Leakage Reduction through Pressure Management in South Africa

by

Willem Wegelin and Ronnie McKenzie

Concepts and Case Studies

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LEAKAGE REDUCTION THROUGH PRESSURE MANAGEMENT IN SOUTH AFRICA

Concepts and Case Studies

developed through

SOUTH AFRICAN WATER RESEARCH COMMISSION

By

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IMPORTANT

PREFACE

This document includes the results from eight pressure management pilot projects undertaken in South Africa, using the PRESMAC Pressure Management Program which has been developed for the South African Water Research Commission. The objectives of the report is :

- provide a brief background to the principles and types of pressure management;
- provide guidelines for the selection and implementation of suitable pressure management zones;
- demonstrate the savings that can be achieved through advanced pressure management through eight pilot studies undertaken throughout South Africa;
- demonstrate the use of the PRESMAC model to assess the potential savings that can be achieved through advanced pressure management.

The PRESMAC software is available directly from the Water Research Commission and further details can be obtained from the web site at: ***http://www.wrc.org.za.***

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TECHNICAL SUPPORT

The WRC does not provide technical support on the PRESMAC model and any questions or problems associated with the program should be directed to the model developers at ***ronniem@wrp.co.za*** or ***wrp@wrp.co.za.***

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LEAKAGE REDUCTION THROUGH PRESSURE MANAGEMENT IN SOUTH AFRICA

EXECUTIVE SUMMARY

Concepts of pressure management

Most water reticulation systems are designed to provide a minimum pressure at all points in the system throughout the day. This means that the minimum pressure occurs at some critical point in the system which is often either the highest point in the system or the point furthest from the supply.

Since most systems are designed to provide a set minimum pressure throughout the day, they are generally designed to meet this pressure requirement during periods of peak demand when the friction losses are at their highest and inlet pressures at their lowest. As a result of this design methodology, most systems experience higher pressures than necessary during the remaining non-peak demand periods. This is evident from the fact that in water reticulation systems burst pipes tend to occur most frequently during the late evening and early morning periods when system pressures are at their highest.

It is clear that if the excess pressure in a system can be reduced, then so too can the leakage, which in turn will save money. This is the basic philosophy governing pressure management in potable water distribution systems.

Although there is no simple solution to the complex problem of excess pressure in a water distribution system, considerable research and development has taken place over the past decade. This has resulted in the creation of various techniques and equipment that can help to control pressure and thus reduce leakage.

Background to the Project

The first time-modulated pressure controllers were installed in Mogale City (Krugersdorp) in 1997 with the biggest pressure management project undertaken to

date in Johannesburg (54 pressure reducing valve controllers). Although the technology is available and principles are understood, limited legitimate results are currently available with the result that few South African water services providers have sufficient confidence in the methodology to motivate and support the necessary capital investment. This report intends to address these issues as follows:

- provide a brief background to the principles and types of pressure management;
- provide guidelines for the selection and implementation of suitable pressure management zones;
- demonstrate the savings that can be achieved through advanced pressure management in eight pilot studies undertaken throughout South Africa; and
- demonstrate the use of the PRESMAC model to assess the potential savings that can be achieved through advanced pressure management.

The PRESMAC model makes only provision for fixed outlet and time modulated pressure management and for this reason no flow modulated pilot studies were included in this project.

Pilot areas

The following eight pilot projects were selected to illustrate the effects of pressure management in South Africa:

- City of Tswane (Pretoria) – Valhalla high level zone
- City of Tswane (Pretoria) – Meintjieskop
- Rand Water ODI – Slovoville (Mabopane)
- City of Johannesburg – Slovoville
- City of Johannesburg – Tshepisong
- City of Tygerberg – Zone C (Khayelitsha)
- City of Oostenberg - Wallacedene
- City of East London – Mdantsane PRV6

The selected zones do not necessarily represent zones with the highest level of losses, but rather represent a range of typical zones that can be expected in most water supply systems.

Methodology

Before undertaking any form of pressure management the water services provider must first gain a proper understanding and assessment of the selected zone. By following a systematic approach, the likely savings can be estimated and analysed before any major investment in time and/or equipment is made. Alternatively, if a "trial and error" approach is adopted, problems can be encountered and a negative perception of pressure management may occur. In order to commission a successful pressure management installation, the following seven steps are recommended:

- Step 1 : Selection of suitable pressure management zones
- Step 2 : Capture of basic information
- Step 3: Field investigations and retrofitting
- Step 4 : Logging of flows and pressures
- Step 5 : Analysis logging results
- Step 6 : Selection and installation of pressure controllers
- Step 7 : Monitoring and auditing of the results

Key findings from initial logging results

The key findings from the initial logging results are summarised as follows:

- The average zone pressure for the eight selected zones was 58m, with minimum and maximum values of 13m and 102m respectively. This is similar to the international norm of approximately 50m.
- Pressure reducing valves require regular maintenance and checking if they are to serve effectively in any water distribution system. Three of the existing seven PRV installations were not operational when the project commenced. This resulted in large water losses, excessive zone pressures and high frequency of burst pipes.
- Proper sizing of the meter and pressure-reducing valve should always be undertaken before any form of pressure management is implemented to ensure effective operation.
- The average minimum night flow to average daily demand relationship for the eight selected zones was found to be 66%, indicating a very high level of leakage in the pilot zones. A typical value of between 10% and 30% is expected for a well managed system in the South African environment. Internationally the norm for a well managed zone is between 10% and 20%.

Key findings from PRESMAC results

The reduction in inlet pressure and leakage are summarised in **Tables 1.1 and 1.2**.

Table 1.1 : Summary of inlet pressure and leakage reduction

Zone name	Inlet pressure (m) (1)			Minimum night flow (m^3/h)			N1 value
	Before	After	Reduction	Before	After	Reduction	
Valhalla	45	36	9	14	11	3	2.5
Meintjieskop	80	70	10	63	53	10	1.0
Slovoville (ODI)	83	20	63	42	9	33	2.0
Slovoville (Jhb)	100	34	66	34	11	23	1.3
Tshepisong	92	63	29	82	46	36	1.4
Wallacedene	47	20	27	83	52	31	1.0
Khayelitsha	44	21	23	321	180	141	0.8
Mdantsane	52	40	12	14	13	1	0.75
Average/Total	**68**	**38**	**30**	**653**	**375**	**278**	**1.3**

Notes:

(1) Inlet pressure at time of minimum night flow

Table 1.2 : Summary of reduction in zone inflow (m^3/annum)

