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PRETORIA
0001

DWAF / DANCED-IWRM-PROJECT

Output 8 : Water Conservation and Demand Management

Work package 3 : uMngeni Municipality
Pilot Project

PREPARED BY :



AND



**MC AREA PRV
COMPLETION REPORT**

JULY 2004



DWAF / DANCED IWRM Project

Output 8 : Water Conservation and Demand Management

MC Area Pressure Management Project

Completion Report

August 2004

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PRETORIA

0001

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GLOSSARY OF ACRONYMS

ACRONYM	MEANING
AZP	Average Zone point
DWAF	Department of Water Affairs and Forestry
IWRM	Integrated Water Resources Management
MNF	Minimum Night Flow
PRV	Pressure Reducing Valve
PSC	Project Steering Committee
uMM	uMngeni Municipality
WCDM	Water Conservation and Demand Management

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The project team would like to thank the uMngeni Municipality and the Department of Water Affairs and Forestry for supporting this project and working together with the Consultants. The support from the municipal staff was essential in order to ensure that the project was a success and that the predicted savings were achieved. Specific reference is made to Mr Vincent Gumede, Mr Raveen Singh and their team members.

1. INTRODUCTION

1.1. BACKGROUND

The uMngeni Municipality (uMM) and the Department of Water Affairs and Forestry (DWAF) have been undertaking an Integrated Water Resources and Management (IWRM) project over the past few years. One of the phases of this IWRM project comprised a pilot project to implement certain Water Conservation and Demand Management (WCDM) measures in Mpophomeni Township, the location of which is shown in **Figure A.1** in **Annexure A**.

One of the proposed WCDM measures was pressure management. Unfortunately, the pilot project was completed before an assessment of the pressure management intervention could be undertaken. A Pressure Reducing Valve (PRV) was installed in a discrete zone and an assessment of the intervention was undertaken subsequent to the completion of the pilot project. The intention of this report is to provide an addendum document to the main Technical Report outlining the assessment of the pressure management intervention.

1.2. STUDY AREA

Mpophomeni Township is supplied with water by Umgeni Water Board into two separate service reservoirs. The current tariff to uMM for bulk water supplied by Umgeni Water Board is R 2.20/kl. The top water levels of both reservoirs are at an elevation of 1 175 m.a.s.l and the supply zones of the two reservoirs were inter-connected at the commencement of the pilot project. One of the original objectives of the pilot project was to subdivide the Mpophomeni supply area into two zones, each being fed independently and each of which could be considered for pressure management. This proved to be difficult within the scope of the pilot project, so an alternative sectorisation plan was proposed, the details of which are provided in the Technical Report and are not repeated here.

In recent years significant housing development has occurred on the periphery of the original township. One such area is the MC Housing Area located on the low lying eastern boundary, the location of which is indicated in **Figure A.2** in **Annexure A**. The terrain is relatively flat and it is the lowest lying area in Mpophomeni with the result that the pressures are the highest. The housing project was completed at the end of 2003 and dwellings were filled in early 2004. All the properties are serviced with individual metered household connections and water borne sewage.

Given the high pressures and the fact that the MC Area zone was planned to be fed by a single connection, it made sense to consider pressure management in this zone. Furthermore, the construction of the service infrastructure in the MC Area was being undertaken at the same time as the pilot project so it was convenient to engage with the housing project to ensure that the correct water management facilities were put in place for this zone.

1.3. REPORT STRUCTURE

This report discusses the results from the pressure management intervention project planned by WRP and implemented by the uMM in the MC Area of Mpophomeni. The structure of the report is along the following lines :

- Summarise the scope of work carried out;
- Document the status of the performance of the water supply infrastructure before any pressure management intervention;
- Outline the assessment of the potential for pressure management including the projected savings;
- Report on the status of the performance of the water supply infrastructure after the pressure management intervention; and

- Finally, provide summaries and conclusions.

2. SCOPE OF WORK

2.1. OVERVIEW

A breakdown of the scope of work was as follows :

- Task 1 : Collection of basic zone data;
- Task 2 : Installation of equipment;
- Task 3 : Pre-installation logging of pressures and flows;
- Task 4 : Analysis of logging results;
- Task 5 : Post-installation logging of pressures and flows; and
- Task 6 : Reporting.

Details of the various tasks are provided in the following sections.

2.2. TASK 1 : COLLECTION OF BASIC ZONE DATA.

Basic zone information is required for a complete understanding of the leakage in a distribution zone and the potential for reducing the leakage through pressure management. The zone data required for the assessment included the following :

- Water system (reticulation and bulk mains);
- Cadastral information (property/stand numbers);
- Topographical information (contours);
- Zone boundaries and condition;
- Reservoir locations and operating levels;
- PRV size, make, pressure settings and location; and
- Meter size, make and location.

The latter two elements were to be constructed as part of the housing project so was the subject of Task 2. Working drawings were created in ArcView GIS for the MC Area in order to plan the pressure management assessment. The following information is provided on the drawings :

- Cadastral layout;
- Contours of elevation;
- Reticulation and trunk mains;
- Zone boundaries;
- Locations and elevations of the service reservoirs; and
- Locations of the monitoring points (inlet, critical and average zone points);

Understanding the operation of the distribution network is a pre-requisite for the efficient management of potable water. As part of the main Technical Study, the following information was obtained :

- **Zone connectivity** : Details on how zones are linked to the bulk supply, zone boundaries, boundary conditions and location of supply points were collected;
- **Supply points** : Information on the number, type and size of meters and PRVs for each zone was obtained;
- **Pressure distribution** : The critical, average and low pressure points were identified from the topography, reservoir operating levels and spot pressure tests;
- **Schematic diagram** : A diagram indicating the bulk supply and zone information was prepared;
- **Logging Points** : Significant time and effort is spent on selecting the most appropriate logging points that will provide a clear understanding of pressures throughout the zone.

Information on the number of stands and length of mains were determined from the electronic drawings. The number of connections was assumed equal to the number of properties and the population was calculated using a factor of 8 persons/property

2.3. TASK 2 : INSTALLATION OF EQUIPMENT

The Project Steering Committee (PSC) requested that the Consultant provide a design and specification for the new connection supplying the MC Area. Construction drawings were prepared by the Consultant and handed to the Municipality for implementation. The Municipal staff procured all of the civil materials while the Consultant procured the fittings and pipe work. Furthermore, the uMM took on the responsibility of all construction work. The advantages of this approach included the following :

- Municipal staff had the opportunity to provide input in the designs considerations that would suit their operating conditions;
- Municipal staff now better understand the system operation;
- The interaction between the Consultant and the uMM facilitated transfer of skills and technology; and
- All shutdown activities were undertaken and co-ordinated through the uMM resulting in minimum disruption to the system.

The scope of the intervention work comprised the following :

- Construction of a chamber to house a PRV and meter to supply the MC Area;
- Appropriate flanged spool sections;
- Appropriate couplings for the upstream and downstream pipework;
- 80mm AVK flanged RSV gate valves with hand wheel;
- 80mm Invensys protection sieve WP-F dynamic; and
- 80mm Invensys WPD turbine water meter.

Copies of the Construction Drawings and specifications are provided in **Figures A.3** and **A.4** of **Annexure A**. It should be noted that the installation of the equipment was undertaken in two phases, namely :

- The complete chamber was constructed and all equipment except for the PRV was installed so that the pre-installation conditions for the PRV could be monitored and logged;
- After an assessment of pressure management, a PRV and settings were specified and installed so that the post-installation conditions could be monitored and logged.

A photographic record of the construction activities is provided in **Figures B.1 to B.4** in **Annexure B**, which reveals the following problems with the construction of the chamber and installation of the equipment :

- The pipeline and chamber is poorly aligned;
- The brickwork of the chamber is not structurally sound and structural failure of chamber wall has already occurred;
- The proposed scour valve outlet is not connected;
- The meter has been located downstream of the PRV with the result that turbulence from the PRV may influence the meter readings;
- Backfilling of the excavation is incomplete and represents a hazard; and
- The pre-cast catchpit covers are not properly aligned or grouted.

The one drawback of the approach adopted is that the in-house construction capability of the uMM is not adequate. External construction supervision is required at the very least and, in future, the uMM should consider outsourcing this type of activity to a professional contractor. The above-mentioned snags also need to be rectified as soon as possible.

2.4. TASK 3 : PRE-INSTALLATION LOGGING OF PRESSURES AND FLOWS

Pressure and flow statistics over a 24-hour period are required for the pressure analysis programme. Efforts were made with the logging exercise to identify trends by monitoring for a longer period. Once trends were established, a representative 24-hour period was selected. The input requirements for the pressure analysis programme are:

- Flow & pressure at the supply into the zone;
- Pressure at the critical point (usually the highest);
- Pressure at the Average Zone Point (AZP).

Prior to logging, a pressure drop test was undertaken to confirm the discreteness of the zone. The results from the logging exercise were analysed using the SANFLOW night flow analysis model developed through the South African Water Research Commission by WRP (Pty) Ltd. The SANFLOW model requires the following input:

- Measured minimum night flow;
- Average zone night pressure during minimum flow conditions;
- Length of mains, number of connections, number of properties, population; and
- Details of domestic and non-domestic night users.

The model was used to assess the expected minimum night flow for the zone, which was compared to the measured minimum night flow to determine the level of excess leakage in the zone.

2.5. TASK 4 : ANALYSIS OF LOGGING RESULTS;

The PRESMAC Model also developed by WRP (Pty) Ltd through the South African Water Research Commission was used for the pressure analyses. The model was used to assess the likely impacts of two possible pressure reduction activities namely :

- Fixed outlet control (for zones not currently equipped with PRVs) – This traditional method of control is very useful and cost effective in areas with low head losses, high pressures, small seasonal changes in demand and areas with uniform supply characteristics.
- Time based modulation – is used to provide the additional flexibility of adjusting the zone pressures at different times of the day. This is particularly useful for lowering the pressure during off-peak periods such as during the night when consumers are asleep.

The hourly average pressure and flows over a twenty-four hour period are required for the PRESMAC model. The input requirements for PRESMAC and SANFLOW were captured in templates and are included in the appendices. The PRESMAC model takes into account the estimated loss of metered income due to a reduction in consumption but excludes the potential savings through the reduction in number of burst pipes. The PRESMAC model requires the following input:

- Pressure at inlet point (downstream of PRV), AZP and critical points;
- Zone Inflow;
- Ground levels at the inlet, AZP and critical points;
- Length of mains, number of connections, number of properties, population; and
- Details of domestic and non-domestic night users.

2.6. TASK 5 : POST-INSTALLATION LOGGING OF PRESSURES AND FLOWS

This is essentially the same as Task 3 but was undertaken after the PRV was installed and set.

