
49	480570	1.00	-98.0%	0	0	1	-98.0%	96.80	-3.2%	0	0	1	-3.2%
50	488143	60.10	60.2%	0	0	1	60.2%	99.80	-0.2%	0	1	0	0.0%
51	488797	51.90	3.8%	0	0	1	3.8%	989.40	889.4%				
52	416381	2.20	-95.6%	0	0	1	-95.6%	100.40	0.4%	0	1	0	0.0%
53	488203	45.80	-8.4%	0	0	1	-8.4%	100.20	0.2%	0	1	0	0.0%
54	487007	4.40	-91.2%	0	0	1	-91.2%	102.10	2.1%	0	0	1	2.1%
55	668674	0.00	-100.0%	1	0	0	0.0%	89.00	-11.0%	0	0	1	-11.0%
56	668781	0.00	-100.0%	1	0	0	0.0%	89.00	-11.0%	0	0	1	-11.0%
57	668600	0.00	-100.0%	1	0	0	0.0%	90.00	-10.0%	0	0	1	-10.0%
58	505338	0.00	-100.0%	1	0	0	0.0%	100.00	0.0%	0	1	0	0.0%
59	668703	0.00	-100.0%	1	0	0	0.0%	100.00	0.0%	0	1	0	0.0%
60	668605	0.00	-100.0%	1	0	0	0.0%	100.00	0.0%	0	1	0	0.0%
61	921106253	51.00	2.0%	0	1	0	0.0%	102.00	2.0%	0	1	0	0.0%
62	921106581	52.00	4.0%	0	0	1	4.0%	102.00	2.0%	0	1	0	0.0%
63	920806613	0.20	-99.6%	0	0	1	-99.6%	99.20	-0.8%	0	1	0	0.0%
64	C-KAG-908	49.70	-0.6%	0	1	0	0.0%	100.60	0.6%	0	1	0	0.0%
65	WCJ 924	49.90	-0.2%	0	1	0	0.0%	101.20	1.2%	0	1	0	0.0%
66	C-MCY 942	0.00	-100.0%	1	0	0	0.0%	100.30	0.3%	0	1	0	0.0%
67	668683	0.00	-100.0%	1	0	0	0.0%	90.00	-10.0%	0	0	1	-10.0%
68	668602	0.00	-100.0%	1	0	0	0.0%	100.00	0.0%	0	1	0	0.0%
69	971124	0.00	-100.0%	1	0	0	0.0%	102.00	2.0%	0	1	0	0.0%
70	C-YDU 000	47.40	-5.2%	0	0	1	-5.2%	100.00	0.0%	0	1	0	0.0%
71	428980	51.00	2.0%	0	1	0	0.0%	101.00	1.0%	0	1	0	0.0%
72	776395	0.00	-100.0%	1	0	0	0.0%	111.00	11.0%	0	0	1	11.0%
73	668639	0.00	-100.0%	1	0	0	0.0%	100.00	0.0%	0	1	0	0.0%
74	668783	0.00	-100.0%	1	0	0	0.0%	0.00	-100.0%	1	0	0	0.0%
75	668605	0.00	-100.0%	1	0	0	0.0%	0.00	-100.0%	1	0	0	0.0%
76	668653	0.00	-100.0%	1	0	0	0.0%	0.00	-100.0%	1	0	0	0.0%
77	668648	70.00	40.0%	0	0	1	40.0%	100.00	0.0%	0	1	0	0.0%
78	668645	0.00	-100.0%	1	0	0	0.0%	100.00	0.0%	0	1	0	0.0%
79	668615	0.00	-100.0%	1	0	0	0.0%	100.00	0.0%	0	1	0	0.0%
80	668647	0.00	-100.0%	1	0	0	0.0%	0.00	-100.0%	1	0	0	0.0%
81	668635	0.00	-100.0%	1	0	0	0.0%	0.00	-100.0%	1	0	0	0.0%
82	668638	0.00	-100.0%	1	0	0	0.0%	0.00	-100.0%	1	0	0	0.0%
83	668665	0.00	-100.0%	1	0	0	0.0%	0.00	-100.0%	1	0	0	0.0%
84	668646	0.00	-100.0%	1	0	0	0.0%	100.00	0.0%	0	1	0	0.0%
85	940705138	47.60	-4.8%	0	0	1	-4.8%	104.20	4.2%	0	0	1	4.2%
86	489094	49.00	-2.0%	0	1	0	0.0%	897.60	797.6%				
87	488775	10.00	-80.0%	0	0	1	-80.0%	92.60	-7.4%	0	0	1	-7.4%
88	488147	152.00	204.0%	0	0	1	204.0%	105.30	5.3%	0	0	1	5.3%
89	436298	152.00	204.0%	0	0	1	204.0%	107.20	7.2%	0	0	1	7.2%
90	488248	52.70	5.4%	0	0	1	5.4%	105.10	5.1%	0	0	1	5.1%
91	414112	1.00	-98.0%	0	0	1	-98.0%	0.00	-100.0%	1	0	0	0.0%
92	414041	0.00	-100.0%	1	0	0	0.0%	0.00	-100.0%	1	0	0	0.0%
93	414176	0.00	-100.0%	1	0	0	0.0%	0.00	-100.0%	1	0	0	0.0%
94	414036	0.00	-100.0%	1	0	0	0.0%	100.00	0.0%	0	1	0	0.0%
95	414348	10.00	-80.0%	0	0	1	-80.0%	100.00	0.0%	0	1	0	0.0%
96	414349	0.00	-100.0%	1	0	0	0.0%	100.00	0.0%	0	1	0	0.0%
				37	9	50	-981.9%			10	33	27	14.2%
				38.5%			-19.6%			13.9%			0.5%

Appedix 1 : Meter test results

APPENDIX 2

WATER QUALITY ANALYSES

DIE STAD CITY OF
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SOL PLAATJE MUNISIPALE LABORATORIUM

WATER CHEMIESE ANALISE: RIVERTON

19/02/03 07:30

Resultate in mg/l, tensy anders vermeld:

Monster	ROU	BEHANDEL	NEWTON	FILTER	INSP BOX
pH	7.68	7.65	7.51	7.74	7.69
Konduktiwiteit (mS/m)	70	70	60	70	70
Totale Hardheid (as CaCO3)	140.8	144.7	142.3	146.7	148.3
Karbonaat Hardheid (as CaCO3)	46	45.9	45.8	49.6	46.8
Nie-Karbonaat Hardheid (as CaCO3)	94.8	98.8	96.5	97.1	101.5
P-Alkaliniteit (as CaCO3)	1.9	0.7	0.9	2.8	2.7
M-Alkaliniteit (as CaCO3)	112.1	105.2	102	113.3	110.7
Kalsium (as Ca)	18.5	18.4	18.4	19.9	18.8
Magnesium (as Mg)	23	24	23.4	23.6	24.7
Chloriede (as Cl)	52.6	55.9	52.3	55.9	55.2
Sulfate (as SO4)	ND	ND	ND	ND	ND
Nitrate (as N)	ND	ND	ND	ND	ND
Natrium (as Na)	ND	ND	ND	ND	ND
Sink (as Zn)	ND	ND	ND	ND	ND
Vrye Koolstofdioksied (as CO2)	4.7	4.7	6.3	4.2	4.6
Monster temperatuur (°C)	24.9	24.9	24.8	24.3	24.2
Totale Vaste Stowwe	392	396	326	352	366
Totale Opgeloste Vaste Stowwe	388	393.6	325.2	342	360.8
Totale Gesuspendeerde Vaste Stowwe	4	2.4	0.8	10	5.2
Turbiditeit (NTE)	5.27	0.98	0.72	4.73	3.51
Langeliers Versadigings Indeks	-0.48	-0.54	-0.68	-0.38	-0.43
Versadigings pH	8.16	8.19	8.19	8.12	8.12
Ryznar Stabiliteits Indeks	8.64	8.73	8.87	8.5	8.55
Konduktiwiteitsverhouding	0.18	0.178	0.185	0.205	0.194
Chlorofil a (mikrogram/l)	ERR	ERR			
Fluoride	ND	ND	ND	ND	ND

OPMERKINGS:

NB = NIE BEPAAL

DATUM: 20/2/03

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SOL PLAATJE MUNISIPALE LABORATORIUM

WATER CHEMIESE ANALISE: RIVERTON

05/11/02 07:30

Resultate in mg/l, tensy anders vermeld:

Monster	ROU	BEHANDEL	NEWTON
pH	7.56	7.3	7.12
Konduktiwiteit (mS/m)	56.4	39.8	39.1
Totale Hardheid (as $CaCO_3$)	161.2	161.8	155.4
Karbonaat Hardheid (as $CaCO_3$)	77	78	70.3
Nie-Karbonaat Hardheid (as $CaCO_3$)	84.2	83.8	85.1
P-Alkaliniteit (as $CaCO_3$)	0	0	0
M-Alkaliniteit (as $CaCO_3$)	151.5	146.2	139
Kalsium (as Ca)	30.9	31.3	28.2
Magnesium (as Mg)	20.5	20.4	20.7
Chloriede (as Cl)	54.7	50.8	46
Sulfate (as SO_4)	225	188	194
Nitrate (as N)	0.4	0.4	0.4
Natrium (as Na)	ND	ND	ND
Sink (as Zn)	ND	ND	ND
Vrye Koolstofdioksied (as CO_2)	8.3	14.6	21.1
Monster temperatuur (°C)	19.8	19.9	19.9
Totale Vaste Stowwe	270	268	240
Totale Opgeloste Vaste Stowwe	255.6	268	239.6
Totale Gesuspendeerde Vaste Stowwe	14.4	0	0.4
Turbiditeit (NTE)	14.1	0.52	0.36
Langeliers Versadigings Indeks	-0.33	-0.6	-0.84
Versadigings pH	7.89	7.9	7.96
Ryznar Stabiliteits Indeks	8.22	8.5	8.8
Konduktiwiteitsverhouding	0.221	0.149	0.163
Chlorofil a (mikrogram/l)	ERR	ERR	
Fluoride	0.150	0.05	0.1

OPMERKINGS:______________________________________

NB = NIE BEPAAL

DATUM: 5/11/02

HANDTEKENING: ____________________

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SOL PLAATJE MUNISIPALE LABORATORIUM

WATER CHEMIESE ANALISE: RIVERTON

10/09/02 07:20

Resultate in mg/l, tensy anders vermeld:

Monster	ROU	BEHANDEL	NEWTON
pH	7.79	7.51	7.43
Konduktiwiteit (mS/m)	64.2	53.4	51.4
Totale Hardheid (as CaCO3)	136.1	156.6	136.6
Karbonaat Hardheid (as CaCO3)	63	56.8	59.9
Nie-Karbonaat Hardheid (as CaCO3)	73.1	99.8	76.7
P-Alkaliniteit (as CaCO3)	0	0	0
M-Alkaliniteit (as CaCO3)	117.4	109.5	115.9
Kalsium (as Ca)	25.2	22.8	24
Magnesium (as Mg)	17.8	24.3	18.6
Chloriede (as Cl)	27.9	28.1	28.5
Sulfate (as SO4)	179	88	92
Nitrate (as N)	0.1	0.3	0.1
Natrium (as Na)	ND	ND	ND
Sink (as Zn)	ND	ND	ND
Vrye Koolstofdioksied (as CO2)	3.8	6.7	8.6
Monster temperatuur (°C)	16.9	16.9	16.9
Totale Vaste Stowwe	306	278	236
Totale Opgeloste Vaste Stowwe	291.6	272.6	235.4
Totale Gesuspendeerde Vaste Stowwe	14.4	5.4	0.6
Turbiditeit (NTE)	8.11	2.37	0.61
Langeliers Versadigings Indeks	-0.37	-0.72	-0.75
Versadigings pH	8.16	8.23	8.18
Ryznar Stabiliteits Indeks	8.53	8.95	8.93
Konduktiwiteitsverhouding	0.22	0.196	0.218
Chlorofil a (mikrogram/l)	ERR	ERR	
Fluoride	ND	ND	ND

OPMERKINGS: ____________________

NB = NIE BEPAAL

DATUM: 10/09/02

HANDTEKENING: [signature]

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SOL PLAATJE MUNISIPALE LABORATORIUM

WATER CHEMIESE ANALISE: RIVERTON
19/03/02 07:15

Resultate in mg/l, tensy anders vermeld:

Monster	ROU	BEHANDEL	KRAAN	NEWTON	GREENPOIN	CASSAN	GALES
pH	7.79	7.67	7.61	7.65	7.71	7.52	7.59
Konduktiwiteit (mS/m)	86.9	59.8	61.4	59.9	62.3	58.6	58.9
Totale Hardheid (as CaCO3)	97.7	96.5	101.5	101.6	112.7	101.6	103.6
Karbonaat Hardheid (as CaCO3)	52	54.6	55.8	53.1	61	56.2	54.7
Nie-Karbonaat Hardheid (as CaCO3)	45.7	41.9	45.7	48.5	51.7	45.4	48.9
P-Alkaliniteit (as CaCO3)	0.3	0	0	0	0	0	0
M-Alkaliniteit (as CaCO3)	72	70.8	73	70.7	79.5	70.4	69.1
Kalsium (as Ca)	20.8	21.9	22.4	21.3	24.5	22.5	21.9
Magnesium (as Mg)	11.1	10.2	11.1	11.8	12.6	11	11.9
Chloriede (as Cl)	27.8	27.3	25.5	25.5	27	25.3	24.2
Sulfate (as SO4)	97	114	ND	119	119	ND	ND
Nitrate (as N)	2.3	2.7	ND	2.7	2.7	ND	ND
Natrium (as Na)	25.95	24.88	25.24	25.82	25.82	25.92	26.31
Sink (as Zn)	0.026	0.028	0.026	0.027	0.027	0.044	0.027
Vrye Koolstofdioksied (as CO2)	2.3	3	3.6	3.2	3.1	4.2	3.5
Monster temperatuur (°C)	23.4	23.3	23.3	23.4	23.2	23.1	23.3
Totale Vaste Stowwe	296	240	248	252	242	250	248
Totale Opgeloste Vaste Stowwe	260.6	239.6	246.2	251.8	242	248.4	246.8
Totale Gesuspendeerde Vaste Stowwe	35.4	0.4	1.8	0.2	0	1.6	1.2
Turbiditeit (NTE)	41.2	0.08	0.04	0.06	0.18	0.09	0.26
Langeliers Versadigings Indeks	-0.51	-0.62	-0.66	-0.65	-0.59	-0.76	-0.71
Versadigings pH	8.3	8.29	8.27	8.3	8.3	8.28	8.3
Ryznar Stabiliteits Indeks	8.81	8.91	8.93	8.95	8.89	9.04	9.01
Konduktiwiteitsverhouding	0.333	0.25	0.249	0.238	0.257	0.236	0.239
~~Chlorofil a (mikrogram/l)~~	~~31.526~~	~~1.1464~~					
Fluoride	ND	ND	ND	ND	ND	ND	ND

OPMERKINGS: ____________________

NB = NIE BEPAAL

DATUM: 20/3/02

HANDTEKENING: [signature]

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SOL PLAATJE MUNICIPAL LABORATORY

WATER CHEMICAL ANALYSES: RIVERTON

04/06/02 07:50

Results in mg/l unless stated otherwise:

Sample	Rou	Beh	BHT-Set	BHT-Filt	DOW-Set	DOW-Filt
pH	8.08	7.81	8.24	8.21	8.32	8.32
Conductivity (mS/m)	45.6	47.6	46.6	46.5	46.2	46.1
Total hardness (as CaCO3)	147.7	151.7	153.4	152	158.1	153.7
Carbonate hardness (as CaCO3)	75.1	78.5	80.1	79.2	80.3	83.5
Non-carbonate hardness (as CaCO3)	72.6	73.2	73.3	72.8	77.8	70.2
P-alkalinity (as CaCO3)	1.9	0.4	2.8	2.6	3.9	3.2
M-alkalinity (as CaCO3)	60	59.6	62	59.2	63	64.7
Calsium (as Ca)	30.1	31.5	32.1	31.8	32.2	33.5
Magnesium (as Mg)	17.6	17.8	17.8	17.7	18.9	17.1
Chloride (as Cl)	27.7	31.3	28.4	29	28.4	28.9
Sulphate (as SO4)	93	107	156	103	99	112
Nitrate (as N)	0.6	0.8	0.6	0.5	0.6	0.5
Free carbon dioxide (as CO2)	1	1.8	0.7	0.7	0.6	0.6
Sample temperature (°C)	15.2	15.9	15.8	15.6	15.5	15.6
Total solids	250	208	234	236	274	274
Total dissolved solids	230.4	208	210.8	236	265.6	274
Total suspendid solids	19.6	0	23.2	0	8.4	0
Turbidity (NTU)	23.7	1.32	18.2	0.72	10.1	1.16
Langeliers saturation index	-0.32	-0.55	-0.1	-0.17	-0.03	0
Saturation pH	8.4	8.36	8.34	8.38	8.35	8.32
Ryznar stability index	8.72	8.91	8.44	8.55	8.38	8.32
Conductivity relationship	0.198	0.229	0.221	0.197	0.174	0.168
NATRIUM (Na)	34.59	32.45	32.42	32.68	33.21	33.57
ZINK (Zn)	0.061	0.056	0.072	0.068	0.075	0.069
IRON (Fe)	ND	ND	ND	ND	ND	ND

REMARKS:______________________________

DATE:____________

SIGNED:____________________
HEAD: LABORATORY SERVICES

APPENDIX 3

BURST MAINTENANCE RECORDS 2000/2001/2002

Date	AC										Steel											
	50	75	100	150	200	225	250	300	350	450	50	75	100	150	200	225	250	300	350	450	600	900
January-00	4	8	4	17								6		12		5			6	3		
February-00	5	8	18	18							4					5			6			
March-00	6	8	21	18							5	7		12		4	1		3	1		
April-00		12	47	60								3				8			6	1		
May-00		11	28	22								6	3	2				5	7		2	1
June-00		10	22	31								6				3			5			
July-00		9	31	24								5							2	2	5	
August-00		16	36	34								2				5						
September-00	4	16	23	40												4			4		5	1
October-00		14	12	32								6				4		1			2	
November-00		10	9	29											1	6				3		
December-00	2	14	18	26								1	2			4			2	2		
January-01		10	9	13							2	6				3			2			
February-01		6	16	15								7	2			2						
March-01		3	18	19										1		2			4			
April-01		12	10	25										1					4			
May-01		9	13	25							2			2		2	5		5			
June-01	4	10	11	21								5	6			8			2			
July-01		2	10	21									1	4		4						
August-01		7	20	23										2		3			5			
September-01		12	15	16								1				4			1			
October-01		6	8	7								3				5			2			
November-01		8	8	7	1							5				7			6			
December-01	2	7	5	21	2							6				3			6	2		
January-02			6	16											2	4			1	2		
February-02		12	9	14												4			3			
March-02		9	4	14								6				4		1	5	1		
April-02	2	10	14	22								2				2		1	3			
May-02		4	8	12								3				1	1		3			
June-02		7	7	16	3											1	3					
July-02		4	16	15								3				3			1			
August-02	2	9	4	10				2							1		2					
September-02		9	17	23			1	1	1											1		
October-02		2	13	15	2											3			2			
November-02			12	25	1											5	1	1	4			
December-02	.	10	13	16															1			
Total	27	296	531	745	9		1	3	1			83	14	24	4	113	13	9	95	15	14	2

Date	uPVC					Hdpe / Service				Non-defined														Rising Main				Total
	50	63	75	110	150	50	63	75	450	50	63	75	100	110	150	200	225	300	350	450	500	600	900	450	600	900	N/S	
January-00		3											17															85
February-00					2																							66
March-00					2																							88
April-00						6																						143
May-00						5					3																	95
June-00		2	4																									83
July-00				3		5	2																					88
August-00		6		4																2					5			110
September-00							2																					99
October-00		3		2								5	3		5												3	92
November-00		3				8						3	6		4													82
December-00																												71
January-01				1	2	7												1		1								57
February-01				1		4																		6	1			60
March-01				2		9						11								3	3				5	2		82
April-01				2		2																			1	1		58
May-01						2																						65
June-01				3			3																					73
July-01				3		3						8																56
August-01												3	6		4										5			78
September-01						5																						54
October-01				4		4																						39
November-01						2																			3			47
December-01		1										2																57
January-02						10						11																52
February-02				3		8																						53
March-02				1		3																						48
April-02				2																								58
May-02						4																						36
June-02						14																						51
July-02						3																						45
August-02																												30
September-02																												53
October-02																												37
November-02						4						7																60
December-02						3											4										1	48
Total			4	31	6	111						50	15		13		4	1		6	3			6	20	3	4	2276