Zone name	Inflow without pressure management	Reduced distribution losses	Reduced consumption	Total reduction	Inflow with pressure management
Valhalla	592 395	6 903	368	7 271	585 124
Meintjieskop	1 307 795	24 317	827	25 145	1 282 650
Slovoville (ODI)	439 460	192 051	4 455	196 506	242 954
Slovoville (Jhb)	361 715	127 690	4 257	131 947	229 768
Tshepisong	1 411 090	212 930	11 892	224 822	1 186 268
Wallacedene	1 133 453	58 832	2 101	60 934	1 072 519
Khayelitsha	3 295 220	202 864	-6 135	196 729	3 098 491
Mdantsane	191 625	4 698	81	4 780	186 845
Average	**8 732 753**	**830 285**	**17 846**	**848 134**	**7 884 619**

An average inlet pressure reduction of 10m in the Valhalla, Meintjieskop and Mdantsane zones resulted in leakage reduction of 14m^3/h. The pressures in these zones were already reduced to a large degree through the use of fixed outlet pressure reducing valves and no further reductions could be made without the use of time or flow modulated controllers. The leakage and pressures in these zones were already well managed, and there was limited scope for further improvement which is indicated by the modest savings achieved.

The leakage and pressures in Slovoville (ODI), Slovoville (Jhb), Tshepisong, Wallacedene and Khayelitsha, however, were found to be very high with considerable scope for improvement. A combined average inlet pressure reduction of 42m resulted in a combined leakage reduction of 264m^3/h. Fifty-three percent of this was achieved in Khayelitsha alone which had very high leakage levels and fluctuating pressures.

The influence of pressure management was also clearly evident from the sewer flow loggings undertaken in Khayelitsha. The sewer minimum night flow reduced by approximately 100m^3/h through the introduction of pressure management corresponding to the 141m^3/h reduction in minimum night flow.

Conclusion and Recommendations

It is clear from the eight pilot studies undertaken that pressure management is an effective measure of water demand management. In certain cases, pressure management is by far the most effective form of leakage control that can be undertaken. If implemented properly it can provide very significant and cost effective savings which are both immediate and sustainable. Pressure management has substantial benefits which include:

- improved level of service;
- reduced level of distribution network leakage;
- reduced level of domestic leakage in areas with poor internal plumbing;
- reduced consumption, beneficial in areas with low levels of cost recovery;
- reduced number of burst and subsequent disruption in the supply;
- reduced costs to the authority and customers; and
- increasing the working life of the water distribution system.

Pressure management can also have additional benefits, which are unfortunately not always easy to quantify and often excluded from the calculations. Additional benefits include :

- reduced capacity required of water treatment works;
- reduced capacity required of sewer treatment works; and
- by installing a pressure controller with an integral logger the benefit of constant monitoring is obtained. Through constant monitoring increases in the minimum night flow can be identified, bursts in the system, open zone valves and general performance of the controller.

It is therefore recommended that the systematic approach presented in this report, be followed when implementing pressure management in order to achieve greater successes and associated savings.

Basic considerations

Pressure management can be applied in any zone with varying success. When selecting a suitable zone, zones with one or more of the following characteristics tend to be the most suitable :

- zones with more than 1 000 properties;
- zones with fluctuating inlet pressures (supplied from rising main, bulk service provider, etc.);
- zones with fluctuating pressures at the critical point;
- zones with high minimum night flow to average daily demand (MNF/ADD) ratios (> 50%); and
- zones with no industrial use, high rise buildings with sprinkler fire systems, hospitals or other buildings which may be adversely effected by reduced pressures.

Implementing pressure management

When implementing pressure management the selected zone should have the following characteristics :

- the zone should be discrete with all zone valves closed. The desired savings through pressure management cannot be achieved if the zone is not discrete. It is recommended that all zone valves are properly marked and checked at regular intervals;
- a flow meter is required to calculate the volume of water entering the system and subsequent savings/losses. The meter must also be properly sized to measure the flow correctly, especially during low flow conditions;
- a pressure reducing valve is required the provide pressure control with the electronic pressure control device. Prior to the implementation of pressure control, the pressure-reducing valve should be checked to ensure that it is stable and properly sized. Oversized valves will be unstable at low flows, resulting in cavitation, pressure surges and destruction to the pipe work. It is recommended that a pro-active pressure reducing valve maintenance programme be implemented rather than a re-active programme.

Pressure management analysis

The PRESMAC model can be used with confidence to illustrate the potential savings that can be achieved through pressure management. The predicted savings calculated by the model will be conservative in most cases compared to the actual savings achieved. It is also recommended that the controller settings be optimised during the actual implementation to achieve maximum savings.

It should be noted that the results from the model are proportional to the quality of the information entered. It is recommended that basic information is checked carefully before use. In particular, the logging results should be checked for errors and be representative of a typical day.

Management and monitoring

As one of the key initiatives to reduce unaccounted-for water, it is essential that the pressure management installations perform as planned. The correct performance of the pressure management installations is critical in terms of:

- return on the capital investment;
- savings in reduced water losses; and
- future pressure management installations.

The management of the controller installations requires commitment and technical expertise, which can only be developed over time. Water Service Providers should invest in providing sufficient training and transfer of technology in the operation and maintenance of the pressure management zones and installations. It is recommended that training is provided in following aspects :

- system characterises and operation;
- controller operations and maintenance;
- basic principles of pressure management;
- night flow analysis;
- logging of pressures and flows;
- interpreting logging results; and
- meter and pressure reducing valve operation and maintenance.

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1. INTRODUCTION

1.1. GENERAL CONCEPTS OF PRESSURE MANAGEMENT

Most water reticulation systems are designed to provide a minimum pressure at all points in the system throughout the day. This basically means that the minimum pressure (normally specified in the local by-laws) occurs at some critical point in the system which is often either the highest point in the system or the point furthest from the supply.

As a result of the basic design methodology, most water distribution systems experience significant fluctuations in demand throughout the day with morning and evening peaks coupled with periods of low demand during the night and sometimes also during the early afternoons. Many systems also experience seasonal fluctuations caused by climatic factors that influence irrigation requirements or by holiday migration that can significantly influence the demand for periods of days or weeks at a time.

Since most systems are designed to provide a set minimum pressure throughout the day, they are generally designed to meet this pressure requirement during periods of peak demand when the friction losses are at their highest and inlet pressures at their lowest. As a result, most systems experience higher pressures than necessary during the remaining non-peak demand periods. This is evident from the fact that in most areas the major burst pipes tend to occur during the late evening and early morning periods when system pressures are at their highest.

This concept is shown graphically in **Figure 1.1** which represents a typical pressure situation for a zone at peak demand periods where the minimum pressure required is 20 m.