2.7. TASK 6 : REPORTING

A summary report (this report) has been prepared on the completion of the assignment. The findings and recommendations have been compiled into a brief report along with the necessary data and information referred to in the assignment. The summary report also makes recommendations for further work.

3. PRE-INSTALLATION CONDITIONS (FEBRUARY 2004)

3.1. NIGHT FLOW ANALYSIS

The inflow to the MC Area was logged for the period 20th February 2004 to 23rd February 2004, the time series of which is shown in **Figure 3.1** and is summarised in **Table 3.1**. **Figure B.5** in **Annexure B** provides a photographic record of the flow logging. The 21st and 22nd February were a Saturday and Sunday respectively. A relatively high minimum night flow (2.30 m³/hour) is evident from the time series, which is some 61% of the average system input (3.77 m³/hour) over the three day period. The accepted norm for a reasonably well managed system is between 20% and 30%. The average monthly consumption for the zone is relatively low, however, this is to be expected in an area where there are very small properties and dwellings.

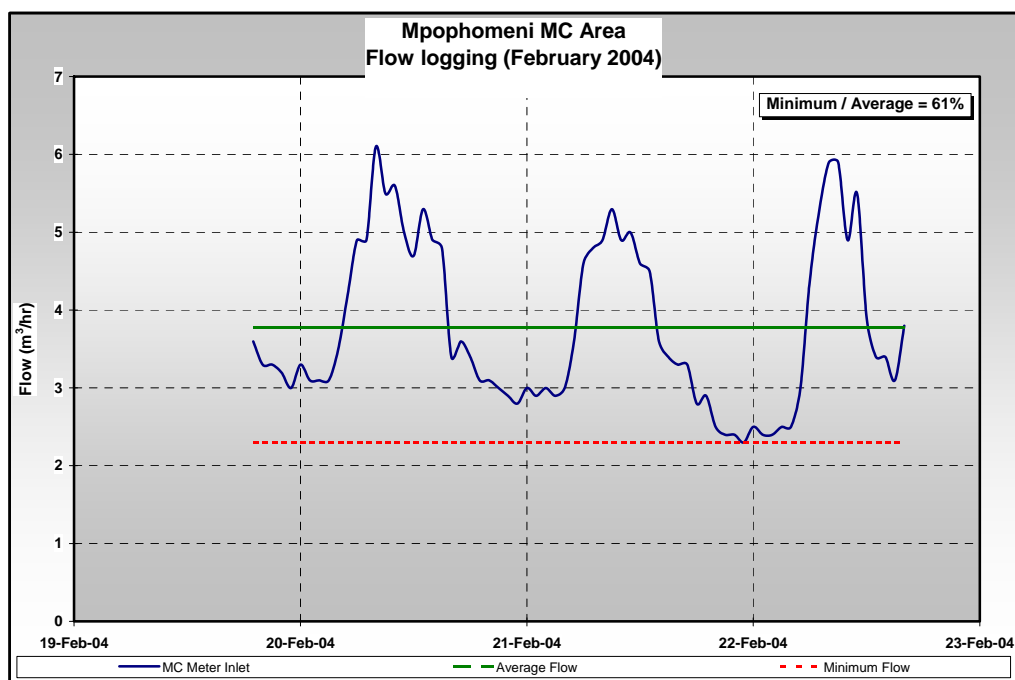


Figure 3.1 : Logged inflow to MC Area (February 2004).

Table 3.1 : Summary of flow logging results (February 2004).

Average Flow (m ³ /h)	MNF (m ³ /h)	MNF/ Average (%)	Average consumption (m ³ /connection/month)	Average consumption (l/person/day)
3.77	2.30	61	16.8	70

The levels of leakage in the MC Area were assessed on the basis of this logged record. The system and consumer data for the night flow analysis is provided in **Table 3.2**. Additional water loss parameters had to be assumed for the analysis, the details of which are provided in **Table 3.3**.

Table 3.2 : Base data for the MC Area night flow analysis (February 2004).

Description	Unit	Value
Length of mains	m	2,580
Number of connections	-	162
Estimated population	-	1,296
Average zone night pressure (AZNP)	m	92

Table 3.3 : Default loss parameters for the MC Area night flow analysis (February 2004).

Description	Unit	Value
Background losses from mains	ℓ/km/hr	40
Background losses from connections	ℓ/connection /hr	3
Background losses from properties	ℓ/connection /hr	1
Population active during night	%	6
Quantity of water used in toilet cistern	ℓ	10
Number of small non-domestic users	-	0
Ave. use of small non-domestic users	ℓ/hr	0
Use by large non-domestic users	m ³ /hr	0
Background losses pressure exponent	-	1.5
Burst/leaks pressure exponent	-	0.5

The MC Area comprises entirely domestic users so it was assumed that normal night use is only made up from this sector. The calculations of normal night use and background leakage are summarised in **Tables 3.4** and **3.5** respectively.

Table 3.4 : Estimated normal night use in the MC Area (February 2004).

Description	Calculation	Value
Domestic night use	1,296 @ 6 %/hr @ 10 ℓ	0.8 m ³ /hr
Small non-domestic night use	-	-
Large non-domestic night use	-	-
Total normal night use		0.8 m³/hr

Table 3.5 : Estimated background leakage in the MC Area (February 2004).

Description	Calculation	Value
Mains losses	2.58 km @ 40 ℓ/km/hr	0.1 m ³ /hr
Connection losses	162 @ 3 ℓ/connection /hr	0.5 m ³ /hr
Property losses	162 @ 1 ℓ/connection /hr	0.2 m ³ /hr
Total background leakage @ 50 m pressure		0.8 m³/hr
Pressure correction factor	$(92/50)^{1.5}$	2.50
Total background leakage @ 92 m pressure		1.9 m³/hr

The difference between the measured minimum night flow and the estimated legitimate use provides an indication of the unexplained leakage. This calculation is provided in **Table 3.6**, where it is noted that the measured minimum night flow is the same as the total expected night use. This indicates that the background leakage is at the expected level for given system conditions. This would be expected since the infrastructure is new, however, site inspections revealed that there are visual leaks both in the network as well as in the plumbing on properties.

Table 3.6 : Estimation of the unaccounted for leakage in the MC Area (February 2004).

Description	Unit	Value
Expected normal night use	m ³ /hr	0.8
Expected background leakage	m ³ /hr	1.9
Total expected night use	m³/hr	2.7
Measured minimum night flow	m ³ /hr	2.3

Unaccounted for leakage	m ³ /hr	-0.4
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3.2. PRESSURE ANALYSIS

The location of the zone is such that it lies on relatively flat terrain with a slight slope away from the inlet point (see **Figure A.2** in **Annexure A**). Point pressure readings were taken throughout the Mpophomeni supply system which revealed that the MC Area inlet point is also the critical point (i.e. pressures in other parts of the system are higher than those at the inlet). Hydrants for logging pressures were identified at positions that were close enough to be representative of the critical point / inlet point and the average zone point. Photographic records of the logging of these points are provided in **Figures B.6 and B.7** in **Annexure B**.

The pressures within the MC Area were logged for the same period as the inflows reported in **Section 3.1**. The time series of the pressure loggings are shown in **Figure 3.2** and are summarised in **Table 3.7**. It is noted that, although the pressures were very high, there is no significant variation in the pressures. As with consistent high pressures, severe fluctuations in pressure are also damaging to a reticulation system.

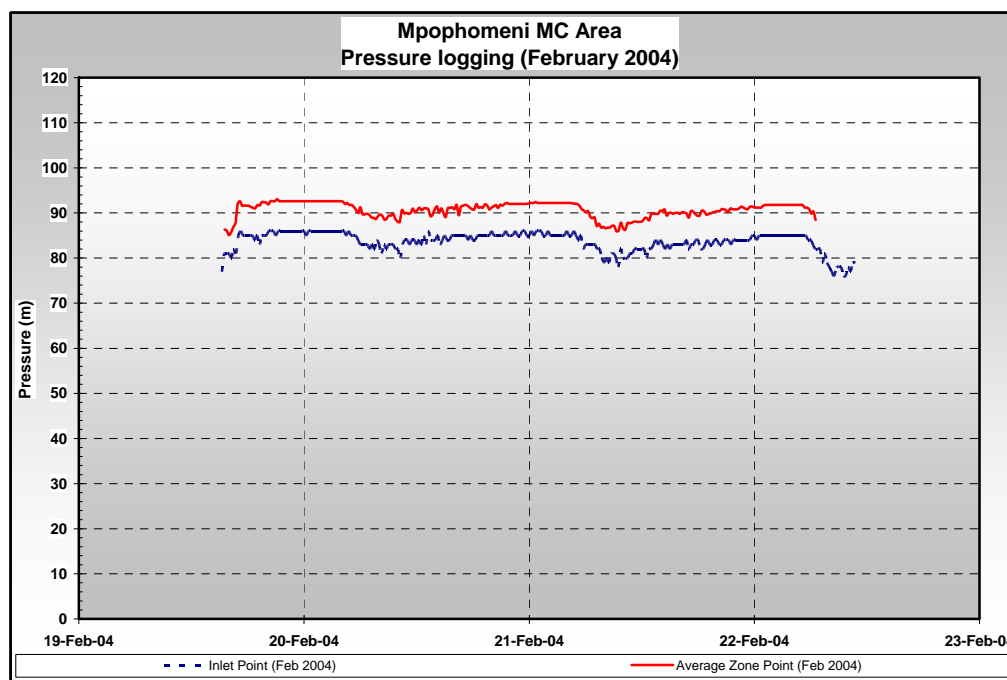


Figure 3.2 : Logged pressures in the MC Area (February 2004).

Table 3.7 : Summary of pressure logging results (February 2004).

Location	Maximum	Average	Minimum
Inlet / Critical point	86.0	83.7	76.0
Average zone point	93.0	90.7	85.1

3.3. CONCLUSIONS AND RECOMMENDATIONS

The following conclusions were drawn from the pressure and flow loggings in the MC Area in February 2004 :

- The average consumption was 16.8 kl/connection/month or some 70 l/person/day. This is considered to be above average for the level of service provided and type of dwelling developed.

Furthermore, the level of use was well above the free basic water threshold of 6 kℓ/connection/month.

- The minimum night flow into the zone was 61% of the average flow. This is well in excess of the accepted norm for a reasonably well managed system of between 20% and 30%.
- The night flow analysis results suggested that the zone does not have an excessive leakage problem, however, these results are pressure related.
- The pressures in the system were considered to be excessive and there was evidence of both internal plumbing leakage and mains leakage (although this was not evident from the night flow analysis).

Given this background, it was concluded that a reduction in pressure would reduce the background leakage as well as the end user consumption. There is a very poor record of payment for water services in Mpopphomeni so this latter component was important from a consumption management perspective. As a result, an assessment was undertaken to determine the viability of pressure management in the MC Area.