Appendix 3 : Pipe burst details

INTERIMS FOR FOUR MONTHS

Code	Description	Feb 2003	Jan 2003	Dec 2002	Nov 2002	Average
910	Residential					
	Meters Read	11438	5577	12486	12880	
	Meters Interim	2474	8298	1475	1026	
	Interim Raised	314106	1285323	174045	Error	
	Interim Reversed	(1271810)	(113633)	(110741)	(176679)	
919	Business-Kina					
	Meters Read	3	2	3	2	
	Meters Interim	0	1	0	1	
	Interim Raised	0	332	0	Error	
	Interim Reversed	(332)	-	0	-	
920	Business					
	Meters Read	791	589	874	863	
	Meters Interim	319	516	226	239	
	Interim Raised	289792	415847	206455	Error	
	Interim Reversed	(347406)	(270065)	(215181)	(246526)	
930	School Sport Fields					
	Meters Read	182	74	180	207	
	Meters Interim	84	184	79	52	
	Interim Raised	106021	263761	104363	Error	
	Interim Reversed	(283313)	(38410)	(40077)	(101412)	
932	Builders Water					
	Meters Read	8	3	8	7	
	Meters Interim	4	10	5	6	
	Interim Raised	339	1555	201	Error	
	Interim Reversed	(1532)	(24)	(296)	(159)	
940	Business Industrial					
	Meters Read	9	11	23	15	
	Meters Interim	18	15	3	12	
	Interim Raised	378339	76897	314337	Error	
	Interim Reversed	(47990)	(313196)	(24551)	(14168)	
950	Charities: Churches					
	Meters Read	79	33	87	88	
	Meters Interim	27	72	20	18	
	Interim Raised	25913	53134	8682	Error	
	Interim Reversed	(45897)	(12861)	(21977)	(45153)	
960	Residential					
	Meters Read	4352	6205	5505	6486	
	Meters Interim	2939	1057	1770	836	
	Interim Raised	142665	57148	82548	Error	
	Interim Reversed	(28724)	(70384)	(28791)	(45086)	

INTERIMS FOR FOUR MONTHS CONTINUED

Code	Description	Feb 2003	Jan 2003	Dec 2002	Nov 2002	Average
961	Water – Rural					
	Meters Read	3	3	2	2	
	Meters Interim	5	6	7	7	
	Interim Raised	2404	2612	3423	5301	
	Interim Reversed	(208)	(4418)	(1566)	(346)	
966 – 999	Flats					
	Meters Read	50	19	49	49	
	Meters Interim	10	37	5	4	
	Interim Raised	31274	30053	2149	2220	
	Interim Reversed	(33384)	(208)	(1031)	(7048)	
	Total					
	Meters Read	**16915**	**12516**	**19617**	**20599**	**17412**
	Meters Interim	**5880**	**10196**	**3590**	**2201**	**5467**
	Interim Raised	**1290853**	**2186662**	**896203**	**7521 + Errors**	
	Interim Reversed	**(2060596)**	**(823199)**	**(444211)**	**(636577)**	
	Percentage of Interims to meters read	**35**	**81**	**18**	**11**	**31**
	Percentage of Interims to total	**25**	**45**	**15**	**10**	**23**

REPORT BY ELECTRICAL ENGINEER

KIMBERLEY: SOL PLAATJE MUNICIPALITY: WATER LOSS MANAGEMENT STUDY: EFFECT OF ELECTRICAL CONSUMPSION

1. INTRODUCTION:

Mega Tech Inc has appointed Ninham Shand to conduct a Water Loss Management Study on the Water System utilised by Sol Plaatje Municipality in Kimberley.

In order to investigate the electrical infrastructure and electrical consumption related to the Water System an electrical engineer has been appointed as part of the study group.

2. PURPOSE OF REPORT:

The purpose of this section of the study is to report and comment on relevant aspects related to the electrical infrastructure that forms part of the Water System.

3. INSTRUCTION:

The instruction and scope of work issued to the Contractor Team, including the electrical engineer in the study group is noted as follows:

General – The Contractor Team will conduct an on-site assessment of the current water management situation from available information including:

a. physical infrastructure
b. monitoring and measuring mechanisms
c. billing systems and statistics
d. GIS and linkages to other systems.

Specific - The Contractor and in particular the electrical engineer will be required to execute the following tasks:

a. Formulate detailed recommendations regarding the installation of an electric metering scheme for the Riverton and Newton pumping stations including consideration of the following:
   i. power factor
   ii. peak demand
   iii. feasibility of installing capacitor banks
   iv. feasibility of soft-start technology.

Mentoring - It is expected that the Contractor Team will work jointly in a mentoring relationship with designated municipal employees in carrying out the Scope of Work to enhance their capacity to meter and monitor water and energy use in the system in future.

Outputs / Deliverables - At the end of the assignment, a final report should detail the following:

a. assessments carried out

b. recommendations formulated
c. suggested summary action plan as required.

Instruction Summary - In essence the instruction to the electrical engineer involves the following:

a. investigate the electrical infrastructure associated with the Water System
b. discuss the aspects related to measuring and control with the officials at Sol Plaatje
c. apply electrical engineering principles and report on relevant aspects with recommendations where applicable.

4. BACKGROUND:

"The water supply for Sol Plaatje is extracted from the Vaal River at Riverton, approximately 24 kilometres from Kimberley. This water is extracted via low lift pumps and metered for the purpose of payment to the Department of Water Affairs and Forestry. The water is purified at Riverton and then pumped via high lift pumps either directly into the reticulation or to the main storage reservoir complex in Kimberley. The water leaving Riverton is metered. All main reservoir intakes are sited at the bottom of the reservoirs and the pipelines thus serve as delivery lines during pumping periods and gravity fed delivery lines during periods when no pumping is taking place.

In addition the link between energy consumption and water pumping is inadequately measured and monitored. Once water losses are accounted for, baseline information on pump performance and consumption will be required to efficiently operate the existing pumps and minimize energy charges while supplying the minimum flow required. Currently, no metering scheme exists at the Newton Reservoir and an incomplete system is in place at the Riverton Intake Station."

(The above is an extract from the Mega Tech Inc. Statement of Work Document.)

5. WATER AND ELECTRICITY:

The primary object of this study into the current water management situation is water loss. Electricity however is consumed in the pumping and purification facilities forming part of the Water System. In order to complete the picture it is necessary to include related aspects with regard to the specific electrical system that serves the water system.

6. ELECTRICAL DISTRIBUTION AT SOL PLAATJE:

Eskom is the national agent for the distribution of electrical energy in South Africa. Electricity is supplied in bulk to the Sol Plaatje local government. From the bulk supply point, electricity is distributed to the consumers in the municipal area allocated to Sol Plaatje. The supply point at Riverton falls outside the jurisdiction of Sol Plaatje as supply authority and therefore Eskom supplies electricity directly to the facilities at Riverton.

Electrical distribution in the Kimberley municipal area is mainly done by underground cable and substations. Distribution is primarily at 11,000 volts and low voltage service connections at 400 or 231 Volts.

The electrical supply at Newton is taken from the distribution grid of the local government. Because of the strategic importance of this water pump station, the design allows for this particular pump station to be served by four alternative substations. When a problem occurs due to a cable fault in one supply, the feed could be transferred to another substation or independent supply with minimum delay or interruption.

For strategic reasons the electrical supply at Riverton as provided by Eskom, is also in the form of a ring feed. When the supply on one feed fails, the source could be transferred to the alternative feed. A schematic diagram with the electrical distribution at Riverton is included as Appendix E with this report.

7. ELECTRICITY TARIFFS:

The price of electricity in South Africa is dictated by the Eskom tariff structure. For the purpose of this report it is necessary to discuss the Eskom tariff structure and the various tariffs applicable to the water system at large.

7.1 Eskom Tariffs and Charges: General

Eskom's Tariffs and Charges make provision for ten (10) tariff structures for the different electricity demands. Electricity tariffs were increased by Eskom on 1st January 2003 and the average increase amounts to 8.43%.

7.2 Tariff Structures MegaFlex and MiniFlex:

There are two Eskom Tariff Structures applicable to Sol Plaatje Municipality. The details of each tariff structure are included in Appendix A to this report. The two tariff structures are MegaFlex, which is applicable for the bulk supply to Sol Plaatje Municipality and MiniFlex, which is applicable to Riverton.

For both MegaFlex and MiniFlex, the applicable unit tariff differs depending on the time of day or week. Eskom's defined time periods for MegaFlex and MiniFlex are included in the Appendix A as part of this report. In addition to the time of day and week differences in tariff, the tariff for MegaFlex and MiniFlex also differs depending on the time of year. The three-month period from June – August is regarded as High-demand season and a high premium is paid on electricity consumed during this period, especially during the peak time of day.

7.3 Comments on the MegaFlex Tariff Structure:

The MegaFlex tariff structure applicable to the bulk supply at Sol Plaatje Municipality is reflected in Appendix A. The following comments highlight some of the key elements applicable to this particular tariff structure: (The cost structure reflects tariffs inclusive of VAT)

- A Service charge for Key customers of R9, 790.32 is payable.
- An Administration charge for Key customers of R1, 283.63 is payable.
- The active energy charge in c/kWh for the different periods are as follows:

  - Off Peak – Low-demand season : 8,62
  - Off Peak – High-demand season : 9,64
  - Standard – Low-demand season : 11,42
  - Standard – High-demand season : 16,26
  - Peak – Low-demand season : 17,26
  - Peak – High-demand season : 56,35

From the above it is important to note that Peak periods of energy consumption, especially in High-demand seasons, should be avoided at all costs. In order to demonstrate the effect of the consumption during the months of High-demand season, a schedule with predicted energy costs as prepared by the City Electrical Engineer is included as Appendix B to this report.

- A Demand charge of R 11.55/kW is payable. This tariff is accrued over 30 minutes integrating period payable in peak and standard periods on weekdays and Saturdays.

7.4 Comments on the MiniFlex Tariff Structure:

The MiniFlex tariff structure applicable to the Riverton electrical supply, which is directly taken from the Eskom grid, is portrayed in Appendix A as part of this report. The following comments highlight some of the key elements applicable to this particular tariff structure: (The cost structure reflects tariffs inclusive of VAT)

- A Service charge for Key customers of R9, 790.32 is payable.
- An Administration charge for Key customers of R1, 207.52 is payable.
- The active energy charge in c/kWh for the different periods are as follows:

  - Off Peak – Low-demand season : 10,47
  - Off Peak – High-demand season : 11,48
  - Standard – Low-demand season : 13,22
  - Standard – High-demand season : 18,00
  - Peak – Low-demand season : 19,00
  - Peak – High-demand season : 57,64

From the above it is important to note that Peak periods of energy consumption, especially in High-demand seasons, should be avoided at all costs.

- *It is important to note that no Demand charge is applicable to the MiniFlex tariff structure. This is applicable to Riverton and is discussed elsewhere in the report.*

8. Main Elements in Water Supply System:

With particular interest to electrical consumption, the main elements that form part of the Water Supply System are discussed in the following paragraphs:

8.1 Water Intake System at Riverton:

Water is taken from the Vaal River at Riverton. Two concrete towers have been built in the river and fitted with low lift pumps and the necessary control systems to pump water from the river to the nearby purification system. The intake system has been developed in two phases. The last phase was in the 1970's and makes provision for submersible pumps for the low lift pumping action. The older concrete tower is fitted with top mount electrical motors and pumps propelled by vertical driving shafts. The pump sets at the older concrete tower are not in full operation and repair work is in progress to salvage these pump sets.