The same zone is shown again in **Figure 1.2** for periods of low demand, typically experienced during the late evening and early hours of the morning (assuming that the properties use direct feeds with little or no roof storage).

From **Figures 1.1 and 1.2** it can be appreciated that for most of the time the pressure in a water distribution system is likely to be considerably higher than required (unless some form of active pressure management has already been implemented). If it is also accepted that leakage increases with increased pressure, then it can be concluded that leakage levels in most systems are higher than they should be most of the time.

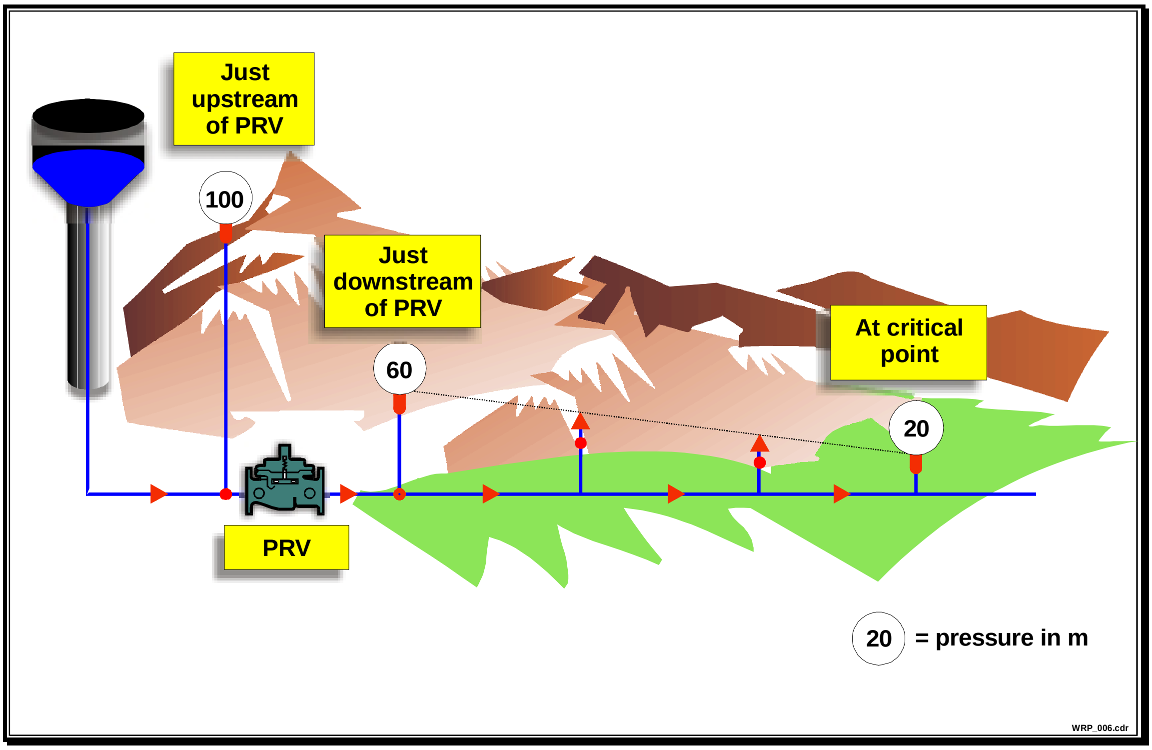


Figure 1.1 : Typical zone pressure distribution during peak demand periods

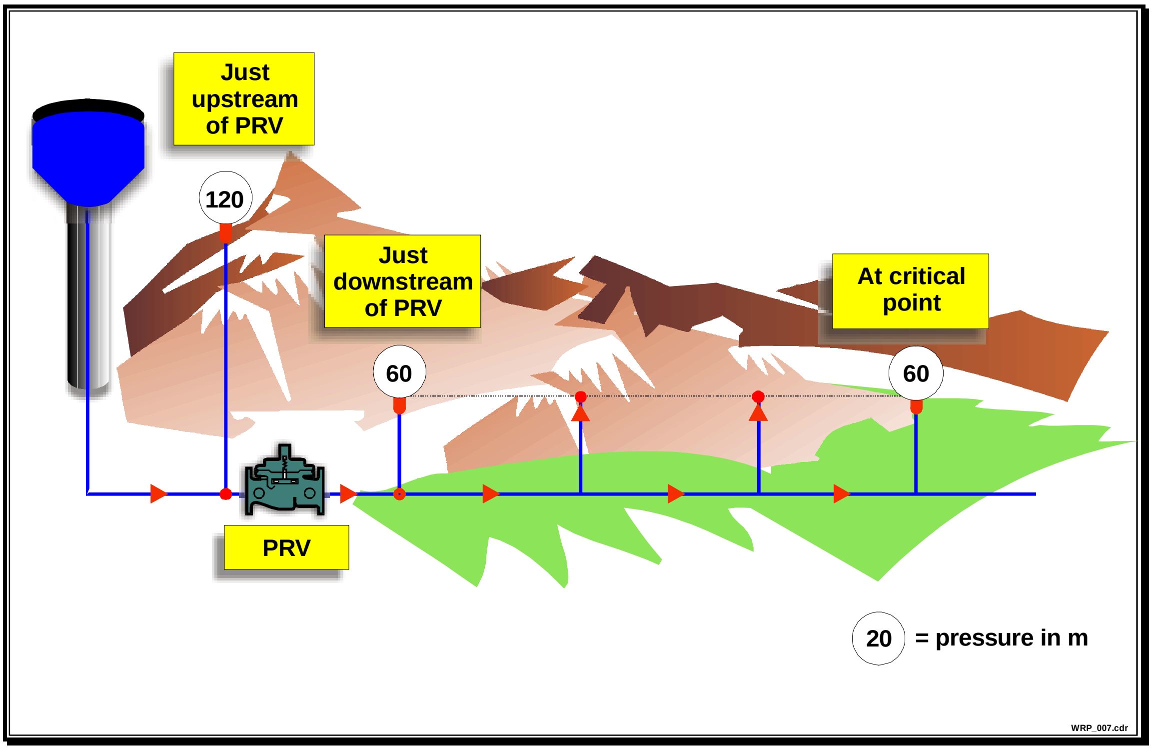


Figure 1.2 : Typical zone pressure distribution during low demand periods

It is clear that if the excess pressure in a system can be reduced, then so too can the leakage, which in turn will save water and money. This is the basic objective of pressure management in potable water distribution systems.

Although there is no simple solution to the complex problem of excess pressure in a water distribution system, considerable research has taken place over the past decade. This has resulted in the development of various techniques and equipment that can help to control pressure and thus reduce leakage.