4. PRESSURE MANAGEMENT ANALYSIS

4.1. PRESENT SITUATION

The PRESMAC programme requires pressure and flow data over a 24-hour period to undertake a pressure analysis. As mentioned in **Section 3**, the logging exercise was extended for a longer period to identify trends and to give a more accurate estimate of the night flows. A representative 24-hour period was selected from this record for the assessment. The basic system data for the MC Area is listed in **Annexure C.1** and the input requirements for the PRESMAC model for the pre-installation conditions are provided in **Annexure C.2**. It should be noted that the inlet point and the critical point were assumed to be the same hence the same data being indicated for both points. Time series of the pressures at the various monitoring points and the various components of the inflow as broken down in the PRESMAC model are depicted in **Figure 4.1**.

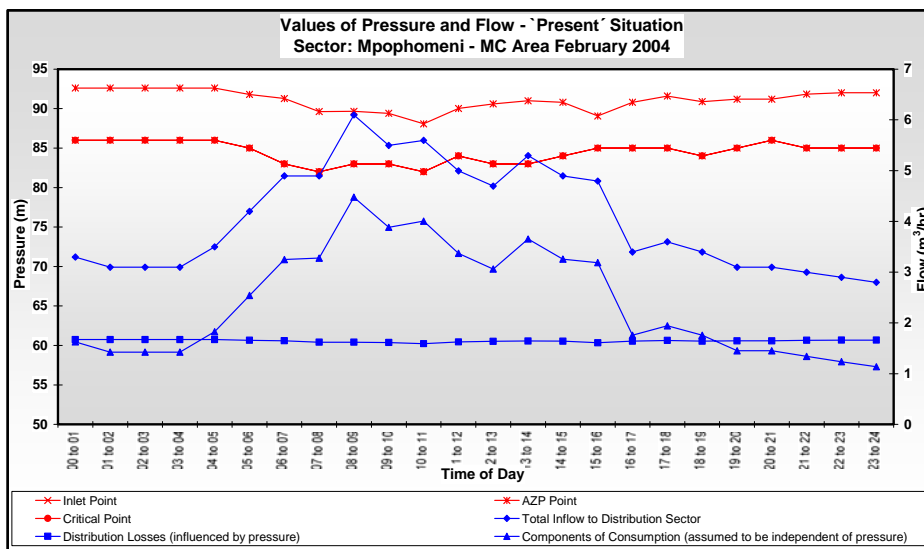


Figure 4.1 : Flow and pressures in the MC Area before intervention.

The first step in the pressure management assessment was to determine the cost of the intervention, which is summarised in **Table 4.1**. It should be noted that these costs exclude professional time and internal costs of the uMM to construct the chamber and install the pipe work and fittings. The costs of the chamber, pipe work and equipment were not considered in this analysis since the chamber and the meter installation would normally have been part of the cost covered by the provision of services for the housing project. To this end, only the cost of the PRV and the controller were considered.

Table 4.1 : Summary of the costs of the chamber and PRV.

Location	Maximum
Chamber	R 5,198
Pipe work and equipment	R 14,428
PRV	R 7,182
Controller	R 9,835
Total	R 36, 643

4.2. FUTURE SITUATION

As mentioned in **Section 2.5**, two possible pressure reduction measures were considered, one being the installation of a fixed outlet PRV and the other being a time modulated PRV. Two settings were considered for the fixed outlet PRV so a total of three scenarios were analysed. The pressure

settings analysed are provided in **Table 4.2** and the PRESMAC model outputs are listed in **Annexures C.3, C.4 and C.5**.

Table 4.2 : Scenarios of pressure regulation analysed.

Intervention	Setting
Fixed inlet PRV	Pressure set at 50 m for 24 hours
Fixed inlet PRV	Pressure set at 30 m for 24 hours
Time modulated PRV	Pressure set at 50 m between 05:00 am and 07:00 pm thereafter drops to 20 m

The relationship between the rate of distribution losses and pressure is based on the concept of “fixed” and “variable” area leakage paths. The value of the power law exponent (N1) is the key factor in this relationship. The value of N1 for the MC Area is not known so it is considered acceptable to assume that the N1 value is 1.0 (i.e. loss rate from the distribution system varies linearly with pressure).

The reduction in distribution losses and consumption predicted by the PRESMAC model for the three scenarios analysed are provided in **Tables 4.3 and 4.4** respectively and the associated time series data are depicted in **Figures 4.2, 4.3 and 4.4**. It should be noted that the reduction in consumption is based on the assumption that only 10% of the consumption under pre-installation conditions is pressure dependant.

Table 4.3 : Predicted reduction in distribution losses.

Condition	Daily loss (m ³ /day)	Annual loss (m ³ /yr)	Saving (m ³ /yr)	Saving (%)
Pre-installation	39.5	14,409	-	
Fixed inlet PRV @ 50m	25.0	9,115	5,294	37%
Fixed inlet PRV @ 30m	16.5	6,028	8,381	58%
Time modulated PRV	20.2	7,384	7,025	49%

Note 1 : Savings determined for N1 = 1.0

Table 4.4 : Predicted reduction in consumption.

d	Total consumption (m ³ /day)	Pressure dependent consumption (m ³ /day)	Pressure dependent consumption (m ³ /yr)	Saving (m ³ /yr)	Saving (%)
Pre-installation	57.8	5.8	2,108	-	-
Fixed inlet PRV @ 50m	56.6	4.6	1,681	428	20%
Fixed inlet PRV @ 30m	55.7	3.7	1,366	742	35%
Time modulated PRV	56.3	4.3	1,583	525	25%

Note 1 : Savings determined for N1 = 1.0

Note 2 : Pressure dependant consumption pre-installation assumed to be 10% of the total consumption.

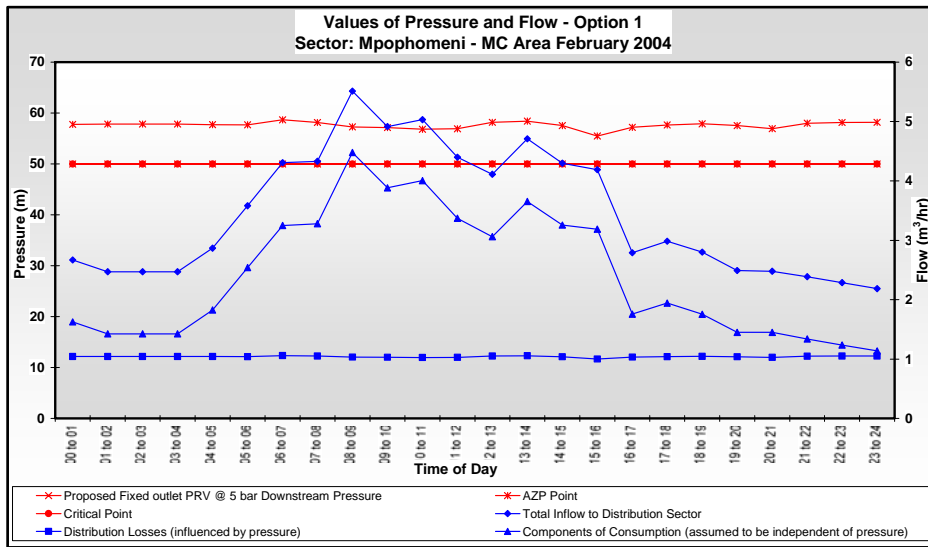


Figure 4.2 : Flow and pressures in the MC Area for a fixed outlet PRV @ 50m.

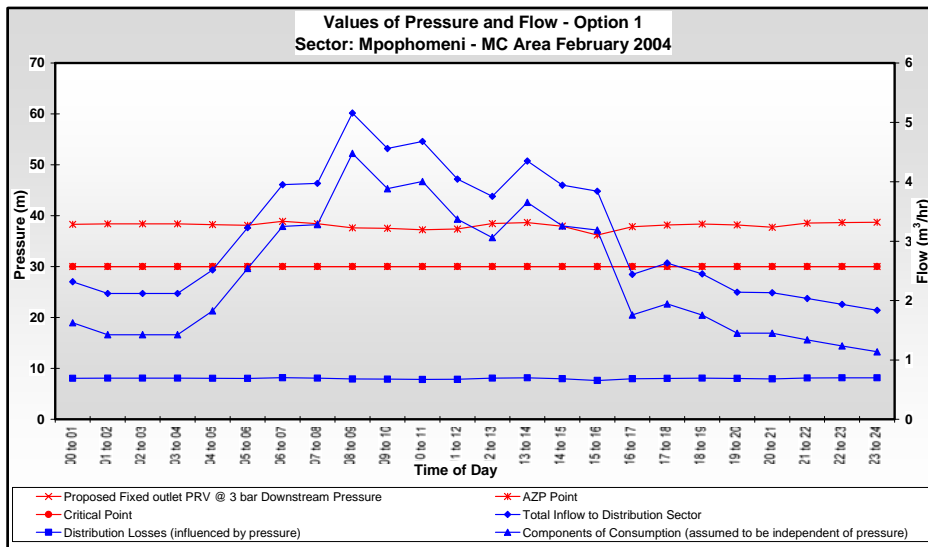


Figure 4.3 : Flow and pressures in the MC Area for a fixed outlet PRV @ 30m.

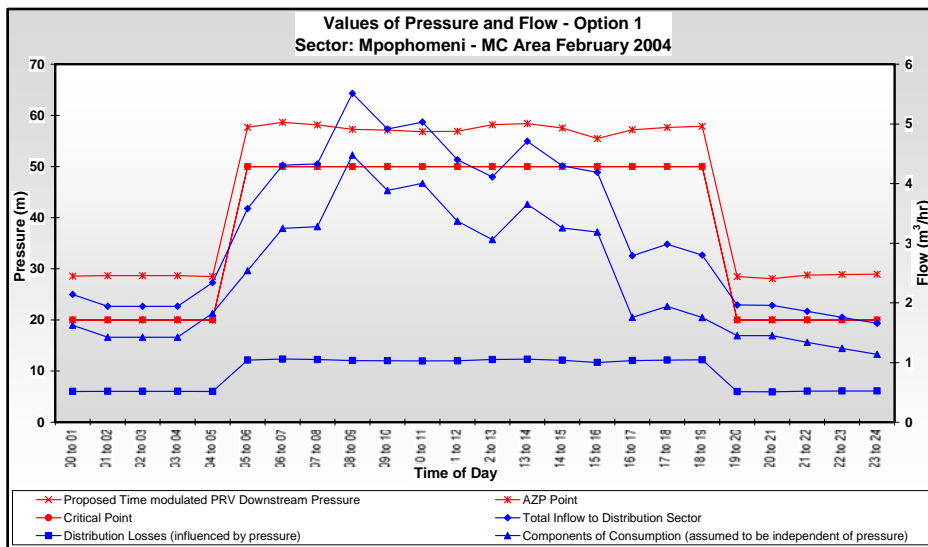


Figure 4.4 : Flow and pressures in the MC Area for a time modulated PRV.