Electricity to the pump sets at both towers is fed at 3,3kV. The necessary protection and starters for the pump sets are housed in safe machine rooms at high level to be above the flood line.

8.2 Water Purification System at Riverton:

The water from the intake facility is directly fed into the purification plant by the low level pumps. The open purification dams operate on gravity and after the process of purification and filtering has been completed, the water is pumped into a reservoir system comprising of three reservoirs. One of these reservoirs is not in operation due to a water leak.

With the upgrading of the intake system in the 1970's the purification facility has also been upgraded. Additional storage has been added to provide for the peak water demand to the Kimberley water reticulation system.

At the main purification facility in Riverton there are mainly three groups of pump sets installed as part of the process:

- Small pump sets that form part of the purification process. These include pumps to keep the filters clean and to back wash the system.
- A high lift pumping facility situated in the High Lift Pump Station. This is the older of the two pumping facilities and dated from the 1940's.
- A second high lift pumping facility is situated in the Clements Pump Room. This facility has been upgraded in the 1970's.

The rest of the facility at Riverton consist of office building, store rooms and staff facilities.

8.3 Piping System to Kimberley:

From the water purification system at Riverton water is pumped by the high lift pumps to the water reticulation system in Kimberley. The water is taken by three sets of water pipes. The three pipes could be used at random as the demand dictates. Most of the water from Riverton goes to the water storage facility at Newton.

8.4 Water Storage Facility at Newton:

The facility at Newton mainly comprise of water storage tanks and a water tower for the balancing of water pressure into the water reticulation system. In three pump rooms a variation of pump sets are utilised for the pumping of water into the water reticulation system via the water tower.

9. Riverton Water Intake and Purification System:

Because of the remote location and the independent electrical supply from Eskom, the Riverton facility could be seen as a separate entity with particular problems. The situation at Riverton is discussed in the following paragraphs with emphasis on the consumption of electricity and the application of electricity in general:

9.1 Electrical Supply from Eskom:

Eskom supplies electricity to Riverton at 66kV. The supply feed is on a ring main system and in the case of failure on one part of the ring; the supply could be partially maintained by using the alternative section of the ring. This practice however has proven to be unsatisfactorily as the pumping facility suffers excessive voltage drops under these circumstances. Eskom maintenance staff is aware of this problem and in the case of preventative maintenance the operation staff at Riverton is warned by the Eskom maintenance staff and the starting of motors is done more discretely. The electrical reticulation system at Riverton is portrayed in a schematic diagram included as Annexure E as part of this report.

At Riverton, Eskom has installed two (2) 5MVA transformers. A firm capacity of 10MVA therefore is available at 3,3kV for supply to the pumps and another three (3) 3,3kV/0, 4kV distribution transformers for the domestic supply at 400 / 231 Volts on the premises. The schematic diagram as part of the Appendixes indicates the fault level at the various bus bar locations. Although the diagram includes only the high voltage motors, a number of low voltage motors are in use as part of the process and fed from the secondary side of the distribution transformers.

9.2 High Lift Pump Station:

At Riverton two pump stations accommodate high lift pump sets. The first room, furthest away from the administrative block, is in operation since the 1940's. Older generation pumps and electric motors, as well as electric switchgear are used. Four (4) high lift pump sets of which one is out of commission, are utilized in this room. The electric motors are fitted with liquid starters.

9.3 Clements Pump Room:

The second high lift pump room at Riverton is called the Clements Pump Room. This pump room has been upgraded. Old technology motors and pumps have been replaced with new pumps, electric motors and starters. Three (3) new pump sets have been fitted into this pump room of which one is a 1,000kW unit.

9.4 Round Tower Low Lift Station:

The older of the two towers in the Vaal River, round in shape, accommodate three (3) pump sets. This facility dates back to the 1940's and has most probably reached the end of its economical life cycle. It is doubtful whether any of the three pump sets could perform a sustainable function.

9.5 Oblong Tower Low Lift Station:

The new Oblong Tower in the Vaal River at Riverton which was constructed in the 1970's accommodates five (5) submersible low lift pump sets. These pumps are not new but reliable. Four (4) of these pumps were operational during inspection.

9.6 Separate Low Lift Station:

As indicated on the schematic diagram in the Appendix E, Riverton also includes a separate Low Lift Station. This station accommodates two (2) low lift pump sets driven by 3,3kV electric motors.

9.7 Comments on Electrical Aspects Pertaining to Riverton Intake and Purification:

9.7.1 Eskom has reported problems with voltage drop at the Riverton substation.

9.7.2 The 10MVA capacity of the Eskom supply seems to be sufficient at present. Should the owner however intend installing pump sets in excess of 1,000kW in demand, Eskom should be consulted. Starting problems because of voltage drop could occur.

9.7.3 It has been reported that Power Factor Correction equipment forms part of the upgraded switching system in the Clements Pump Room. The Power Factor as portrayed by the Power

Factor meters in the two main high lift pump rooms were between 0.95 and 0.98 lagging. Little scope for improvement of power factor therefore exists.

9.7.4 When studying the MiniFlex Tariff structure applied by Eskom at Riverton it is noted that this tariff structure does not include Demand charges. No incentives therefore exist for load shedding, load switching, PF Correction, load management or any procedures to limit demand on the supply.

9.7.5 The reported storage capacity of purified water at Riverton amounts to about 30 Mega litres. This capacity matches the daily reported water consumption of 30 – 40 Mega litres in Kimberley. This means that on average the daily quantum of purified water has to be pumped to Newton or the Sol Plaatje water reticulation system. The Newton reservoir system however has a capacity of 240 Mega litres which allows some 8 days reserve should a major failure at Riverton occur.

9.7.6 At Riverton a monitor console forms part of the facilities to monitor the process. The monitor includes an array of digital miniature displays, which indicate the flow rate of the three pipe lines leading to Newton and the Kimberley Water System. Apart from this display unit, limited monitoring and control facilities are utilized at Riverton for the monitoring and management of the water purification and pumping facilities.

9.7.7 A study of the MiniFlex Tariff structure reveals that pumping of water at Riverton outside the Off Peak periods could have a severe impact on the cost of electricity consumption. Although the MiniFlex Tariff structure does not include Demand charges, the diversified time table for Peak, Standard and Off Peak demands close collaboration between management and pump operators in an effort to combat electricity costs. The schedule with a summary of electricity bills for Riverton reveals that the pumping of water outside peak and standard time should take top priority and needs to be monitored and managed continuously.

9.7.8 The lack of communication systems at Riverton also poses a threat to the effective management of a low energy cost pumping facility. This issue is discussed in more detail in another part of the report.

10. Newton Water Storage and Pumping Facility:

Newton facility is located centrally to the water reticulation system of the Sol Plaatje Municipality. The situation at Newton is discussed in the following paragraphs with emphasis on provision and consumption of electricity in general:

10.1 Electrical Supply:

The electrical supply at Newton is taken from the 11kV reticulation system operated by Sol Plaatje Municipality. Because of the strategic importance of the Newton facility, the supply configuration has been arranged in such a way that alternative feeds from four locations or substations is possible. This methodology enhances the integrity of the electrical supply at Newton and ensures continuity of supply under severe conditions of failure.

Electricity at Newton is fed into a substation where 3 x 500kVA transformers provide the necessary 400 / 231 Volts supply. From the substation the various elements and local distribution boards are fed by low tension electrical cable.

10.2 Metering of the Electricity Consumption at Newton:

It has been reported that the electrical supply at Newton is metered by Demand- and kWh meters operated by summation transformers. The energy costs for the Newton facility is paid by departmental transfer of funds from one department to another for budget purposes. In real terms the electricity costs for Newton are included in the monthly bulk electricity account in accordance with the MegaFlex Tariff structure.

The monthly electricity account for Newton as provided by the electrical department is included as Appendix D to this report. A discussion of the electrical consumption is included in a separate section of the report.

10.3 Water Pumping at Newton:

The main objective at Newton Storage and Pumping facility is to keep the water tower full of clean water from the reservoirs. For this purpose electrical pump sets has been installed in three (3) separate pump rooms.

The first pump room accommodates two (2) low lift pump sets. These motors are equipped with normal star-delta starters. These motors are controlled by hand and no sophisticated control systems are included. This pump room also accommodates a small diesel engine generator set that could feed emergency power to a number of floodlights that could illuminate the site for maintenance and safety under power failure conditions.

The second pump room accommodates three (3) low lift pump sets. These are 400 Volt pumps with star-delta starters with hand control. In this pump room the three pumps are installed in a recessed pit under natural ground level. This pump room also accommodates the level sensing device which monitors the water level in the water tower. The sensing device includes audible alarm facilities to draw the attention of the operating staff when the water level is outside the pre-selected levels of operation. Depending on the alarm condition, the operating staff will switch pump sets of and on by hand.

In a third pump room another three (3) low lift pump sets are accommodated. These are 400 Volt pumps. One of these pump sets operates on a star-delta starter. The remaining two (2) pump sets however have been fitted with electronic controlled starters. These starters are known as Soft Starters.

Outside the building between the reservoirs another two low level pumps have been noted. From the control and switching configuration these are 400 Volt pump sets with hand control and should be utilized in the pumping facility to pump water between reservoirs.

10.4 Comments on Electrical Aspects Pertaining to Newton Storage and Pumping:

10.4.1 No problems with insufficient electrical supply or voltage drop have been reported for the electrical supply by the local municipality as supply authority to Newton.

10.4.2 It is assumed that the capacity of the low tension cables that feed the facility at Newton is sufficient to provide for the connected load at all times and conditions.

10.4.3 No Power Factor Correction equipment has been installed at Newton. With the inductive load expected at Newton, limited success with Power Factor Correction equipment could be ensured. After measurement of the Power Factor at Newton during applicable operational conditions, the effect and cost saving on consumption could be calculated. It needs to be noted that Newton is connected to the municipal grid in Kimberley and therefore will add to the monthly Demand reading for the bulk supply in accordance with the MegaFlex Tariff structure. Prior to the installation of PF Correction a survey to establish the effects of harmonics caused by the soft starters should be done. If necessary suitable inductors should form part of the PF Correction capacitor bank to avoid resonant disturbances due to expected harmonics.