There are several types of Pressure Reducing Valve (PRV) controllers available both electrically operated and hydraulically operated. For the purpose of the study, three possible forms of pressure control were considered of which the first two are incorporated into the PRESMAC Model (WRC, 2001)

- Fixed outlet PRV;
- Time-modulated PRV;
- Flow-modulated PRV.

1.2. CONCEPTS OF ACTIVE PRESSURE CONTROL

The main objective of active pressure control is to minimise the excess pressure in a water distribution system which in turn will reduce leakage as well as the frequency of burst pipes. This simple objective is often difficult to achieve in practice due to numerous external factors that must be taken into account such as fire-fighting requirements, high-rise buildings etc. In general, however, significant savings can often be made and there are many examples throughout the world (and now also in South Africa) where active pressure control has been extremely successful.

It should be noted that there is often a misconception that pressure control is aimed at reducing the levels of service to the consumer. While pressure management can be used with great success to reduce customer demand, this is generally not the primary objective. As mentioned previously, the main objective is to reduce the “excess pressure” in the water reticulation system during periods of low demand. If this can be achieved through proper and careful pressure management measures, it should be possible to reduce leakage and burst frequency without any detrimental effect to either the consumer or the fire-fighting services. Obviously there are numerous potential problems and pit-falls, however, through experienced planning it should be possible to overcome most of these.

The first option is simply a normal PRV which is used to provide a continuous pressure at the inlet to a zone as shown in **Figure 1.3**.

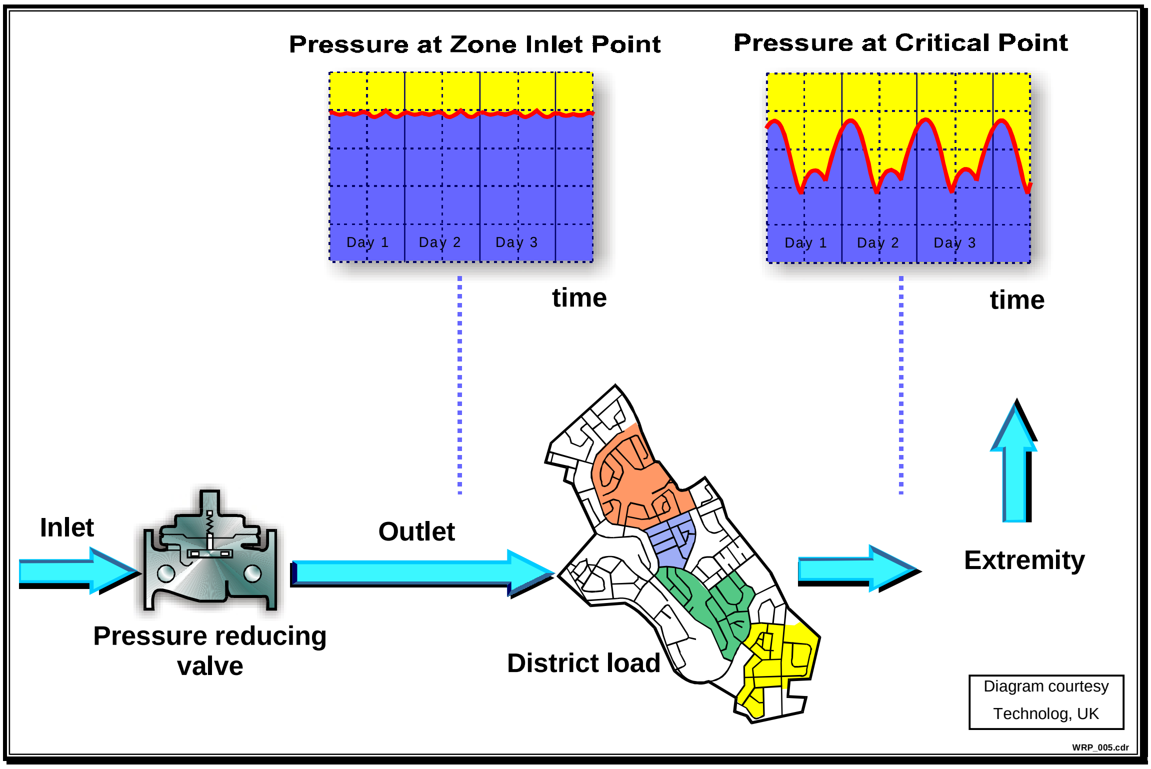


Figure 1.3 : Pressure control using conventional PRV

Time modulated controller

The time-modulated controller is the simplest form of Advanced Pressure Control and also the least expensive. It is basically a timing device that can be attached to the controlling pilot on any normal PRV to reduce the outlet pressure at certain times of the day. It is a very simple and compact device that can accommodate four switching periods each day and two pressure levels: a high level dictated by the PRV itself and a low level as set on the controller. This is a simple but effective method of reducing pressures in systems where there is some consistent pattern of demand on a daily basis. It is an ideal solution for reducing excessive pressures at night when most of the consumers are asleep and the demand for water is therefore minimal. In such cases the night-time pressure can often be reduced significantly without lowering the normal levels of service to the consumers.

Up to two time periods can be specified (see **Figure 1.4**) per day although in most cases only one is needed. A typical installation of a time-modulated controller is shown in **Figure 1.5** and the general objectives are shown in **Figure 1.6**.