The predicted savings for each of the pressure management scenarios analysed are summarised in **Table 4.5** . These savings have been determined on the basis that the cost of water supplied by Umgeni Water Board to the uMM is R 2.20/m³. The loss of income due to the reduction in consumption should also be considered, however, this is largely an area of non-payment so this component has been left out of the analyses. Finally, it should be noted that the predicted savings are dependant on the value assigned to the N1 variable.

Table 4.5 : Summary of predicted savings.

Condition	Predicted losses ^{(1) (2)}		Reduction in losses ^{(1) (2)}			Estimated saving from reducing inflow (R/yr)	Payback period (Months)
	(m ³ /day)	(m ³ /yr)	(m ³ /day)	(m ³ /yr)	(%)		
Pre-installation	45.252	16,517					
Fixed inlet PRV @ 50m	29.578	10,796	15.673	5,721	35%	R 12,588	6.8
Fixed inlet PRV @ 30m	20.257	7,394	24.994	9,123	55%	R 20,071	4.3
Time modulated PRV	24.567	8,967	20.684	7,550	46%	R 16,609	12.3

Note 1 : Reduction in losses determined for N1 = 1.0

Note 2 : losses = pressure dependant consumption + distribution losses.

4.3. WCWDM GUIDELINES APPROACH

The WCWDM guidelines (Volume 2) provides a rapid approach to assess the reduction in leakage as a result of pressure reduction based on research in the United Kingdom. The initial pressures in the MC Area were above the published range of figures in the look up table in the WCWDM Guidelines. The first step was to extend the range of the table as is outlined in **Table 4.6**. Taking the initial Average Zone Night Pressure (AZNP) of 90 m (see **Table 3.7**), it is possible from this table to predict the reduction in leakage due to any number of pressure reductions.

Table 4.6 : Reduction in leakage due to pressure reduction.

Lowered AZNP (m)		Existing AZNP (m)													
		90	85	80	75	70	65	60	55	50	45	40	35	30	25
	Leakage Index	101.7	93.1	84.8	76.9	69.3	62.1	55.2	48.7	42.5	36.7	31.2	26.1	21.3	16.9
85	93.1	8%													
80	84.8	17%	9%												
75	76.9	24%	17%	9%											
70	69.3	32%	26%	18%	10%										
65	62.1	39%	33%	27%	19%	10%									
60	55.2	46%	41%	35%	28%	20%	11%								
55	48.7	52%	48%	43%	37%	30%	22%	12%							
50	42.5	58%	54%	50%	45%	39%	32%	23%	13%						
45	36.7	64%	61%	57%	52%	47%	41%	34%	25%	14%					
40	31.2	69%	66%	63%	59%	55%	50%	43%	36%	27%	15%				
35	26.1	74%	72%	69%	66%	62%	58%	53%	46%	39%	29%	16%			
30	21.3	79%	77%	75%	72%	69%	66%	61%	56%	50%	42%	32%	18%		
25	16.9	83%	82%	80%	78%	76%	73%	69%	65%	60%	54%	46%	35%	21%	
20	12.8	87%	86%	85%	83%	82%	79%	77%	74%	70%	65%	59%	51%	40%	24%

Reading down the column for the existing AZNP of 90 m indicates that a reduction in the AZNP to 50 m (i.e. 44 % reduction in pressure) should result in a 58 % reduction in leakage, and that a reduction in the AZNP to 30 m (i.e. 67 % reduction in pressure) should result in a 79 % reduction in leakage. Comparison with the predicted savings provided by the PRESMAC approach and listed in **Table 4.5** reveals that the WCWDM approach results in significantly higher predicted savings.

4.4. CONCLUSIONS AND RECOMMENDATIONS

The following conclusions were drawn from the pressure management analyses undertaken for the MC Area :

- The “incremental” costs of installing a fixed outlet PRV and a time modulated PRV in the new chamber at the MC Area inlet would be R 7,182 and R 17,017 respectively.
- The predicted savings according to the PRESMAC approach vary between 15.7 and 25.0 m³/day (35 and 55 %). The fixed outlet PRV set at a pressure of 30 m provides the best results.
- The payback period for the installations range between 4 and 12 months, all of which are considered to be feasible.
- The estimate of the savings are highly dependant on the value of the power law exponent (N1) in relationship between the rate of distribution losses and pressure. This was assumed to be 1.0 for this assessment.
- The WCWDM Guidelines indicate that the potential reduction in leakage would be 58 % and 79% if the pressure is reduced to 50 m and 30 m respectively. This is significantly higher than the PRESMAC approach.

On the basis of these conclusions, it was recommended that a fixed outlet PRV be installed and that the outlet pressure fixed at 50 m. Thereafter, it was recommended that the effect of the pressure drop be monitored and the pressure could be dropped further to some 30 m depending on the monitoring exercise.

5. POST-INSTALLATION CONDITIONS (JULY 2004)

5.1. NIGHT FLOW ANALYSIS

The inflow to the MC Area was logged after installation and setting of the PRV for the period 6th July 2004 to 9th July 2004, the time series of which is shown in **Figure 5.1** and a summary of which is provided in **Table 5.1**. In this case, a weekend was not included in the logging exercise. The minimum night flow (1.37 m³/hour) dropped to some 51% of the average system input (2.68 m³/hour) after installation. This ratio is still considered to be high but it may be the result of a small zone and relatively low consumptions. Comparison of the results presented in **Tables 3.1 and 5.1** indicates that there was a marked reduction in both average and minimum flows into the MC Area.

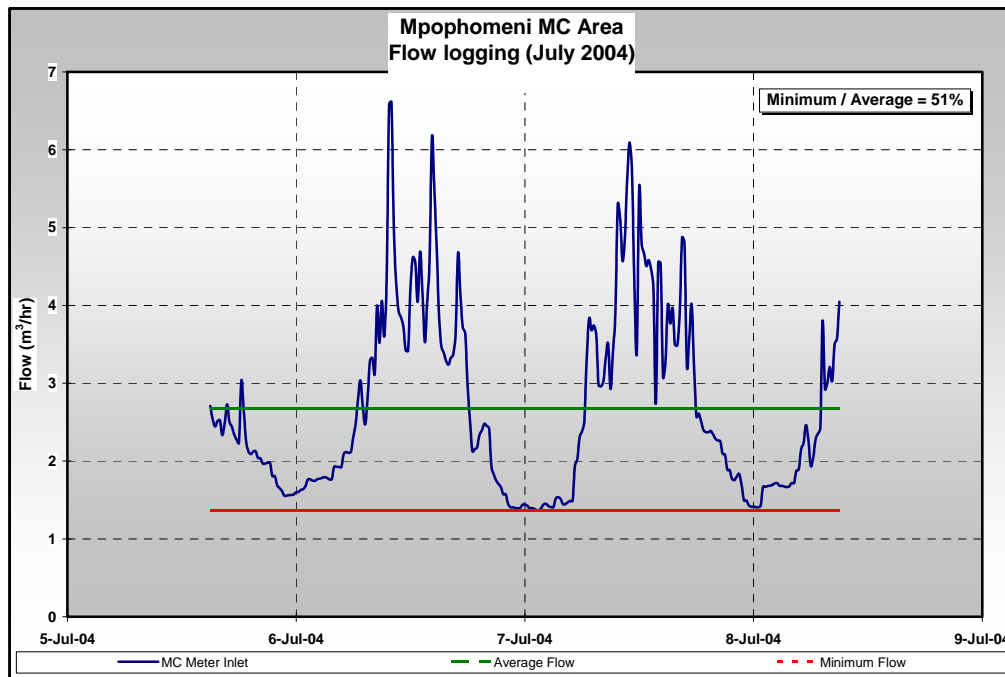


Figure 5.1 : Logged inflow to MC Area (July 2004).

Table 5.1 : Summary of flow logging results (July 2004).

Average Flow (m ³ /h)	MNF (m ³ /h)	MNF/ Average (%)	Average consumption (m ³ /connection/month)	Average consumption (l/person/day)
2.68	1.37	51	11.9	50

The levels of leakage in the MC Area after installation of the PRV were assessed on the basis of this second logged record. The system and consumer data and the water loss parameters used in the night flow analysis remain as listed in **Tables 3.2 and 3.3** with the average pressure being the only setting changed (50m compared to 92m). The calculations of normal night use and background leakage are summarised in **Tables 5.2 and 5.3** respectively.

Table 5.2 : Estimated normal night use in the MC Area (July 2004).

Description	Calculation	Value
Domestic night use	1,296 @ 6 %/hr @ 10 ℓ	0.8 m ³ /hr
Small non-domestic night use	-	-
Large non-domestic night use	-	-
Total normal night use		0.8 m³/hr

Table 5.3 : Estimated background leakage in the MC Area (July 2004).

Description	Calculation	Value
Mains losses	2.58 km @ 40 ℓ/km/hr	0.1 m ³ /hr
Connection losses	162 @ 3 ℓ/connection /hr	0.5 m ³ /hr
Property losses	162 @ 1 ℓ/connection /hr	0.2 m ³ /hr
Total background leakage @ 50 m pressure		0.8 m³/hr
Pressure correction factor	$(50/50)^{1.5}$	1.00
Total background leakage @ 92 m pressure		0.8 m³/hr

The difference between the measured minimum night flow and the estimated legitimate use is outlined in **Table 5.4**. Once again, it is noted that the measured minimum night flow was the same as the total expected night use, which indicates that there is no problem with leakage in the system.

Table 5.4 : Estimation of the unaccounted for leakage in the MC Area (July 2004).

Description	Unit	Value
Expected normal night use	m ³ /hr	0.8
Expected background leakage	m ³ /hr	0.8
Total expected night use	m³/hr	1.5
Measured minimum night flow	m ³ /hr	1.4
Unaccounted for leakage	m³/hr	-0.1

5.2. PRESSURE ANALYSIS

The pressure analysis undertaken in February 2004 revealed that the inlet point is also the critical point, and that there is not a large difference in pressure between the AZP and the critical point. To this end, pressures were logged after the PRV installation at the critical point only. The time series of the pressure loggings are shown in **Figure 5.2** and are summarised in **Table 5.5**. The effect of the PRV maintaining a constant pressure is noted in the logged record.