10.4.4 The storage capacity of the Water Tower at Newton is not known. It however is not sufficient to store the equivalent of a day’s water consumption. From this it is eminent that pumping during Peak and Standard billing periods could not be avoided. However, efforts to ensure a full water tower at the end of each Off Peak period and almost empty tower when Standard and Off Peak period elapse, would save on electrical consumption costs. Additional fine tuning of the pumping cycle and the implementation of the correct pump sets could add to further savings in energy costs.

10.4.5 At Newton a monitor console for monitoring the water level in the Water Tower has been installed. A small LED digital display with numeric characters gives indication of the water level in the Water Tower as a percentage of full capacity. When the Water Tower capacity is depleted to a point below 10% and when it is filled beyond 90% an audible alarm is generated to alert the operational staff of the condition. During the period of inspection which was in the Standard Tariff period, the capacity of the Water Tower was at 74%.

10.4.6 In studying the MegaFlex Tariff structure which is indirectly applicable to Newton it could be seen that pumping of water outside the Peak and Standard periods could reduce electricity costs. Effective management of the pumping cycles and the implementation of a dedicated cost saving plan could improve the savings on the total Municipal electricity bill.

10.4.7 Newton Storage and Pumping facility reveals lack of communication systems, which has a negative effect on the ability to manage a cost effective pumping facility. This issue is discussed in more detail in another part of the report.

10.4.8 It has been reported that two of the electrical motors in the third pump room has been fitted with Soft Starters in a retrofit operation. Existing star-delta starters has been replaced with electronic Soft Start starters. The brand names of the two Soft Starters are reported to be a Cutler-Hammer A435 and Allen Bradley.

10.4.9 In the third pump station a cubicle with components of an incomplete Telemetry system was observed. Due to lack of information further comments on this element could be inappropriate.

11. Telemetry and SCADA:

Effective communications with monitoring and control functions is of paramount importance to any successful industrial operation. The water distribution system at Sol Plaatje could undoubtedly benefit from the implementation of a successful communications system operated by dedicated and competent staff. In the industrial sector it is known that the key to sustainable performance improvement is better decisions. Without information or communications decisions are jeopardised or bluntly impossible.

It has been reported that the electricity department of Sol Plaatje local municipality operates a Telemetry system with SCADA functionality on their electricity network. Over twenty substations and other measured points are monitored by the electricity department in their efforts to enhance effectiveness of the distribution system. The main control of the Telemetry system is accommodated in the control room of the electricity department.

Contractors and suppliers have investigated the water reticulation system at Riverton and Kimberley with the objective of creating a suitable communications system. It has been reported that for a budget figure between R50, 000.00 – R60, 000.00 a suitable communications system could be implemented. The details and functions of such a system should be configured after discussions and the establishment of requirements and deliverables in collaboration with the municipal principles.

An independent Telemetry and SCADA system with a separate control room should be a priority in the combat against water losses at Sol Plaatje. This should form a separate exercise by knowledgeable staff and other participants.

Detailed comments on the Monitoring and Control as well as the benefits offered by a Telemetry and SCADA (***S****upervisory* ***C****ontrol* ***A****nd* ***D****ata* ***A****cquisition*) System are included as Appendix F to this report.

The measuring of electricity forms an important part as monitoring element in the management of electrical consumption. Detailed comments on the metering of electricity at Riverton and Newton are included as Appendix G to this report. At a budget price of R15,000.00 a metering system could be implemented at Riverton and Newton with the addition of valuable monitoring functions.

12. Power Factor Correction:

Power factor correction in principle is effective and appropriate when the Demand charges in an electrical installation or process could be reduced. In addition to the reduction of Demand charges the efficiency of distribution cables increase when the power factor is improved. Industrial power factor correction is achieved by the connection of capacitor banks in parallel to the load in operation. In most industrial installations the power factor is lagging or inductive because of the inductive characteristics of the electric motors connected to the supply. Power factor correction then is achieved by the addition of capacitive load in the form of capacitor banks. Because of the incremental nature of load patterns it is practice to provide the capacitor bank in increments to satisfy the specific need at a given time instead of overcorrecting which is illegal. With the introduction of an intelligent relay, the power factor is monitored and arrays of capacitor banks switched in and out by means of contactors. Power factor correction can be done at High Voltage and at Low Voltage.

The implementation of power factor correction at Riverton does not contribute to the saving of energy costs. The Tariff structure at Riverton excludes Demand charges and therefore negates the opportunity of cost savings by PF Correction.

At Newton the electrical supply is taken from the Kimberley municipal grid. The load pattern of Newton therefore will add to the bulk supply pattern and will increase the Demand charges proportionally. It therefore could be considered appropriate to implement power factor correction at Newton after measurements and a survey on site. As mentioned the harmonic content due to Soft Starters already installed should be surveyed extensively.

13. Electronic Starters or Soft Start Applications:

Soft Start applications are implemented where direct on line starters and star-delta starters cause problems. Soft Start applications are expensive and for that reason the advantages must justify the cost.

The main advantage of Soft Start applications is the ability of the starter unit to reduce the starting current without a reduction in starting torque. Electronic or Soft Start applications reduce the need for mechanical parts like contactors and therefore offer savings on maintenance costs.

Because of the resultant reduction in starting current, the introduction of Soft Start applications also reduces the quantum of transients caused by starting currents. The induced interference in the form of unwanted harmonics and voltage and current spikes on transmission lines is therefore limited when Soft Start applications are introduced. Especially in an environment like Newton where the pumping facility is adjacent to a residential consumer area the introduction of Soft Start applications could eliminate unwanted interference and enhance the quality of electrical power distributed to municipal consumers.

Electronic devices like Soft Starters and Variable Speed Drives are sophisticated elements and costly to implement. This is a specialised field and should be regarded as a separate study. Full knowledge of the functions and performance of all pump sets in every location is a prerequisite to the successful investigation into the application of Soft Starters and Variable Speed Drives. The functions and performance of pump sets could most probably alter depending on the results of the water loss management study in total context. It therefore is strongly recommended that the implementation of electronic motor control be executed as a separate study.

14. Discussion of Data in Electricity Accounts:

Electricity accounts, especially if the information is available for a 12 month period, makes interesting reading if compiled in a spread sheet. Often it is possible to observe trends by studying the data or it could be possible to note defects in the operational structure. With acknowledgement to the staff in the electrical department of Sol Plaatje Municipality the information of electricity accounts for the two facilities at Riverton and Newton and the predicted bulk supply is included in the Appendixes to this report.

14.1 Bulk Supply as Measured at Herlear Homestead:

The information available on the predicted electricity accounts for the bulk supply from Eskom is included in Appendix B. Page 1 reflects the data and page 2 of Appendix B portrays a graphic illustration of the compiled data. The following comments and observations with regard Appendix B is offered:

- Eskom’s MegaFlex tariff structure is applicable. Demand charges at R11.55/kW measured over a 30 minute integrating period is payable. The effect of the High-demand season (June-August) is shown in the totals column of the graph.
- Although the maximum demand reflects a typical S-curve the deviation from summer to winter is not excessive.
- The consumption of units appears to reflect fairly similar proportions of standard and off peak units whilst the units consumed in peak periods is half of that.
- In order to reduce electricity costs on the bulk supply the Sol Plaatje electrical department has implemented a system of load management by switching off the electrical supply to water heaters remotely. The effects of this operation are unknown.

14.2 Supply at Riverton as measured and billed by Eskom:

The information available on the Riverton electricity accounts from Eskom is included in Appendix C. Page 1 reflects the data and page 2 of Appendix C portrays a graphic illustration of the compiled data. The following comments and observations with regard Appendix C is offered:

- Eskom's MiniFlex tariff structure is applicable. The effect of the High-demand season is not that obvious. The reduction in demand for water during the winter months result in less electricity consumption due to less pumping and the excessive energy tariff is cancelled. From the table on page 1 of Appendix C the highest energy consumption was in January which could have been the hottest month.
- In this case Demand charges are not applicable. Total units consumed do not reflect true demand but a seasonal trend could be observed in the graph with peaks in the month of January.
- When compared with the graph in Appendix B the effect of energy management becomes clear. In Appendix B the off peak and standard peak units were of the same proportion. In the graph of Appendix C the standard period units amounts to about 50 percent of the off peak units whilst the peak period units are substantially less. The graph indicates a clear strategy of energy consumption in the most cost effective tariff periods. Taking into consideration the measurement and communications instruments at the disposal of the management and operating staff the cost saving achieved is commendable.

14.3 Supply at Newton as measured by Electrical Department:

The information made available by the electrical department for electricity accounts for Newton is included in Appendix D. Page 1 reflects the data and page 2 of Appendix D portrays a graphic illustration of the compiled data. The following comments and observations with regard Appendix D is offered:

- Eskom's MegaFlex tariff structure is applicable. Demand charges at R11.55/kW measured over a 30 minute integrating period is payable, but this account is settled by transfer of money between departments.
- The higher cost of electricity in the High-demand season has little if any effect on the account. This indicates that less water is pumped during the winter months.
- Little seasonal trend on the total account is visible. The total amount stays reasonable constant over the billing period under scrutiny.
- Little if any correlation between demand and units can be observed. Units are given as a total without division in the three time period categories applicable.

15. Conclusion:

Following the investigation into electrical elements related to the Water System at Sol Plaatje Municipality the following can be concluded:

- During the investigation no signs could be found of negligence or deliberate actions to waste electrical energy.
- The investigation as reported above has revealed areas where measures could be introduced to reduce electricity costs to the benefit of the authority and the consumer.

16. Recommendation:

As reflected in the report, certain areas have been identified where measures could be introduced in an effort to save electricity. With the knowledge at our disposal and the application of electrical engineering principles the following recommendations are offered:

16.1 The implementation of a functional and effective communication system for the total water facility should be considered as a priority. This communication system should include a Telemetry system with SCADA software independent of any other systems in the municipal environment. The capacity and layout of such a communication system should be tailored in harmony with the outcome and findings in the principal report.

16.2 The electricity metering system at Newton should be investigated and upgraded to get it on par with the metering of energy at the bulk supply point. Once this is done the management of pumping cycles should be monitored closely to further save on electricity costs.

16.3 Depending on the outcome of the principal report a mentoring session is recommended to establish a master plan. This should include the defining of pumping requirements at each existing and new location and the resizing of pumps and motors where necessary.

16.4 Following the establishment of a master plan and management strategy the introduction of cost saving mechanisms like Variable-Speed Drives and Soft-Starters on electric motors and PF Correction could be investigated effectively.

16.5 Because of the present status of the communication systems available to the operational team it is eminent that further energy saving can only be achieved by implementing an enhanced management strategy with emphasis on cost saving procedures and effective control and monitoring protocols. This management strategy should include the training of staff and a management style that will create a total awareness and culture of energy saving. A sustainable audit function should form part of the management strategy to monitor targets on a continuous basis.