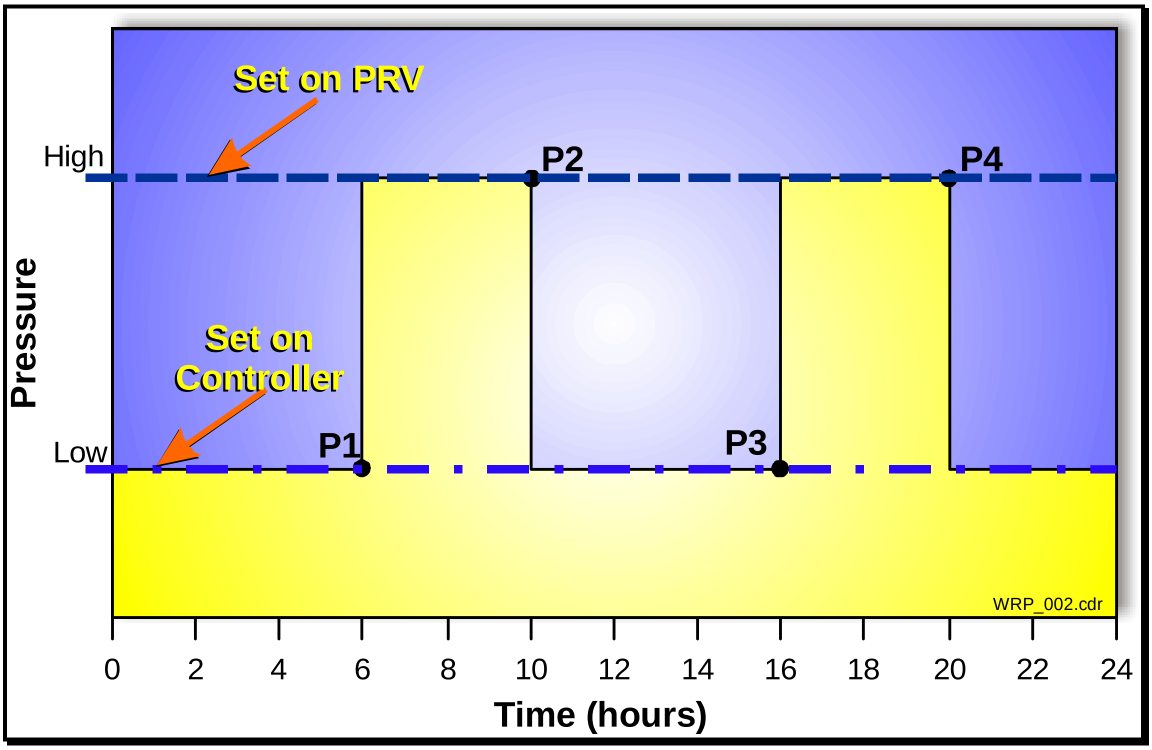


Figure 1.4 : Typical 4-point time modulated pressure profile

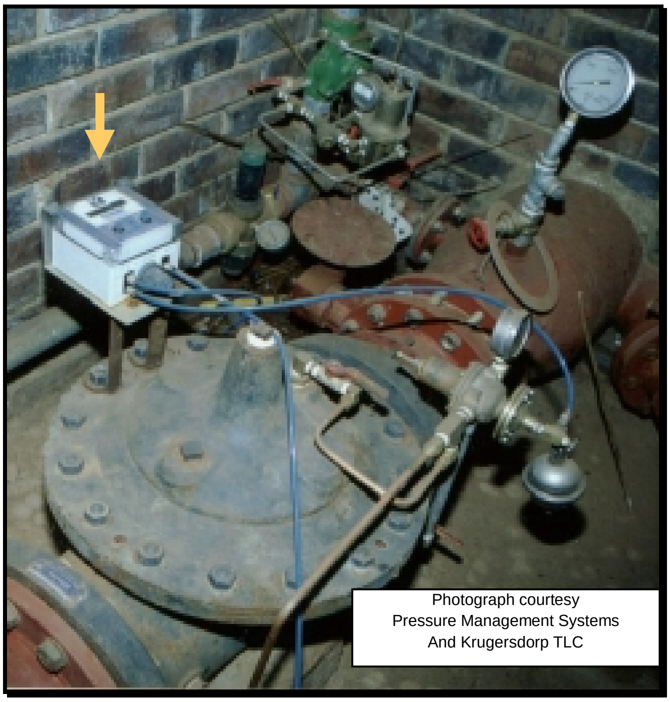


Figure 1.5 : Typical installation of a time-modulated PRV controller

It should be noted that the time-modulated controller shown in **Figure 1.5** (see arrow) is a simple and self-powered unit which can operate for approximately 5 years on a single battery. It is programmed through the use of two buttons on the fascia much in the same way as one sets a normal digital watch or alarm clock.