Table 5.5 : Summary of pressure logging results (July 2004)

Location	Maximum	Average	Minimum
Inlet / Critical point	51.7	51.0	50.4

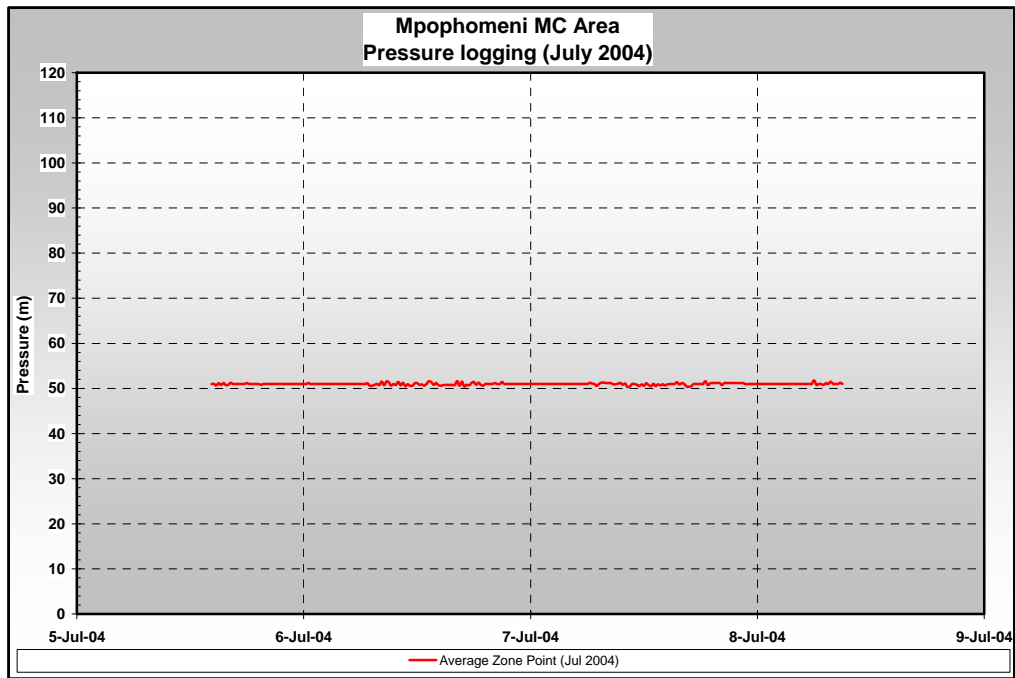


Figure 5.2 : Logged pressures in the MC Area (July 2004).

5.3. COMPARISON WITH PRESMAC PREDICTIONS

An attempt was made to quantify the savings achieved by comparing the system inputs before and after the installation. The logged inflow profiles from February and July were compared for a sixty hour period and have been depicted in **Figure 5.3**. It is clear from the superimposed flow records that there has been a substantial reduction in inflow.

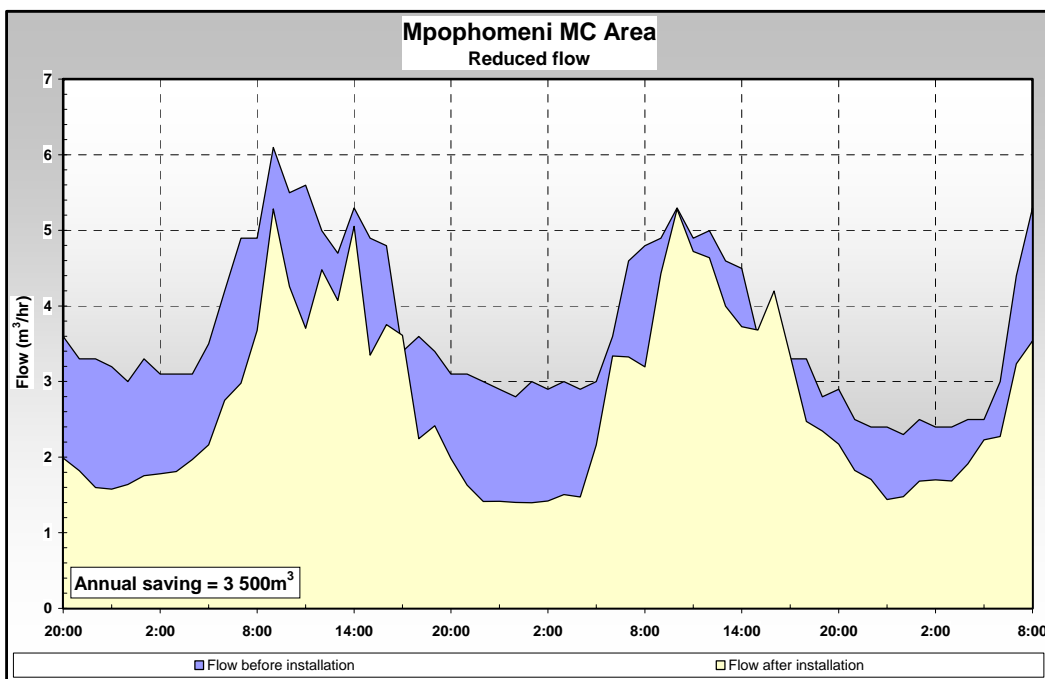


Figure 5.3 : Comparison of flow profiles.

A summary of the predicted and actual savings is provided in **Table 5.6**, which indicates that the inflows have reduced by 9.5 m³/day and the annual savings are some 3 500 m³/yr. This is only 61% of the predicted savings by the PRESMAC approach, however, this comparison may have been influenced by the following :

- The predicted savings may have been optimistic since the value of N1 was assumed to be 1.00, and a lower N1 value would result in lower savings being predicted; and
- There have been additional connections made in the MC Area between February and July which would have resulted in an increase in actual consumption.

Another measure of savings is to compare the drop in the minimum night flow, which reduced from 2.30 m³/hr to 1.37 m³/hr. The reduction in minimum night flow indicates a daily saving of 22.3 m³, which is greater than the predicted savings. Either way the savings are estimated, pressure management in the MC Area is clearly a success.

Table 5.6 : Comparison of the actual versus the predicted savings.

Pre-installation	Predicted reduction in inflow (m ³ /day)	Predicted reduction in inflow (%)	Predicted payback period (Months)
-	15.7	35%	6.8
Post-installation : savings calculation method	Actual reduction in inflow (m ³ /day)	Actual reduction in inflow (%)	Actual payback period (Months)
Difference in logged flows over 60 hours	9.5	21%	11.2
Difference in night flow analysis results	22.3	50%	4.7

5.4. WCWDM GUIDELINES APPROACH

The WCWDM guidelines indicated that a reduction in 58 % of leakage would be achieved by dropping the pressure from 90 m to 50 m. This prediction was significantly above that of the PRESMAC approach and well above the actual savings realising based on both methods applied to measure the savings.

5.5. CONCLUSIONS AND RECOMMENDATIONS

The following conclusions can be drawn from this assignment :

- The project has shown that significant savings can be achieved through proper sectorisation, metering and pressure control. The minimum night flow into the zone improved by 10% to 51% of the average flow.
- Training and transfer of technology has been achieved through the involvement of the uMM staff, which should ensure the sustainability of the project.
- The construction capability of the uMM is not adequate and alternative approaches to construction and implementation of such projects should be considered in future.
- The average consumption dropped by almost 30% to 11.9 kl/connection/month (50 l/person/day). This is still short of the free basic water threshold of 6 kl/connection/month.
- A pressure drop test was undertaken in the MC Area and this confirmed the discreteness of the zone.
- Operations staff have established a thorough understanding of the distribution network and its operation.

- Detailed drawings and documentation for infrastructure in the zone has been produced which will be extremely valuable for future water loss management and asset management initiatives.
- The PRESMAC approach, which was developed for South African conditions, seems to provide a more realistic prediction of potential savings compared to that of the WCWDM Guidelines, which was developed for UK conditions.

Based on the successful completion of the project, the following recommendations are made :

- The pressures in the zone could be dropped further (to say 30m) without affecting the level of service. This would require an iterative approach of reducing the pressure by say 10m and checking the effect on the supply system.
- Consideration should be given to either reducing the predicted savings due to pressure management in the WCWDM Guidelines approach, or the PRESMAC approach should be incorporated into the guidelines.
- PRV's and meters are mechanical devices which require regular maintenance. A preventative maintenance programme is should be developed and implemented whereby all mechanical; components of the installation are checked on a monthly basis for setting and performance. Training should also be provided to the operations staff in the maintenance of the equipment.
- A bulk meter reading programme should be initiated to monitor the performance of each zone on a monthly basis.