16.6 As part of the envisaged management strategy mentioned in par 16.5 a complete survey of the mechanical status of pumps and equipment should be conducted. The survey should report on the condition of all pumps, electric motors and ancillary equipment and identify equipment due for replacement or major overhauls.

16.7 The electricity metering system at Riverton should be investigated thoroughly. If not already in place a procedure of checking the meter reading exercise with Eskom should be implemented. This will ascertain the exact metering cycle which is important for the analysing of metered data in an effort to establish trends and procedures for the saving of energy.

17. Summary of Action Plan:

In order to establish a final action plan it is important for all participants in the study group to contribute on a mentoring basis and define some priorities and strategies. Once these priorities have been set a final action plan can be formalised and implemented. For the purpose of this report a number of action steps have been identified for consideration and inclusion in the final action plan as follows:

- Study the main report and extract all elements that could have an effect on the consumption or distribution of electricity.
- Arrange a workshop session with the officials at Sol Plaatje and compile a Statement of Requirements (SOR) of all electrical related aspects.

- With the SOR as basis compile a budget for approval by authorities concerned.
- Prepare tender documents with specifications or compile Requests for Proposals (RFP's) for the Communications and Metering installations envisaged.
- Arrange for the procurement of the works from inception till final hand over.

END OF REPORT

APPENDIX : A

SOL PLAATJE WATER LOSS MANAGEMENT STUDY

ELECTRICAL CONSUMPTION

APPENDIX TO REPORT

EXTRACT FROM ESKOM'S TARIFF AND CHARGES DOCUMENT

FOR 2003

LIST OF DOCUMENTS:

1. MegaFlex
2. MiniFlex
3. Eskom's Defined Time Periods

MEGAFLEX

TOU electricity tariff for urban$_p$ customers with supplies greater than 1 MVA

Megaflex is a tariff applicable to urban$_p$ customers with supplies greater than 1 MVA and who can shift their load to defined time periods.

Connection fee: Refer to *table 1* on page 25.

Capital costs: For a new connection, in order for Eskom to recover capital costs that are not covered by the tariff, a monthly connection charge and/or up-front payment may be applied in addition to the standard tariff.

Where applicable, the monthly connection charge for all existing and new connections will be subject to a rebate (not beyond extinction) at R2,00 per kW of chargeable demand.

Service charge: Charged per account and is based on the sum of the utilised capacity of all POD's linked to an account.

> 1 MVA	R1 455,07 + VAT = **R1 658,78**
Key customers	R8 588,00 + VAT = **R9 790,32**

Administration charge: Determined by, and payable for, the utilised capacity of each POD linked to an account.

> 1 MVA	R1 099,96 + VAT = **R1 253,95**
Key customers	R1 125,99 + VAT = **R1 283,63**

Demand charge: R10,13 + VAT = **R11,55/kW**

Payable for each **kW** of the **maximum chargeable demand** supplied during the month measured over **30 minutes integrating periods**, payable in peak or standard periods on weekdays and Saturdays. No demand charge is applicable during the off-peak periods.

Active energy charge:	**High-demand season (June – August)**	**Low-demand season (September – May)**
Peak	49,43c + VAT = **56,35c/kWh**	15,14c + VAT = **17,26c/kWh**
Standard	14,26c + VAT = **16,26c/kWh**	10,02c + VAT = **11,42c/kWh**
Off-peak	8,46c + VAT = **9,64c/kWh**	7,56c + VAT = **8,62c/kWh**

Reactive energy charge: 3,09c + VAT = **3,52c/kvarh**

Supplied in excess of 30% (0,96 PF) of kWh recorded during peak and standard periods. The excess reactive energy is determined per 30-minute integrating period and accumulated for the month.

Voltage surcharge: Calculated as a percentage of demand and active energy charges.

Supply voltage	Surcharge
> 132 kV	0,00%
≥ 66 kV and ≤ 132 kV	7,63%
≥ 500 V and < 66 kV	10,07%
< 500 V	17,30%

Transmission surcharge: Calculated as a percentage of the demand, active and reactive energy charges after the voltage surcharge has been levied, depending on the distance from Johannesburg.

Distance from Johannesburg	Surcharge
≤ 300 km	0%
> 300 km and ≤ 600 km	1%
> 600 km and ≤ 900 km	2%
> 900 km	3%

Time periods: Refer to page 23.

MINIFLEX

TOU electricity tariff for urban$_p$ customers with supplies of 100 kVA to 5 MVA

Miniflex is a tariff applicable to urban$_p$ customers with supplies of 100 kVA to 5 MVA and who can shift their load to defined time periods.

Connection fee: Refer to *table 1* on page 25.

Capital costs: For a new connection, in order for Eskom to recover capital costs that are not covered by the tariff, a monthly connection charge and/or up-front payment may be applied in addition to the standard tariff.

Where applicable, the monthly connection charge for all existing and new connections will be subject to a rebate (not beyond extinction) at 1,81c/kWh of all active energy consumed during peak periods.

Service charge: Charged per account and is based on the sum of the utilised capacity of all POD's linked to an account.

≤ 100 kVA	R 90,20 + VAT = **R 102,83**
> 100 kVA and ≤ 500 kVA	R 477,88 + VAT = **R 544,78**
> 500 kVA and ≤ 1 MVA	R1 454,95 + VAT = **R1 658,64**
> 1 MVA	R1 455,07 + VAT = **R1 658,78**
Key customers	R8 588,00 + VAT = **R9 790,32**

Administration charge: Determined by, and payable for, the utilised capacity of each POD linked to an account.

≤ 100 kVA	R 80,77 + VAT = **R 92,08**
> 100 kVA and ≤ 500 kVA	R 121,31 + VAT = **R 138,29**
> 500 kVA and ≤ 1 MVA	R1 059,23 + VAT = **R1 207,52**
> 1 MVA	R1 059,23 + VAT = **R1 207,52**
Key customers	R1 059,23 + VAT = **R1 207,52**

Active energy charge:	**High-demand season (June – August)**	**Low-demand season (September – May)**
Peak	50,56c + VAT = **57,64c/kWh**	16,67c + VAT = **19,00c/kWh**
Standard	15,79c + VAT = **18,00c/kWh**	11,60c + VAT = **13,22c/kWh**
Off-peak	10,07c + VAT = **11,48c/kWh**	9,18c + VAT = **10,47c/kWh**

Reactive energy charge: 1,55c + VAT = **1,77c/kvarh**

Supplied in excess of 30% (0,96 PF) of the kWh recorded during the entire billing period. The excess reactive energy is determined using the billing period totals.

Voltage surcharge: Calculated as a percentage of active energy charges.

Supply voltage	Surcharge
> 132 kV	0,00%
≥ 66 kV and ≤ 132 kV	7,63%
≥ 500 V and < 66 kV	10,07%
< 500 V	17,30%

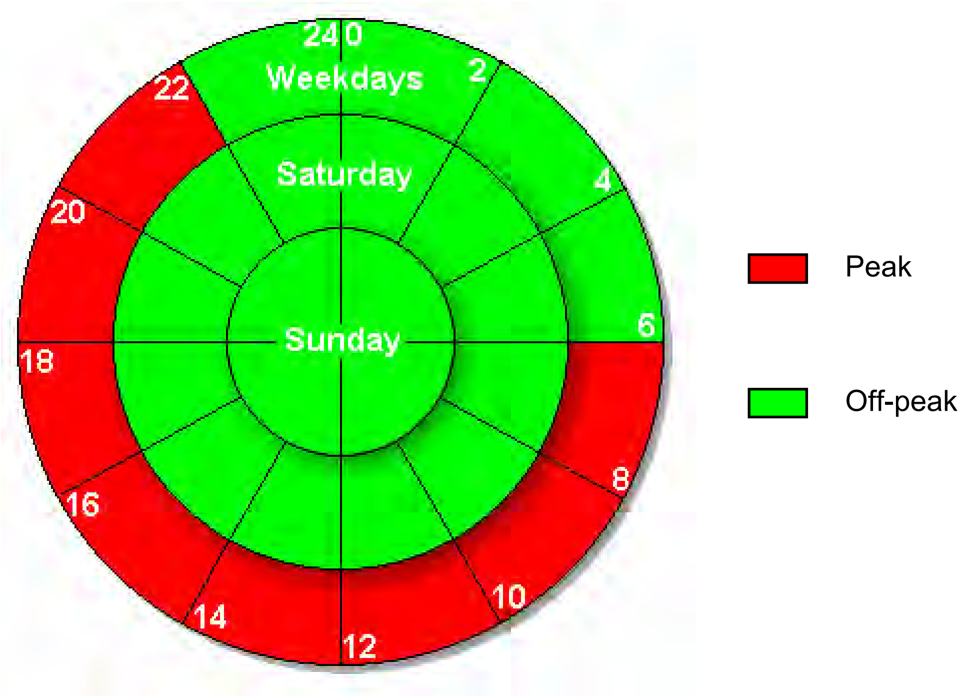
Transmission surcharge: Calculated as a percentage of the active and reactive energy charges after the voltage surcharge has been levied, depending on the distance from Johannesburg.

Distance from Johannesburg	Surcharge
≤ 300 km	0%
> 300 km and ≤ 600 km	1%
> 600 km and ≤ 900 km	2%
> 900 km	3%

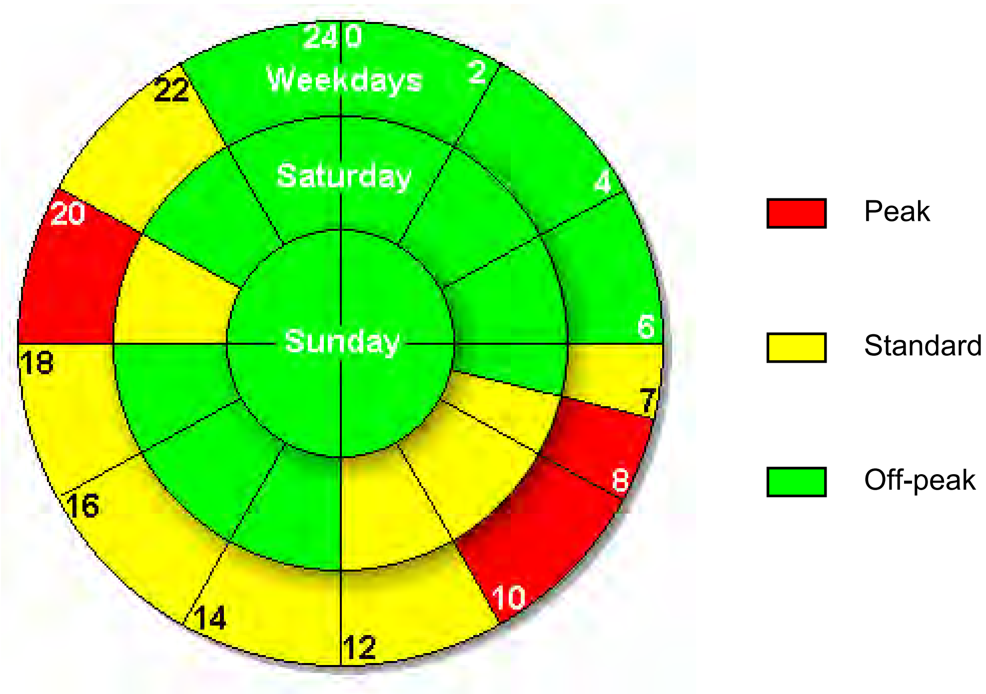
Time periods: Refer to page 23.