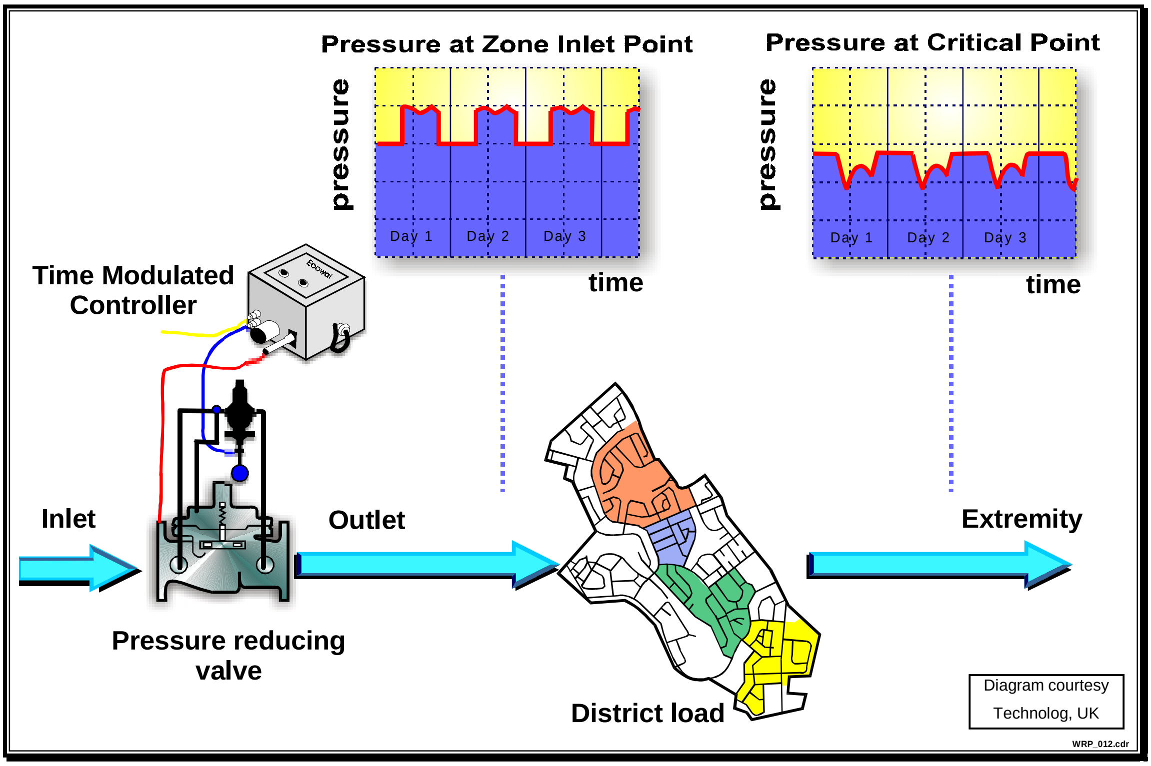


Figure 1.6 : Pressure control using a time-modulated PRV controller

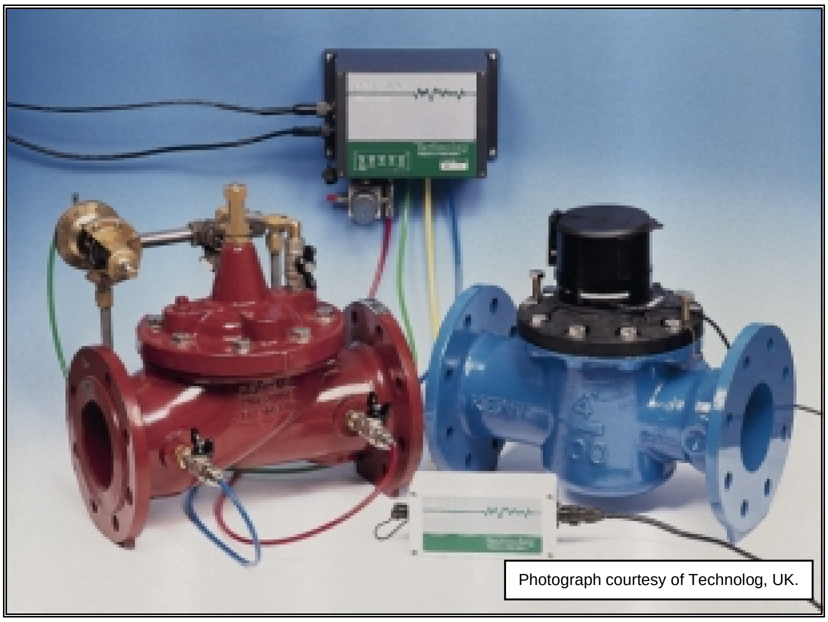
The main application of the time-modulated PRV is to reduce pressures during periods of low demand when the system pressures tend to be higher than necessary resulting in excessive pressures at the critical point. Through the use of such a controller it is possible to reduce some of the high-pressure peaks especially during night-time periods.

The main potential problem with the time-modulated controller concerns the fire-fighting requirements. The controller cannot react to an increase in demand caused by the opening of a fire hydrant with the result that there can be problems if a fire breaks out during the period of low pressure. In many parts of South Africa, however, it appears from discussions with various fire departments that this is not a problem since there are either no fire hydrants or they have been vandalised to the extent that they are inoperable. Under such conditions, the fire departments bring in their own water and do not try to use the fire hydrants even if they are available. Another limitation of the time-modulated controller is that the pressure difference between the high and low settings should ideally not exceed 20 m otherwise water hammer and/or cavitation may cause problems.

It should also be noted that some time-modulated controllers could also be operated in a flow control mode in which case the problem of fire-fighting flows can be overcome. In this mode, however, it is then necessary to make use of a property sized flow meter which can often be a problem issue. If the flow meter is available, it is often simpler and more reliable to make use of the more sophisticated flow modulated controller as discussed in the following section.

Flow Modulated Controller

The second and more complex controller is the flow-modulated controller which provides greater flexibility and control than that offered by the simpler time-modulated controller. Unfortunately the greater flexibility is accompanied by a higher cost and the flow-modulated controller is approximately double the cost of the time-modulated version. The typical components required for a flow-modulated PRV installation are shown in **Figure 1.7**.



Photograph courtesy of Technolog, UK.

Figure 1.7 : Components required for a flow modulated PRV installation

The flow-modulated controller will control the pressure at the inlet point in accordance with the demand being placed on the system. During peak demand periods, the maximum pressure as dictated by the PRV will be provided, while at low demand periods the pressure will be reduced to minimise excess pressure and the associated leakage. The concepts of the flow-modulated controller are shown in **Figure 1.8**.

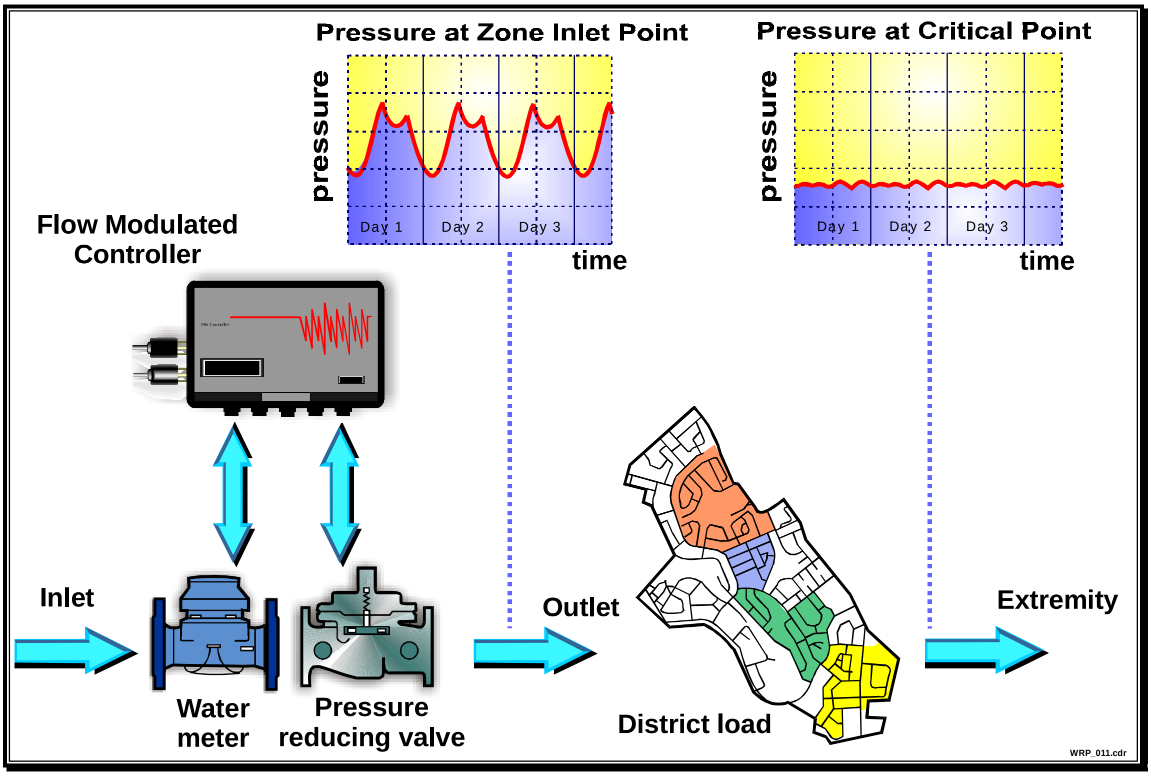


Figure 1.8 : Pressure control using a flow-modulated PRV controller

The flow-modulated controller can easily be equipped with a telephone or radio link to the critical point and in this manner the inlet pressure can be adjusted to ensure that there is virtually no excess pressure at the critical point at any time throughout the day. This will provide the most effective control possible (without reducing the size of the zone) and is depicted in **Figure 1.9**