ANNEXURE A : FIGURES

A.1 : General locality map of Mpophomeni Township

A.2 : Locality map showing the MC Area

A.3 : PRV and meter installation : Mechanical details

A.4 : PRV and meter installation : Civil details



MPOPHOMENI WATER DEMAND MANAGEMENT PROJECT

General locality map of Mpophomeni township



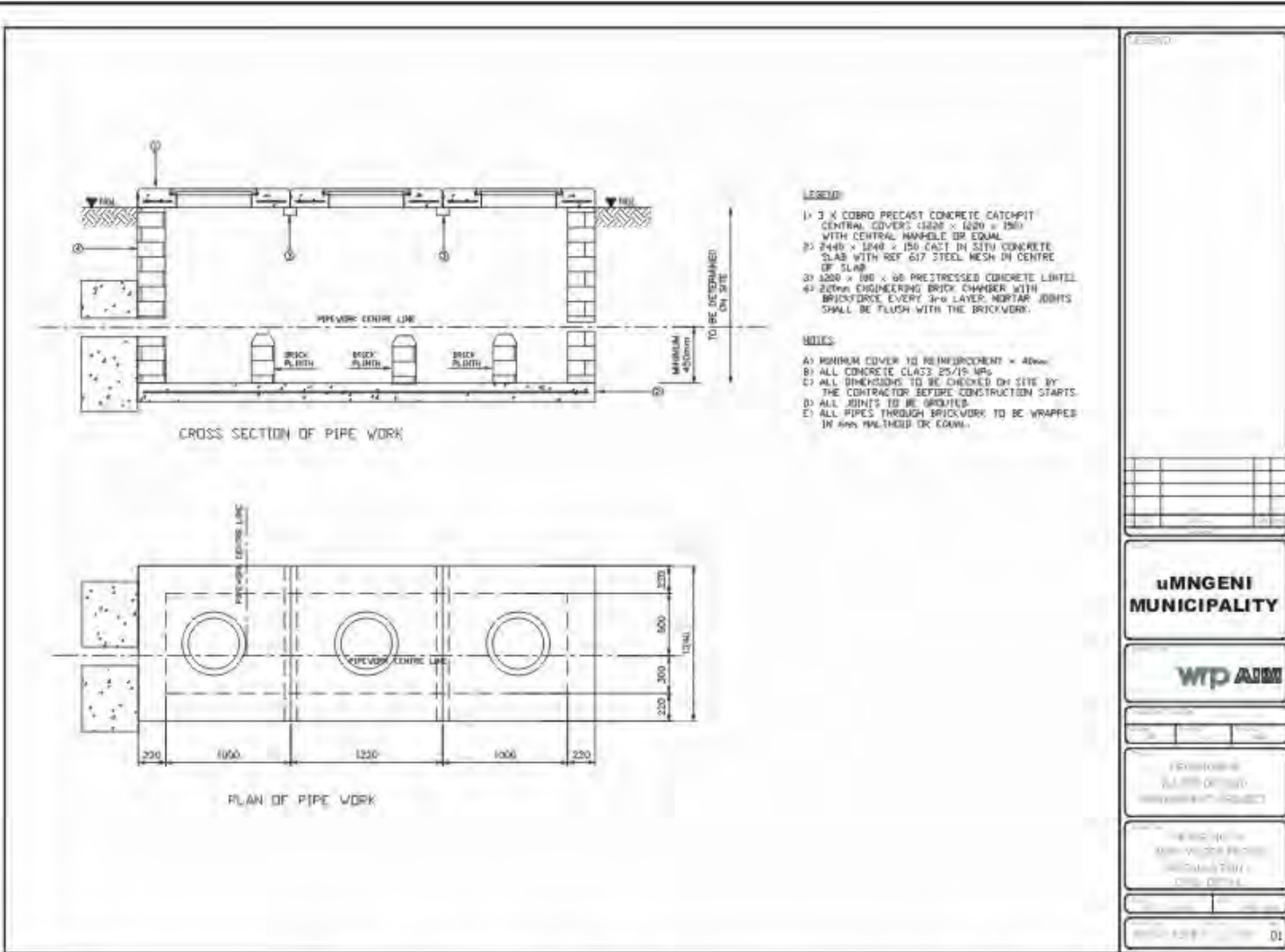
Consulting Engineers (Pty) Ltd



MPOPHOMENI WATER DEMAND MANAGEMENT PROJECT

Locality map of the MC area





uMNGENI MUNICIPALITY

WTP ADMM

REVISIONS

NO.	DESCRIPTION	DATE

DATE: 2004/07/04

SCALE: 1:100

PROJECT NO: DL



MPOPHOMENI WATER DEMAND MANAGEMENT PROJECT

MC Area PRV Chamber : Civil details



ANNEXURE B : PHOTOGRAPHIC RECORD

B.1. INSTALLATION DURING CONSTRUCTION. 2

B.2. INSTALLATION DURING CONSTRUCTION. 2

B.3. CHAMBER AFTER CONSTRUCTION. 3

B.4. CHAMBER AFTER CONSTRUCTION. 3

B.5. LOGGING AT THE INLET METER..... 4

B.6. LOGGING AT A HYDRANT AT THE INLET/CRITICAL POINT. 4

B.7. LOGGING AT A HYDRANT AT THE AVERAGE ZONE POINT..... 5

B.8. INSTALLATION AFTER COMMISSIONING. 5



B.1. Installation during construction.

Note 1 : Poor alignment of pipeline and chamber.

Note 2 : Brickwork not structurally sound (not overlapping).



B.2. Installation during construction.

Note 1 : Scour valve outlet not connected.



B.3. Chamber after construction.

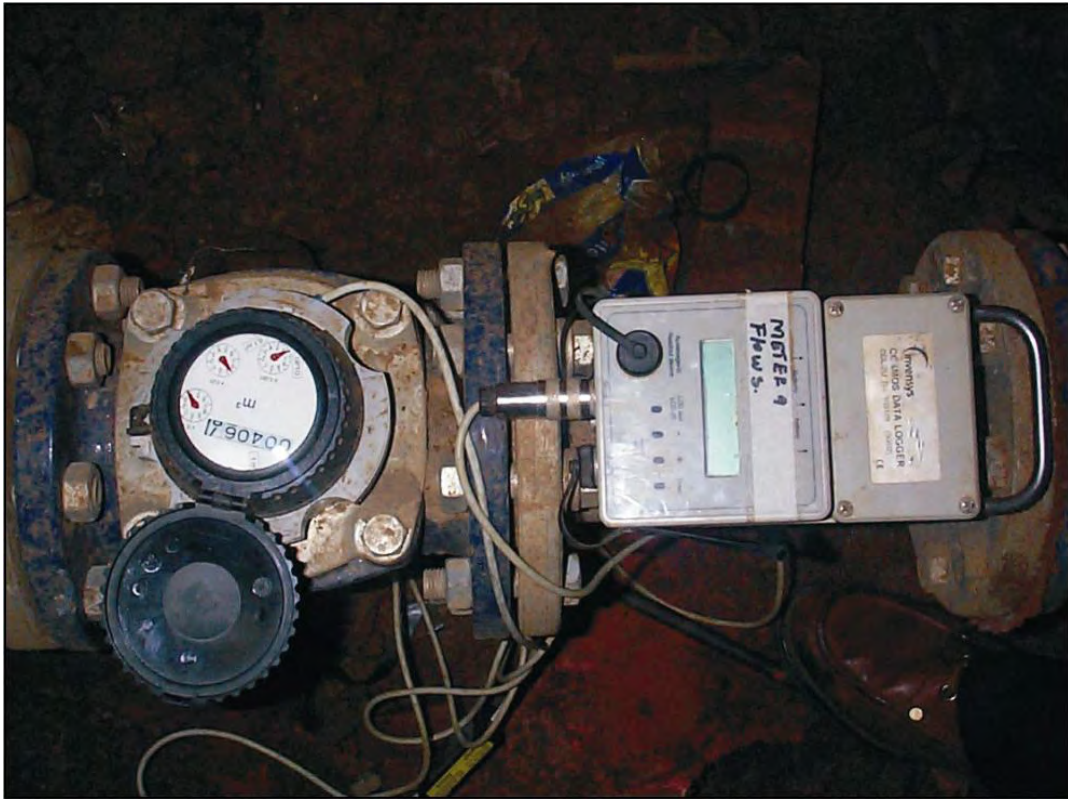
Note 1 : Backfilling incomplete and represents a hazard.

Note 2 : Pre-cast catchpit covers not aligned or grouted.



B.4. Chamber after construction.

Note 1 : structural failure of chamber wall.



B.5. Logging at the inlet meter.



B.6. Logging at a hydrant at the inlet/critical point.



B.7. Logging at a hydrant at the average zone point.



B.8. Installation after commissioning.

Note 1 : PRV positioned incorrectly upstream of meter.

Note 2 : Construction debris not cleaned.

ANNEXURE C : PRESSURE AND FLOW ANALYSES

C.1.	Pressure analysis general information.	2
C.2.	Pre-installation pressure and flow results.....	3
C.3.	Prediction of the effect of a fixed outlet PRV at 5 bar.....	4
C.4.	Prediction of the effect of a fixed outlet PRV at 3 bar.....	5
C.5.	Prediction of the effect of a time modulated PRV.....	6
C.6.	Post-installation pressure and flow results.	7

C.2. Pre-installation pressure and flow results.

Sector Details

Location	Mpophomeni - MC Area		Date of test	February 2004	
Infrastructure	Length of Mains	2.58 km	Ground levels at Pressure measurement points		
	Number of Connections	162 conns	Inlet Point	Specify	1095.00 m above datum
	Number of Properties	162 prop	AZP Point	Specify	1085.00 m above datum
Number of Non-Residential Properties		0 prop	Critical Point	Specify	1095.00 m above datum
Population		1296 hd	Customer Meter Location (start point of consumption)		
			Customer meter at boundary of property with street		

Components of Night Consumption (03 to 04 hours) assumed to be independent of pressure

In the calculations below 'Consumption' consists of both Customer Use and all Losses on Customer pipework after the meter. Consumption is initially assumed to be independent of pressure so that the calculation of changes in distribution losses can be carried out.

Losses per connection	3 l/conn/hr	0.49 m³/hr
Losses per property	1 l/prop/hr	0.16 m³/hr
Residential night use	0.6 l/hd/d	0.78 m³/hr
Non-Residential night use	0.0 l/prop/hr	0.00 m³/hr
Sum of exceptional users > 0.5 m³/hr		0.00 m³/hr
Total Night Consumption assumed to be independent of pressure		1.43 m³/hr

General Relationship between Average Zone Pressure (AZP) and Rate of Losses

If Losses = L₀ when AZP = P₀, then when AZP = P₁ the Losses L₁ = L₀ x (P₁ / P₀)^{N1}

The assumed value of N1 is 1.00 (from the 'Option 1' Worksheet)

Measured and calculated values of pressure and flow for the present situation over 24 hours

Time of day	Average hourly pressure at the:			Headloss between the inlet and the:		Total Inflow to Distribution Sector		Distribution Losses (influenced by pressure)	Components of Consumption (assumed to be independent of pressure)
	Inlet Point	AZP Point	Critical Point	AZP Point	Critical Point				
hr	m	m	m	m	m	l/s	m³/hr	m³/hr	m³/hr
00 to 01	86.0	92.6	86.0	3.4	0.0	0.92	3.30	1.67	1.63
01 to 02	86.0	92.6	86.0	3.4	0.0	0.86	3.10	1.67	1.43
02 to 03	86.0	92.6	86.0	3.4	0.0	0.86	3.10	1.67	1.43
03 to 04	86.0	92.6	86.0	3.4	0.0	0.86	3.10	1.67	1.43
04 to 05	86.0	92.6	86.0	3.4	0.0	0.97	3.50	1.67	1.83
05 to 06	85.0	91.8	85.0	3.2	0.0	1.17	4.20	1.66	2.54
06 to 07	83.0	91.3	83.0	1.7	0.0	1.36	4.90	1.65	3.25
07 to 08	82.0	89.6	82.0	2.4	0.0	1.36	4.90	1.62	3.28
08 to 09	83.0	89.7	83.0	3.3	0.0	1.69	6.10	1.62	4.48
09 to 10	83.0	89.4	83.0	3.6	0.0	1.53	5.50	1.61	3.88
10 to 11	82.0	88.1	82.0	3.9	0.0	1.55	5.60	1.59	4.01
11 to 12	84.0	90.0	84.0	4.0	0.0	1.39	5.00	1.63	3.37
12 to 13	83.0	90.6	83.0	2.4	0.0	1.30	4.70	1.64	3.06
13 to 14	83.0	91.0	83.0	2.0	0.0	1.47	5.30	1.64	3.65
14 to 15	84.0	90.8	84.0	3.2	0.0	1.36	4.90	1.64	3.26
15 to 16	85.0	89.1	85.0	5.9	0.0	1.33	4.80	1.61	3.19
16 to 17	85.0	90.8	85.0	4.2	0.0	0.94	3.40	1.64	1.76
17 to 18	85.0	91.6	85.0	3.4	0.0	1.00	3.60	1.65	1.94
18 to 19	84.0	90.9	84.0	3.1	0.0	0.94	3.40	1.64	1.76
19 to 20	85.0	91.2	85.0	3.8	0.0	0.86	3.10	1.65	1.45
20 to 21	86.0	91.2	86.0	4.8	0.0	0.86	3.10	1.65	1.45
21 to 22	85.0	91.8	85.0	3.2	0.0	0.83	3.00	1.66	1.34
22 to 23	85.0	92.0	85.0	3.0	0.0	0.81	2.90	1.66	1.24
23 to 24	85.0	92.0	85.0	3.0	0.0	0.78	2.80	1.66	1.14
Average	84.46	91.08	84.46	3.4	0.0	1.13	4.05	1.64	2.41
Maximum	86.00	92.60	86.00	5.9	0.0	1.69	6.10	1.67	4.48
Minimum	82.00	88.07	82.00	1.7	0.0	0.78	2.80	1.59	1.14
Daily Totals (m³/day)							97.23	39.48	57.76

Night-Day Factor for Distribution Losses influenced by pressure in the present situation **23.60** hr/d
 If non-residential consumption is **0.00** m³/day
 then it is implied that the residential consumption is **45** l/hd/d

C.3. Prediction of the effect of a fixed outlet PRV at 5 bar.