Appendix C - Eskom's defined time periods

Nightsave (Urban) & Nightsave (Rural)



Megaflex, Miniflex & Ruraflex



APPENDIX : B (Page 1)

SOL PLAATJE WATER LOSS MANAGEMENT STUDY

ELECTRICAL CONSUMPTION

2002/2003 FINANCIAL YEAR : PREDICTED ESKOM ELECTRICITY ACCOUNT

MONTH	MAX DEM	RAND VALUE	PEAK UN	RAND VALUE	STD UN	RAND VALUE	OFF PK	RAND VALUE	SURCHARGE	ADM CHGE	TRANS.%CHGE	TOTAL	PLUS VAT
JULY	86400	R 705,888.00	8544480	R 3,886,883.95	17706120	R 2,321,272.33	14204160	R 1,102,242.82	R 611,642.71	R 888.21	R 8,627,929.81	R 8,628,818.02	R 9,836,852.54
AUG	78240	R 639,220.80	6771960	R 3,080,564.60	14910240	R 1,954,732.46	13786440	R 1,069,827.74	R 514,593.57	R 888.21	R 7,258,939.18	R 7,259,827.39	R 8,276,203.22
SEPT	73000	R 596,410.00	5564520	R 774,581.18	13188600	R 1,214,670.06	12940560	R 898,074.86	R 265,809.07	R 888.21	R 3,749,545.17	R 3,750,433.38	R 4,275,494.05
OCT	58000	R 473,860.00	5918280	R 823,824.58	13445520	R 1,238,332.39	11011200	R 764,177.28	R 251,804.82	R 888.21	R 3,551,999.07	R 3,552,887.28	R 4,050,291.50
NOV	58000	R 473,860.00	5549160	R 772,443.07	12896640	R 1,187,780.54	11854480	R 822,700.91	R 248,492.66	R 888.21	R 3,505,277.19	R 3,506,165.40	R 3,997,028.56
DEC	57000	R 465,690.00	4809440	R 669,474.05	11006880	R 1,013,733.65	13568280	R 941,638.63	R 235,807.92	R 888.21	R 3,326,344.25	R 3,327,232.46	R 3,793,045.00
JAN	57000	R 465,690.00	5340720	R 743,428.22	12854040	R 1,183,857.08	11738040	R 814,619.98	R 244,739.52	R 888.21	R 3,452,334.80	R 3,453,223.01	R 3,936,674.23
FEB	57000	R 465,690.00	5120640	R 712,793.09	12426120	R 1,144,445.65	10984680	R 762,336.79	R 235,405.76	R 888.21	R 3,320,671.29	R 3,321,559.50	R 3,786,577.83
MAR	60000	R 490,200.00	4944120	R 688,221.50	12048720	R 1,109,687.11	12106200	R 840,170.28	R 238,687.68	R 888.21	R 3,366,966.58	R 3,367,854.79	R 3,839,354.46
APR	65000	R 531,050.00	5591600	R 778,350.72	12708680	R 1,170,469.43	12708600	R 881,976.84	R 256,508.93	R 888.21	R 3,618,355.91	R 3,619,244.12	R 4,125,938.30
MAY	75000	R 612,750.00	6718680	R 935,240.26	14755640	R 1,358,994.44	13304360	R 923,322.58	R 292,252.45	R 888.21	R 4,122,559.73	R 4,123,447.94	R 4,700,730.65
JUNE	86000	R 702,620.00	6890760	R 3,134,606.72	15362000	R 2,013,958.20	15407520	R 1,195,623.55	R 537,671.49	R 888.21	R 7,584,479.96	R 7,585,368.17	R 8,647,319.71
												R 55,496,061.46	R 63,265,510.06

PREDICTED ELECTRICITY CONSUMPTION AS MEASURE AT HERLEAR HOMESTEAD

APPENDIX : C (Page 1)

SOL PLAATJE WATER LOSS MANAGEMENT STUDY

ELECTRICAL CONSUMPTION

2002/2003 FINANCIAL YEAR : SUMMARY OF RIVERTON ELECTRICITY ACCOUNTS

MONTH	OFF PEAK	RAND VALUE	PEAK	RAND VALUE	STANDARD	RAND VALUE	VOLT DISC/SUR	TRANS.%CHGE	BASIC CHGE	ADM CHGE	TOTAL	PLUS VAT
JAN	1,068,228	R 76,271.48	25,824	R 8,746.59	541,542	R 67,205.36	-R 10,853.53	R 1,413.70	R 65.34	R 145.00	R 142,993.94	R 163,013.09
FEB	984,576	R 70,298.73	19,680	R 6,665.62	590,520	R 73,283.53	-R 10,712.67	R 1,395.35	R 65.34	R 145.00	R 141,140.89	R 160,900.62
MAR	1,023,348	R 73,067.05	22,554	R 7,639.04	517,044	R 64,165.16	-R 10,329.32	R 1,345.42	R 65.34	R 145.00	R 136,097.69	R 155,151.36
APR*	980,000	R 69,972.00	26,000	R 8,806.20	540,000	R 67,014.00	-R 10,300.00	R 1,350.00	R 65.34	R 145.00	R 137,052.54	R 156,239.90
MAY	964,674	R 68,877.72	28,524	R 9,661.08	552,210	R 68,529.26	-R 10,485.95	R 1,365.82	R 65.34	R 145.00	R 138,158.27	R 157,500.43
JUNE	922,314	R 84,483.96	27,666	R 12,682.09	372,042	R 51,490.61	-R 9,790.36	R 1,275.22	R 65.34	R 145.00	R 140,351.87	R 160,001.13
JULY	973,758	R 89,196.23	35,556	R 16,167.31	404,574	R 57,854.08	R 12,453.50	R 1,756.71	R 822.45	R 145.00	R 178,395.29	R 203,370.63
AUG	886,050	R 81,162.18	15,186	R 6,905.07	452,556	R 64,715.51	R 11,657.32	R 1,644.40	R 822.45	R 145.00	R 167,051.93	R 190,439.20
SEPT	907,170	R 75,930.13	17,232	R 2,598.59	500,484	R 52,751.01	R 10,016.64	R 1,412.96	R 822.45	R 145.00	R 143,676.78	R 163,791.53
OCT	1,044,060	R 87,387.82	20,604	R 3,107.08	631,878	R 66,599.94	R 11,986.34	R 1,690.81	R 822.45	R 145.00	R 171,739.45	R 195,782.97
NOV	1,082,766	R 90,627.51	26,610	R 4,012.79	616,338	R 64,962.03	R 12,177.66	R 1,717.80	R 822.45	R 145.00	R 174,465.24	R 198,890.37
DEC	1,124,406	R 94,112.78	17,442	R 2,630.25	530,736	R 55,939.57	R 11,649.68	R 1,643.32	R 822.45	R 145.00	R 166,943.06	R 190,315.09
JAN	1,095,138	R 100,533.67	18,708	R 3,118.62	644,874	R 74,805.38	R 13,616.32	R 1,920.74	R 1,455.07	R 145.00	R 195,594.81	R 222,978.08
FEB	868,500	R 79,728.30	20,238	R 3,373.67	607,242	R 70,440.07	R 11,715.26	R 1,652.57	R 1,059.23	R 145.00	R 168,114.11	R 191,650.08
				TOTALS : MARCH 2002 - FEBR 2003 …………							R 1,917,641.03	R 2,186,110.77

***NOTE : APR 2002 AND JAN 2003 FIGURES ARE BUDGET**

APPENDIX : D (Page 1)