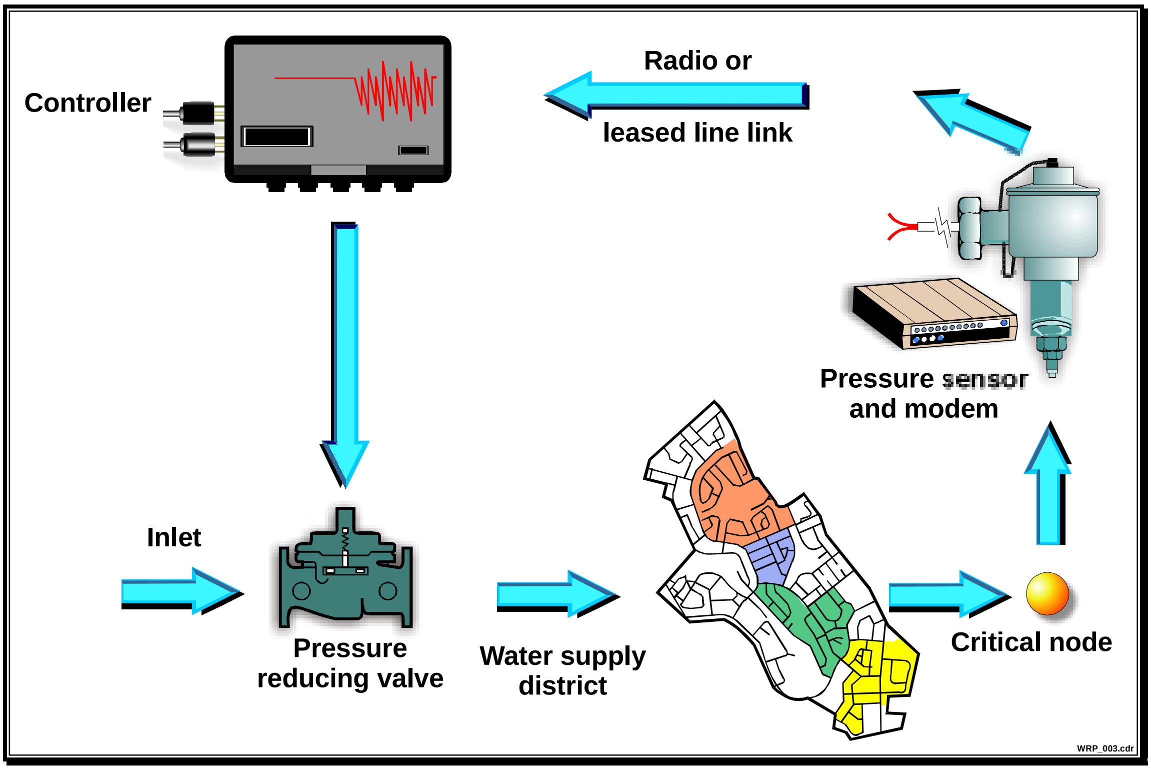


Figure 1.9 : Pressure control using telemetry linked flow-modulated PRV controller

1.3. THE PRESMAC MODEL

The PRESMAC Model is a simple and user friendly computer program developed through the WRC in order to promote the concepts of how pressure management can be used to reduce leakage in water distribution systems. The model is used to assess the likely savings (in monitory terms) of various pressure reduction options in a selected zone metered area. This approach allows the user of the program to gauge the potential for pressure management very quickly and effectively without undertaking a full detailed pipe network analysis. Although the methodology is based on a number of simplifications and assumptions, in practice the predicted savings are generally within 10% to 20% of those actually achieved (erring on the conservative side), which is well within the limits of accuracy needed to establish whether or not pressure management is a viable option.

1.4. STUDY OBJECTIVES

The first time-modulated pressure controllers were installed in Mogale City (Krugersdorp) in 1997 (personal communication: M Rabie) with the biggest pressure management project undertaken to date in Johannesburg (personal communication:

D Verrier). Although the technology is available and principles are understood, limited legitimate results are currently available. Consequently, very few South African water services providers currently have confidence in pressure management as water conservation method and are unsure of the outcome of the project which usually requires a high capital investment. This report intends to address these issues in the following manner:

- provide a brief background to the principles and types of pressure management;
- provide guidelines for the selection and implementation of suitable pressure management zones;
- demonstrate the savings that can be achieved through advanced pressure management by undertaking and documenting eight pilot studies in South Africa; and
- demonstrate the use of the PRESMAC model in assessing the potential savings that can be achieved through advanced pressure management.

It should be noted that the PRESMAC model currently provides for fixed outlet and time modulated pressure management and for this reason no flow modulated pilot studies were included in this project. The input data are captured on templates developed specifically for pressure management studies and are included in **Appendix A and Appendix B** while the results from the model are summarised in **Section 3**.

1.5. LAYOUT OF THIS REPORT

The report contains 4 sections and two appendices, as described below.

Section 1 : Introduction

This section describes the objectives of the study as well as general concepts and types of pressure management.

Section 2 : Methodology

This section describes the typical approach which will be followed for undertaking a pressure management study.

Section 3 : Results from the pressure management pilot studies

This section provides a summary of the selected zones, their basic information, logging results and the PRESMAC results.

Section 4 : Conclusions

This section provides comments on the feasibility of pressure management and criteria in selecting suitable zones.

Appendix A : Results from the pressure management pilot studies

This appendix provides the detailed results from the pressure management study. For each study area considered in the project the following information is provided:

- the basic zone information; and
- flow versus pressure comparative logging results.

Appendix B : Blank data capture forms

2. METHODOLOGY

The following methodology was used in the case studies, which is basically in accordance with the methodology described in the PRESMAC User Guide (WRC, 2001).

Before undertaking any form of pressure management the water services provider must first gain a proper understanding of the selected zone. By following a systematic approach, more realistic results are often obtained and quantified. Alternatively, if a "trial and error" approach is adopted, problems are likely to be encountered and a negative impression of pressure management may result. In order to achieve success, the following seven steps are recommended:

- Step 1: Selection of suitable pressure management zones
- Step 2: Capture of basic information
- Step 3: Field investigations and retrofitting
- Step 4: Logging of flows and pressures
- Step 5: Analysis of logging results
- Step 6: Selection and installation of pressure controllers
- Step 7: Monitoring and auditing of the results

Each step is discussed in detail in the remainder of **Section 2**.