Prediction of the Effect of Fixed inlet PRV @ 50m on Losses and Payback Period

Proposed Method of Controlling Sector Inlet Pressure **Fixed inlet PRV @ 50m**

Do you want a correction for changes in headloss? **Yes**

Assumed value of N1 **1.00**

Time of Day	Present Inlet Pressure	Proposed Fixed inlet PRV @ 50m Downstream Pressure	Predicted Pressure at		Predicted Headloss between		Total Inflow to Distribution Sector		Distribution Losses (influenced by pressure)	Components of Consumption (assumed to be independent of pressure)	
			AZP Point	Critical Point	Fixed inlet PRV @ 50m & AZP Point	Fixed inlet PRV @ 50m & Critical Point	l/s	m ³ /hr			
hr	m	m	m	m	m	m			m ³ /hr	m ³ /hr	
00 to 01	86.0	50.0	57.8	50.0	2.2	0.0	0.74	2.67	1.04	1.63	
01 to 02	86.0	50.0	57.8	50.0	2.2	0.0	0.69	2.47	1.04	1.43	
02 to 03	86.0	50.0	57.8	50.0	2.2	0.0	0.69	2.47	1.04	1.43	
03 to 04	86.0	50.0	57.8	50.0	2.2	0.0	0.69	2.47	1.04	1.43	
04 to 05	86.0	50.0	57.7	50.0	2.3	0.0	0.80	2.87	1.04	1.83	
05 to 06	85.0	50.0	57.7	50.0	2.3	0.0	0.99	3.58	1.04	2.54	
06 to 07	83.0	50.0	58.7	50.0	1.3	0.0	1.20	4.31	1.06	3.25	
07 to 08	82.0	50.0	58.1	50.0	1.9	0.0	1.20	4.33	1.05	3.28	
08 to 09	83.0	50.0	57.3	50.0	2.7	0.0	1.53	5.51	1.03	4.48	
09 to 10	83.0	50.0	57.1	50.0	2.9	0.0	1.37	4.91	1.03	3.88	
10 to 11	82.0	50.0	56.8	50.0	3.2	0.0	1.40	5.03	1.03	4.01	
11 to 12	84.0	50.0	56.9	50.0	3.1	0.0	1.22	4.40	1.03	3.37	
12 to 13	83.0	50.0	58.2	50.0	1.8	0.0	1.14	4.11	1.05	3.06	
13 to 14	83.0	50.0	58.4	50.0	1.6	0.0	1.31	4.71	1.06	3.65	
14 to 15	84.0	50.0	57.5	50.0	2.5	0.0	1.19	4.30	1.04	3.26	
15 to 16	85.0	50.0	55.5	50.0	4.5	0.0	1.16	4.19	1.00	3.19	
16 to 17	85.0	50.0	57.2	50.0	2.8	0.0	0.77	2.79	1.03	1.76	
17 to 18	85.0	50.0	57.7	50.0	2.3	0.0	0.83	2.98	1.04	1.94	
18 to 19	84.0	50.0	57.9	50.0	2.1	0.0	0.78	2.80	1.05	1.76	
19 to 20	85.0	50.0	57.5	50.0	2.5	0.0	0.69	2.49	1.04	1.45	
20 to 21	86.0	50.0	56.9	50.0	3.1	0.0	0.69	2.48	1.03	1.45	
21 to 22	85.0	50.0	58.0	50.0	2.0	0.0	0.66	2.39	1.05	1.34	
22 to 23	85.0	50.0	58.1	50.0	1.9	0.0	0.64	2.29	1.05	1.24	
23 to 24	85.0	50.0	58.2	50.0	1.8	0.0	0.61	2.19	1.05	1.14	
Average	84.5	50.0	57.6	50.0	2.4	0.0	0.96	3.45	1.04	2.41	
Maximum	86.0	50.0	57.8	50.0	4.5	0.0	1.53	5.51	1.06	4.48	
Minimum	82.0	50.0	55.5	50.0	1.3	0.0	0.61	2.19	1.00	1.14	
Daily Totals (m ³ /day)								82.73	24.97	57.76	

Night-Day Factor for Distribution Losses influenced by pressure for Fixed inlet PRV @ 50m option **23.91** hr/d

Predicted Annual Reduction in Distribution Losses

	Daily Losses (m ³ /d)	% Time System Pressurised	Annual Losses m ³ /yr	Predicted Annual Reduction in Distribution Losses
Present Situation	39.5	100.0%	14409	
Proposed Option 1	25.0	100.0%	9115	
Saving	14.5		5294	5294 m ³ /yr

Correction for Predicted change in pressure dependent consumption after the point of metering

	Residential Consumption				Non-residential Consumption				Predicted Annual Reduction in Consumption
	N1= 0.5				N1= 0.5				
	Total (m ³ /d)	% of Total	(m ³ /d)	(m ³ /yr)	Total (m ³ /d)	% of Total	(m ³ /d)	(m ³ /yr)	
Present	57.76	10.0%	5.78	2108	0.00	0.0%	0.00	0	
Option 1	56.59		4.60	1681	0.00		0.00	0	
Saving	1.17		1.17	428	0.00		0.00	0	428 m ³ /yr

Summary of Predicted Annual Savings arising from Implementation of Option 1

Predicted Annual Reduction in Total Inflow	5722 m ³ /yr
Estimated saving derived from reducing total inflow, if inflow is valued at 2.20 R/m ³	12588 Rand/yr
Estimated loss of metered income due to reduction in consumption, if consumption is valued at 0.00 R/m ³	0 Rand/yr
Net Saving	12588 Rand/yr
If the assumed value of N1 = 1.00	
and the cost of Implementing Option1 = 7182.0 Rand	
Payback Period	6.8 months

C.4. Prediction of the effect of a fixed outlet PRV at 3 bar.

Prediction of the Effect of Fixed Inlet PRV @ 30m on Losses and Payback Period

Proposed Method of Controlling Sector Inlet Pressure **Fixed Inlet PRV @ 30m**

Do you want a correction for changes in headloss? **Yes**

Assumed value of N1 **1.00**

Time of Day	Present Inlet Pressure	Proposed Fixed Inlet PRV @ 30m Downstream Pressure	Predicted Pressure at		Predicted Headloss between		Total Inflow to Distribution Sector		Distribution Losses (influenced by pressure)	Components of Consumption (assumed to be independent of pressure)	
			AZP Point	Critical Point	Fixed Inlet PRV @ 30m & AZP Point	Fixed Inlet PRV @ 30m & Critical Point	l/s	m³/hr			
hr	m	m	m	m	m	m			m³/hr	m³/hr	
00 to 01	86.0	30.0	38.3	30.0	1.7	0.0	0.64	2.32	0.69	1.63	
01 to 02	86.0	30.0	38.4	30.0	1.6	0.0	0.59	2.12	0.69	1.43	
02 to 03	86.0	30.0	38.4	30.0	1.6	0.0	0.59	2.12	0.69	1.43	
03 to 04	86.0	30.0	38.4	30.0	1.6	0.0	0.59	2.12	0.69	1.43	
04 to 05	86.0	30.0	38.2	30.0	1.8	0.0	0.70	2.52	0.69	1.83	
05 to 06	85.0	30.0	38.1	30.0	1.9	0.0	0.90	3.23	0.69	2.54	
06 to 07	83.0	30.0	38.9	30.0	1.1	0.0	1.10	3.95	0.70	3.25	
07 to 08	82.0	30.0	38.4	30.0	1.6	0.0	1.10	3.97	0.69	3.28	
08 to 09	83.0	30.0	37.6	30.0	2.4	0.0	1.43	5.16	0.68	4.48	
09 to 10	83.0	30.0	37.5	30.0	2.5	0.0	1.27	4.56	0.68	3.88	
10 to 11	82.0	30.0	37.3	30.0	2.7	0.0	1.30	4.68	0.67	4.01	
11 to 12	84.0	30.0	37.4	30.0	2.6	0.0	1.12	4.05	0.68	3.37	
12 to 13	83.0	30.0	38.5	30.0	1.5	0.0	1.04	3.76	0.69	3.06	
13 to 14	83.0	30.0	38.7	30.0	1.3	0.0	1.21	4.35	0.70	3.65	
14 to 15	84.0	30.0	37.9	30.0	2.1	0.0	1.10	3.94	0.68	3.26	
15 to 16	85.0	30.0	36.2	30.0	3.8	0.0	1.07	3.84	0.65	3.19	
16 to 17	85.0	30.0	37.8	30.0	2.2	0.0	0.68	2.44	0.68	1.76	
17 to 18	85.0	30.0	38.2	30.0	1.8	0.0	0.73	2.63	0.69	1.94	
18 to 19	84.0	30.0	38.4	30.0	1.6	0.0	0.68	2.45	0.69	1.76	
19 to 20	85.0	30.0	38.2	30.0	1.8	0.0	0.59	2.14	0.69	1.45	
20 to 21	86.0	30.0	37.7	30.0	2.3	0.0	0.59	2.13	0.68	1.45	
21 to 22	85.0	30.0	38.5	30.0	1.5	0.0	0.57	2.04	0.70	1.34	
22 to 23	85.0	30.0	38.7	30.0	1.3	0.0	0.54	1.93	0.70	1.24	
23 to 24	85.0	30.0	38.7	30.0	1.3	0.0	0.51	1.84	0.70	1.14	
Average	84.5	30.0	38.1	30.0	1.9	0.0	0.86	3.09	0.69	2.41	
Maximum	86.0	30.0	38.4	30.0	3.8	0.0	1.43	5.16	0.70	4.48	
Minimum	82.0	30.0	36.2	30.0	1.1	0.0	0.51	1.84	0.65	1.14	
Daily Totals (m³/day)								74.27	16.52	57.76	