SOL PLAATJE WATER LOSS MANAGEMENT STUDY

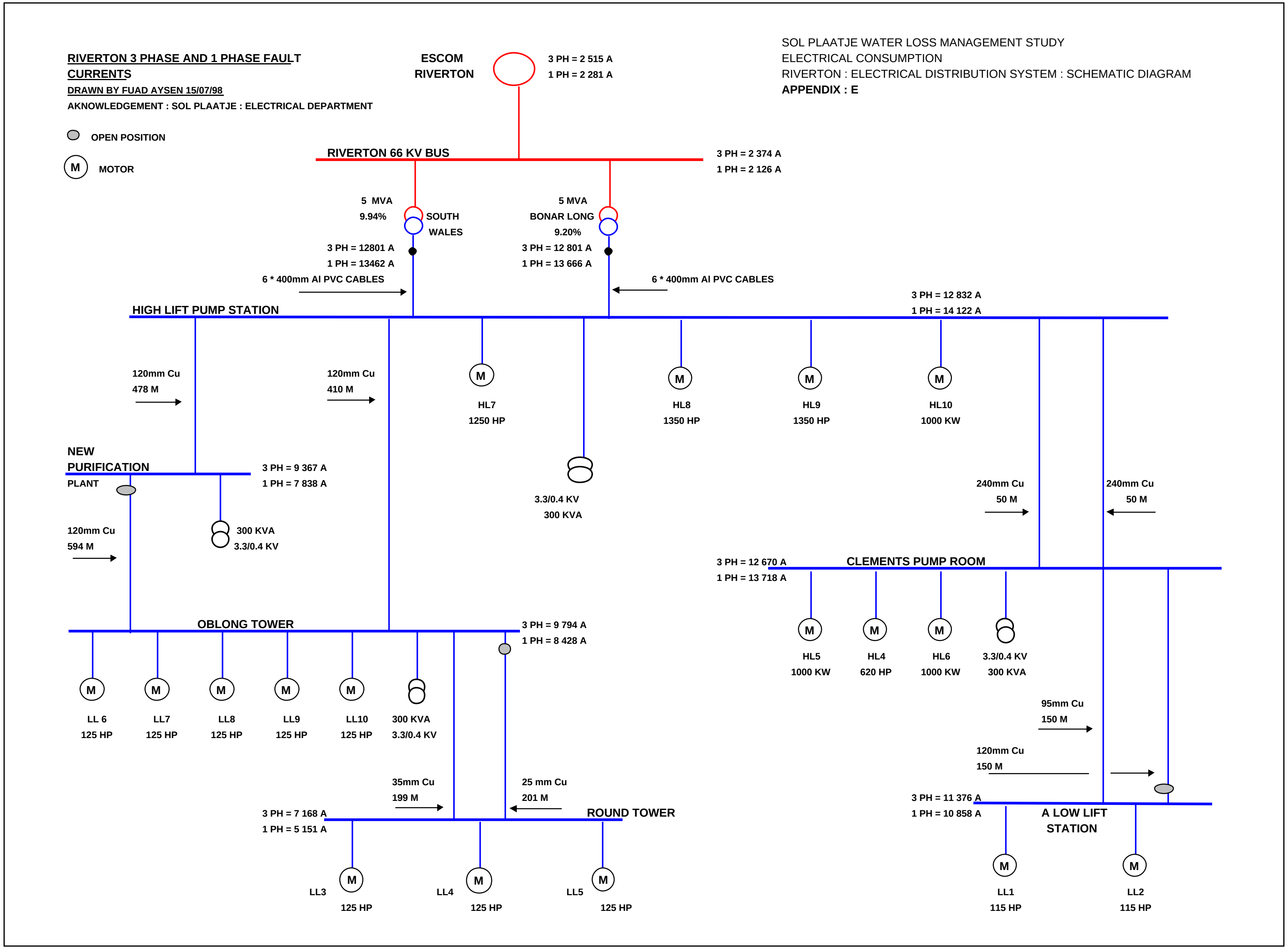
ELECTRICAL CONSUMPTION

2002/2003 FINANCIAL YEAR : SUMMARY OF NEWTON ELECTRICITY ACCOUNTS

MONTH	DEMAND kVA	DEMAND X 100*	RAND VALUE	UNITS (kWh)	RAND VALUE	TOTAL ACCOUNT
FEB	605	60,500	R 32,170.77	139,680	R 23,754.76	R 55,925.53
MAR	504	50,400	R 26,808.97	122,400	R 20,837.90	R 47,646.87
APR	490	49,000	R 26,043.00	162,720	R 27,643.90	R 53,686.90
MAY	446	44,600	R 23,745.08	102,240	R 17,434.90	R 41,179.98
JUNE	461	46,100	R 24,511.06	102,240	R 28,130.04	R 52,641.10
JULY	418	41,800	R 23,090.88	108,000	R 18,420.40	R 41,511.28
AUG	403	40,300	R 22,829.24	126,720	R 21,591.29	R 44,420.53
SEPT	389	38,900	R 22,036.85	113,040	R 19,280.74	R 41,317.59
OCT	374	37,400	R 21,187.09	111,600	R 19,037.52	R 40,224.61
NOV	475	47,500	R 26,908.75	163,440	R 27,793.29	R 54,702.04
DEC	504	50,400	R 28,551.60	167,040	R 28,401.33	R 56,952.93
JAN	504	50,400	R 28,551.60	102,960	R 17,578.23	R 46,129.83
FEB	456	45,600	R 31,837.29	171,360	R 29,130.97	R 60,968.26
		TOTAL AMOUNT MAR 2002 TO FEB 2003				R 581,381.92

**DEMAND X 100 VALUES FOR BETTER SCALE IN GRAPHICS - PAGE 2*

INFORMATION SUPPLIED BY SOL PLAATJE MUNICIPALITY ELECTRICAL DEPARTMEN


RIVERTON 3 PHASE AND 1 PHASE FAULT CURRENTS
DRAWN BY FUAD AYSEN 15/07/98
AKNOWLEDGEMENT : SOL PLAATJE : ELECTRICAL DEPARTMENT
ESCOM RIVERTON
3 PH = 2 515 A
1 PH = 2 281 A
SOL PLAATJE WATER LOSS MANAGEMENT STUDY
ELECTRICAL CONSUMPTION
RIVERTON : ELECTRICAL DISTRIBUTION SYSTEM : SCHEMATIC DIAGRAM
APPENDIX : E
OPEN POSITION
M
MOTOR
RIVERTON 66 KV BUS
3 PH = 2 374 A
1 PH = 2 126 A
5 MVA
9.94%
SOUTH WALES
5 MVA
BONAR LONG
9.20%
3 PH = 12801 A
1 PH = 13462 A
3 PH = 12 801 A
1 PH = 13 666 A
6 * 400mm Al PVC CABLES
6 * 400mm Al PVC CABLES
HIGH LIFT PUMP STATION
3 PH = 12 832 A
1 PH = 14 122 A
120mm Cu
478 M
120mm Cu
410 M
M
HL7
1250 HP
M
HL8
1350 HP
M
HL9
1350 HP
M
HL10
1000 KW
NEW PURIFICATION PLANT
3 PH = 9 367 A
1 PH = 7 838 A
3.3/0.4 KV
300 KVA
240mm Cu
50 M
240mm Cu
50 M
120mm Cu
594 M
300 KVA
3.3/0.4 KV
3 PH = 12 670 A
1 PH = 13 718 A
CLEMENTS PUMP ROOM
OBLONG TOWER
3 PH = 9 794 A
1 PH = 8 428 A
M
HL5
1000 KW
M
HL4
620 HP
M
HL6
1000 KW
3.3/0.4 KV
300 KVA
M
LL 6
125 HP
M
LL7
125 HP
M
LL8
125 HP
M
LL9
125 HP
M
LL10
125 HP
300 KVA
3.3/0.4 KV
95mm Cu
150 M
120mm Cu
150 M
35mm Cu
199 M
25 mm Cu
201 M
3 PH = 7 168 A
1 PH = 5 151 A
ROUND TOWER
3 PH = 11 376 A
1 PH = 10 858 A
A LOW LIFT STATION
M
LL3
125 HP
M
LL4
125 HP
M
LL5
125 HP
M
LL1
115 HP
M
LL2
115 HP

APPENDIX F

KIMBERLEY: SOL PLAATJE MUNICIPALITY: WATER LOSS MANAGEMENT STUDY: EFFECT OF ELECTRICAL CONSUMPSION: MONITORING AND CONTROL

This Appendix reports on Monitoring and Control functions that could be implemented at Riverton and Newton as part of the proposed Telemetry Communications System. It is however strongly recommended that the final monitoring and control functions should be established in collaboration with the Sol Plaatje officials responsible for management and maintenance of the Water Reticulation system. Selection of the monitoring equipment and sensors as well as the point of installation is of importance and need to be planned and engineered after a survey of all related aspects and future development of the water system.

1. RIVERTON: Monitoring and Control Schedule:

1.1 Monitoring:

- Level in Reservoir 1.
- Level in Reservoir 2.
- Level in Reservoir 3. (It is assumed that this reservoir will be reinstated)
- Flow rate from intake at river level to the purification works.
- Totalised flow rate from intake at river level to the purification works.
- Flow rate from Riverton to Kimberley on Main Line 1.
- Totalised flow rate from Riverton to Kimberley on Main Line 1.
- Flow rate from Riverton to Kimberley on Main Line 2.
- Totalised flow rate from Riverton to Kimberley on Main Line 2.
- Flow rate from Riverton to Kimberley on Main Line 3.
- Totalised flow rate from Riverton to Kimberley on Main Line 3.
- Demand in kW of electrical consumption.
- Lift pump status (run/tripped)
- Plant pump status (run/tripped)

1.2 Control:

- Activation of emergency plant alarm from SCADA control room for operating staff to contact the control room.
- Future Automation of plant process from additional SCADA package at pumping and purification facility.

2. NEWTON: Monitoring and Control Schedule:

2.1 Monitoring:

- Level in Reservoir A.
- Level in Reservoir B.
- Level in Reservoir C.
- Level in Reservoir D. (It is assumed that there are four reservoirs at Newton)
- Level in Water Tower.
- Flow rate because of domestic water demand.
- Totalised flow rate because of domestic water demand.
- Flow rate of water pumped into the Water Tower.

- Totalised flow rate of water pumped into the Water Tower.
- Level in any other reservoirs utilised in the system.
- Flow rate of any dominant water reticulation system of importance.
- Totalised flow rate of any dominant water reticulation system of importance.
- Demand in kW of electrical consumption.
- Lift pump status (run/tripped)
- Booster pump status (run/tripped)

2.2 Control:

- Activation of emergency alarm for operating staff to contact the Control Room.
- Any bulk water metering points (flow rate and totalised flow).
- Control of certain main pump sets and motors under emergency conditions. Assume all motors will be started manually.

3. Links between monitoring and control points and the control room:

It is envisaged that all monitoring and control functions will terminate in a central control room with suitable facilities to enable full time monitoring of the water reticulation system under management. Because of the distance between various points and the control room a suitable medium of communication is required. For the specific installation envisaged it is recommended that radio links should be chosen as the communication medium. In order to establish radio links a formal application for licences from the regulatory authority is required. This procedure could take time and need to be initiated timely.

4. Benefits of a Telemetry System:

The installation and management of a Telemetry system for the Sol Plaatje Water Reticulation system could offer certain benefits. It is recommended that the Telemetry system be supplemented with a functional SCADA system which is regarded as essential for the basic control and monitoring of water related elements in the Water system. The following are some of the benefits that could be expected by implementing the Telemetry and SCADA package as management tool on the water system:

- Continuous knowledge on a real time basis of the levels in all reservoirs. Critical levels could be introduced with the option of an alarm condition when levels are exceeded.
- Continuous observation of the flow of water in all main lines.
- Monitoring the electrical demand characteristics in order to assess the rate of consumption during Peak and Standard Tariff consumption periods.
- Switching off of pumps during Peak and Standard Tariff periods when the levels and flow rates indicate sufficient water capacity available.
- The compilation of a data base of historical information to extract trends and patterns of water consumption. These trends and patterns could offer information to assess and identify possible losses due to leakages or fraudulent consumption. Trends could also assist to establish a pumping cycle with minimum energy consumption.
- SCADA would show operators, not familiar with computers, how to operate the plants as the computer screen is a mimic of what an operator would see outside in the real plant.
- Alarm paging via cell phone SMS.
- SCADA can perform semi or complete network automation i.e. pump control according to reservoir or pressure demands.

5. Existing or Future Reservoir in Network

5.1 Monitoring

- Reservoir level
- Flow rate in/out
- Totalised flow
- Valve status

6. Existing or Future Bulk Flow Meter

6.1 Monitoring

- Flow Rate
- Totalised flow
- Out of range conditions

7. Existing or Future Booster Pump Stations

7.1 Monitoring

- Pump status (run/tripped)
- Tripped condition (over voltage, under voltage, etc)
- Intruder status
- Pump current's
- Flow rate
- Totalised flow
- No flow condition
- Line pressure

7.2 Control

- Remote pump control according to reservoir levels
- Remote pump control for emergency situations

END OF APPENDIX F