Night-Day Factor for Distribution Losses influenced by pressure for Fixed Inlet PRV @ 30m option **23.81** hr/d

Predicted Annual Reduction in Distribution Losses

	Daily Losses (m³/d)	% Time System Pressurised	Annual Losses m³/yr	Predicted Annual Reduction in Distribution Losses
Present Situation	39.5	100.0%	14409	8381 m³/yr
Proposed Option 1	16.5	100.0%	6028	
Saving	23.0		8381	

Correction for Predicted change in pressure dependent consumption after the point of metering

	Residential Consumption				Non-residential Consumption				Predicted Annual Reduction in Consumption
	N1= 0.5				N1= 0.5				
	Total (m³/d)	% of Total	(m³/d)	(m³/yr)	Total (m³/d)	% of Total	(m³/d)	(m³/yr)	
Present	57.76	10.0%	5.78	2108	0.00	0.0%	0.00	0	742 m³/yr
Option 1	55.72		3.74	1366	0.00		0.00	0	
Saving	2.03		2.03	742	0.00		0.00	0	

Summary of Predicted Annual Savings arising from Implementation of Option 1

Predicted Annual Reduction in Total Inflow	9123 m³/yr
Estimated saving derived from reducing total inflow, if inflow is valued at 2.20 R/m³	20071 Rand/yr
Estimated loss of metered income due to reduction in consumption, if consumption is valued at 0.00 R/m³	0 Rand/yr
Net Saving	20071 Rand/yr
If the assumed value of N1 = 1.00	
and the cost of Implementing Option1 = 7182.0 Rand	
Payback Period	4.3 months

C.5. Prediction of the effect of a time modulated PRV.

Prediction of the Effect of Time Modulated PRV on Losses and Payback Period

Proposed Method of Controlling Sector Inlet Pressure **Time Modulated PRV**

Do you want a correction for changes in headloss? **Yes**

Assumed value of N1 **1.00**

Time of Day	Present Inlet Pressure	Proposed Time Modulated PRV Downstream Pressure	Predicted Pressure at		Predicted Headloss between		Total Inflow to Distribution Sector		Distribution Losses (influenced by pressure)	Components of Consumption (assumed to be independent of pressure)	
			AZP Point	Critical Point	Time Modulated PRV & AZP Point	Time Modulated PRV & Critical Point	l/s	m ³ /hr			
hr	m	m	m	m	m	m			m ³ /hr	m ³ /hr	
00 to 01	86.0	20.0	28.6	20.0	1.4	0.0	0.59	2.14	0.52	1.63	
01 to 02	86.0	20.0	28.7	20.0	1.3	0.0	0.54	1.94	0.52	1.43	
02 to 03	86.0	20.0	28.7	20.0	1.3	0.0	0.54	1.94	0.52	1.43	
03 to 04	86.0	20.0	28.7	20.0	1.3	0.0	0.54	1.94	0.52	1.43	
04 to 05	86.0	20.0	28.5	20.0	1.5	0.0	0.65	2.34	0.51	1.83	
05 to 06	85.0	50.0	57.7	50.0	2.3	0.0	0.99	3.58	1.04	2.54	
06 to 07	83.0	50.0	58.7	50.0	1.3	0.0	1.20	4.31	1.06	3.25	
07 to 08	82.0	50.0	58.1	50.0	1.9	0.0	1.20	4.33	1.05	3.28	
08 to 09	83.0	50.0	57.3	50.0	2.7	0.0	1.53	5.51	1.03	4.48	
09 to 10	83.0	50.0	57.1	50.0	2.9	0.0	1.37	4.91	1.03	3.88	
10 to 11	82.0	50.0	56.8	50.0	3.2	0.0	1.40	5.03	1.03	4.01	
11 to 12	84.0	50.0	56.9	50.0	3.1	0.0	1.22	4.40	1.03	3.37	
12 to 13	83.0	50.0	58.2	50.0	1.8	0.0	1.14	4.11	1.05	3.06	
13 to 14	83.0	50.0	58.4	50.0	1.6	0.0	1.31	4.71	1.06	3.65	
14 to 15	84.0	50.0	57.5	50.0	2.5	0.0	1.19	4.30	1.04	3.26	
15 to 16	85.0	50.0	55.5	50.0	4.5	0.0	1.16	4.19	1.00	3.19	
16 to 17	85.0	50.0	57.2	50.0	2.8	0.0	0.77	2.79	1.03	1.76	
17 to 18	85.0	50.0	57.7	50.0	2.3	0.0	0.83	2.98	1.04	1.94	
18 to 19	84.0	50.0	57.9	50.0	2.1	0.0	0.78	2.80	1.05	1.76	
19 to 20	85.0	50.0	57.5	50.0	2.5	0.0	0.69	2.49	1.04	1.45	
20 to 21	86.0	20.0	28.1	20.0	1.9	0.0	0.54	1.96	0.51	1.45	
21 to 22	85.0	20.0	28.8	20.0	1.2	0.0	0.52	1.86	0.52	1.34	
22 to 23	85.0	20.0	28.9	20.0	1.1	0.0	0.49	1.76	0.52	1.24	
23 to 24	85.0	20.0	28.9	20.0	1.1	0.0	0.46	1.66	0.52	1.14	
Average	84.5	38.8	46.7	38.8	2.1	0.0	0.90	3.25	0.84	2.41	
Maximum	86.0	50.0	28.7	50.0	4.5	0.0	1.53	5.51	1.06	4.48	
Minimum	82.0	20.0	28.1	20.0	1.1	0.0	0.46	1.66	0.51	1.14	
Daily Totals (m ³ /day)							77.99	20.23	57.76		
Night-Day Factor for Distribution Losses influenced by pressure for Time Modulated PRV option									39.08	hr/d	

Predicted Annual Reduction in Distribution Losses

	Daily Losses (m ³ /d)	% Time System Pressurised	Annual Losses (m ³ /yr)	Predicted Annual Reduction in Distribution Losses (m ³ /yr)
Present Situation	39.5	100.0%	14409	7025
Proposed Option 1	20.2	100.0%	7384	
Saving	19.2		7025	

Correction for Predicted change in pressure dependent consumption after the point of metering

	Residential Consumption				Non-residential Consumption				Predicted Annual Reduction in Consumption (m ³ /yr)
	N1= 0.5		N1= 0.5		N1= 0.5		N1= 0.5		
	Total (m ³ /d)	% of Total	(m ³ /d)	(m ³ /yr)	Total (m ³ /d)	% of Total	(m ³ /d)	(m ³ /yr)	
Present	57.76	10.0%	5.78	2108	0.00	0.0%	0.00	0	525
Option 1	56.32		4.34	1583	0.00		0.00	0	
Saving	1.44		1.44	525	0.00		0.00	0	

Summary of Predicted Annual Savings arising from Implementation of Option 1

Predicted Annual Reduction in Total Inflow	7550 m ³ /yr
Estimated saving derived from reducing total inflow, if inflow is valued at 2.20 R/m ³	16609 Rand/yr
Estimated loss of metered income due to reduction in consumption, if consumption is valued at 0.00 R/m ³	0 Rand/yr
Net Saving	16609 Rand/yr
If the assumed value of N1 = 1.00	
and the cost of Implementing Option1 = 17017.0 Rand	Payback Period = 12.3 months

C.6. Post-installation pressure and flow results.

PRESSURE ANALYSIS : PRESSURE AND FLOW RESULTS

General

Name of Water Undertaking:	Mpophomeni WDM Project
Name of Service Delivery Centre:	uMgeni Municipality
Name of Water Supply Zone:	MC Area
Reference number:	Post installation

Pressure settings

	Source Name (Reservoir/Tower)	Source TWL (m)
Supply 1	Mpophomeni Reservoir	1180.0
Supply 2	Vulindela reservoir	1180.0
Supply 3		
Average		1180.0

	Address	Elevation (m)	Without PRV (m)	Existing Settings (m)	Proposed Settings (m)
Inlet 1	Stand 5833	1095.0	85.0	50.0	
Inlet 2					
Inlet 3					
Average		1095.0	85.0	50.0	
Critical Point	Stand 5833	1095.0	85.0	50.0	
Average Zone Point	Stand 5716	1085.0	95.0	51.0	
Low Point		1080.0	100.0	51.5	

The maximum night-time pressure was calculated in the above table

Pressure and flow data

Logged from: 2004/07/06 00:00 to 2004/07/06 23:00

Hour	Pressure				Flow	
	Inlet Point (m)	Lowest Point (m)	AZP (m)	Critical Point (m)	To zone (m ³ /hr)	To Zone (l/s)
0 - 1	5.1			5.1	1.6	0.4
1 - 2	5.1			5.1	1.6	0.5
2 - 3	5.1			5.1	1.8	0.5
3 - 4	5.1			5.1	1.8	0.5
4 - 5	5.1			5.1	1.8	0.5
5 - 6	5.1			5.1	2.0	0.5
6 - 7	5.1			5.1	2.2	0.6
7 - 8	5.1			5.1	2.8	0.8
8 - 9	5.1			5.1	3.0	0.8
9 - 10	5.1			5.1	3.7	1.0
10 - 11	5.1			5.1	5.3	1.5
11 - 12	5.1			5.1	4.3	1.2
12 - 13	5.1			5.1	3.7	1.0
13 - 14	5.1			5.1	4.5	1.2
14 - 15	5.1			5.1	4.1	1.1
15 - 16	5.1			5.1	5.1	1.4
16 - 17	5.1			5.1	3.3	0.9
17 - 18	5.1			5.1	3.8	1.0
18 - 19	5.1			5.1	3.6	1.0
19 - 20	5.1			5.1	2.2	0.6
20 - 21	5.1			5.1	2.4	0.7
21 - 22	5.1			5.1	2.0	0.6
22 - 23	5.1			5.1	1.6	0.5
23 - 0	5.1			5.1	1.4	0.4
Minimum	5.1	0.0	0.0	5.1	1.4	0.4
Maximum	5.1	0.0	0.0	5.1	5.3	1.5
Average	5.1	#DIV/0!	#DIV/0!	5.1	2.9	0.8
Total					69.3	m ³

Logged vs expected pressure variance 10% 0% 0% 10%

Day time average 3.8 m³/hr

Connections 162

Demand 13 m³/connection/month