2.1. STEP 1 : SELECTION OF PRESSURE MANAGEMENT ZONES

Most districts, sub-districts or zones are suitable to some extent for pressure management. Zones with the following characteristics will generally produce the greatest savings.

- **The zone should be discrete –** with all zone inflows metered and zone valves closed. Pressure management will not achieve the desired savings if the zone is not discrete.

  Most water service providers experience problems with discrete zones. Several of the zones analysed during the initial logging exercise were found to have cross-boundary connections with the result that they were not discrete.

- **The zone inflow should be metered –** and the meter should be functional. Effective metering is a pre-requisite for pressure management in order to undertake the pressure analysis and calculate the savings achieved. In the case of flow-modulated pressure control, it is essential that the meter is sized properly since the controller relies on the pulse from the meter to select the appropriate pressure.

- **The zone inflow should be controlled with a pressure-reducing valve** – and the valve should be functional and stable. Care should be taken to ensure that the pressure-reducing valve is correctly sized and operating within its design parameters. Oversized valves are unstable at low flows, resulting in cavitation, pressure surges, excessive noise and destruction of pipe work.

- **The size of the zone –** small zones tend to produce small savings whereas large zones tend to produce large savings. The main problem associated with large zones (2 000 to 10 000 properties), however, is that such zones are often very difficult to manage, due to multiple supplies (and control points) and non-uniform consumers. Small zones (less than 2000 properties) are easier to manage, often have a single supply (with a single control point) and have uniform consumers.

- **High leakage and high pressure zones –** often result in the greatest savings. Areas subjected to high pressures generally experience high burst frequencies and high levels of minimum night flow. Such zones are ideal pressure management zones and should be targeted first. Use of the SANFLOW model is recommended for analysing the minimum night flow (WRC, 1999).

- **Fire flow considerations –** the fire risk should be carefully assessed and discussed with the fire department. Industrial areas and areas with high-rise buildings should be avoided unless the authorities are certain of the influence and consequences.

- **Zones without strategic industries and/or special facilities -** in general it is best to avoid any zones with large or strategic industries as well as zones with hospitals and other buildings which may have special requirements with regards to water pressure. While pressure management can be introduced in such areas the risks outweigh the benefits. The risks of the pressure management activities being held responsible for any problems with the water system are high, despite the fact that they are most likely beneficial to the operation of the system.

2.2. STEP 2 : CAPTURE BASIC INFORMATION

A desktop study should be undertaken to obtain a complete understanding of the system. The information should be verified during field investigations and is required for use in the PRESMAC model (WRC, 2001). Some of the information required can often be obtained form a Geographic Information System (GIS). The basic information required include :

- length of mains;
- number of residential properties;
- number of non-residential properties;
- large non-residential users and their demands;
- number of connections;
- condition of the network;
- population; and
- pressure exponent for the system as a whole;

The following issues should also be verified during the field investigations:

- position, type and size of the flow meter(s);
- position, type and size of the pressure-reducing valve(s);
- zone valves and their addresses; and
- logging points and their elevation;

To assist the user, a basic information sheet has been developed and is included in **Appendix B**. Although not all the information listed on the sheet is required to run the PRESMAC model, it provides a better understanding of the system operation and condition.

2.3. STEP 3 : FIELD INVESTIGATIONS AND RETROFITTING

Field investigations and retrofitting are required prior to logging to ensure the zone is operating as expected. Typical problems that are identified during the field investigation include:

- meters are not operational or unsuitable for logging;
- zone valves are open or broken;
- cleaning and securing of chambers;
- hydrants are leaking, broken or require maintenance;
- pressure tapping points are required for logging; and
- minor plumbing required at household connections to undertake logging.

It is often found that the pressure-reducing valve is malfunctioning and is fully open. It is recommended that the zone be logged before setting the pressure-reducing valve in order to demonstrate the effect of the open PRV and the importance of proper maintenance.

Figure 2.1 : Valve chamber requiring cleaning and securing

2.4. STEP 4 : LOG FLOW AND PRESSURE

A 24-hour logging profile is required to undertake the PRESMAC analyses. Logging results at the following points are required:

- PRV downstream pressure/s;
- zone inflows;
- pressure at critical point;
- pressure at average zone point; and
- pressure at lowest point (alternative).

The average zone pressure is difficult to predict and in most cases the average between the critical and lowest point is used as the pressure at the average zone point.

It is recommended that logging is undertaken over a 7-day period to ensure varying daily demands and peak flows are taken into account.

Figure 2.2 : Pressure logger installation on a fire hydrant

2.5. STEP 5 : ANALYSE LOGGING RESULTS

On completion of **Steps 1 to 4**, the logging results can be analysed using the PRESMAC model. The use of the model is described in detail in the PRESMAC User Guide (WRC, 2001) and is not discussed further in this report.

2.6. STEP 6 : SELECTION AND INSTALLATION OF PRESSURE CONTROLLERS

Based on the analyses of the logging results, the PRESMAC model can be used to identify the most cost effective method of pressure management for the selected zone. It should be noted that pressure management is not feasible in all cases and can often result in very poor financial returns.

There are various types of pressure controllers on the market, each with it own merits. In selecting a pressure controller, the following should be taken into consideration :

- time or flow modulation control;
- ease of programmability;
- compatibility with existing meter and pressure reducing valve;
- battery or current power supply;
- technical support;
- robustness and security of the unit;
- integral logging facility for flow and/or downstream and/or upstream pressure;
- submersible design (IP68);
- fully open or fully closed failure mode;

- cost;
- remote communications (GSM, telemetry, radio, etc.); and
- programming/management software and hardware requirements.

2.7. STEP 7 : MONITORING

The correct performance of the pressure management installations is critical in terms of:

- return on the capital investment;
- savings in reduced water losses; and
- future pressure management installations.

It is recommended that a controller with an integral logger be installed to enable continuous monitoring. The logging data can then be downloaded on a monthly basis and checked against the design parameters. The management of the controller installations requires commitment and technical expertise, which can only be developed over time.

3. RESULTS FROM THE PILOT STUDY AREAS

3.1. SELECTION OF PILOT AREAS

The locality of the eight pilot studies is shown in **Figure 3.1** and summarised as follows :

- City of Tswane (Pretoria) – Valhalla high level zone
- City of Tswane (Pretoria) – Meintjieskop
- Rand Water ODI – Slovoville (Mabopane)
- City of Johannesburg – Slovoville
- City of Johannesburg – Tshepisong
- City of Tygerberg – Zone C (Khayelitsha)
- City of Oostenberg – Wallacedene
- City of East London – Mdantsane PRV6

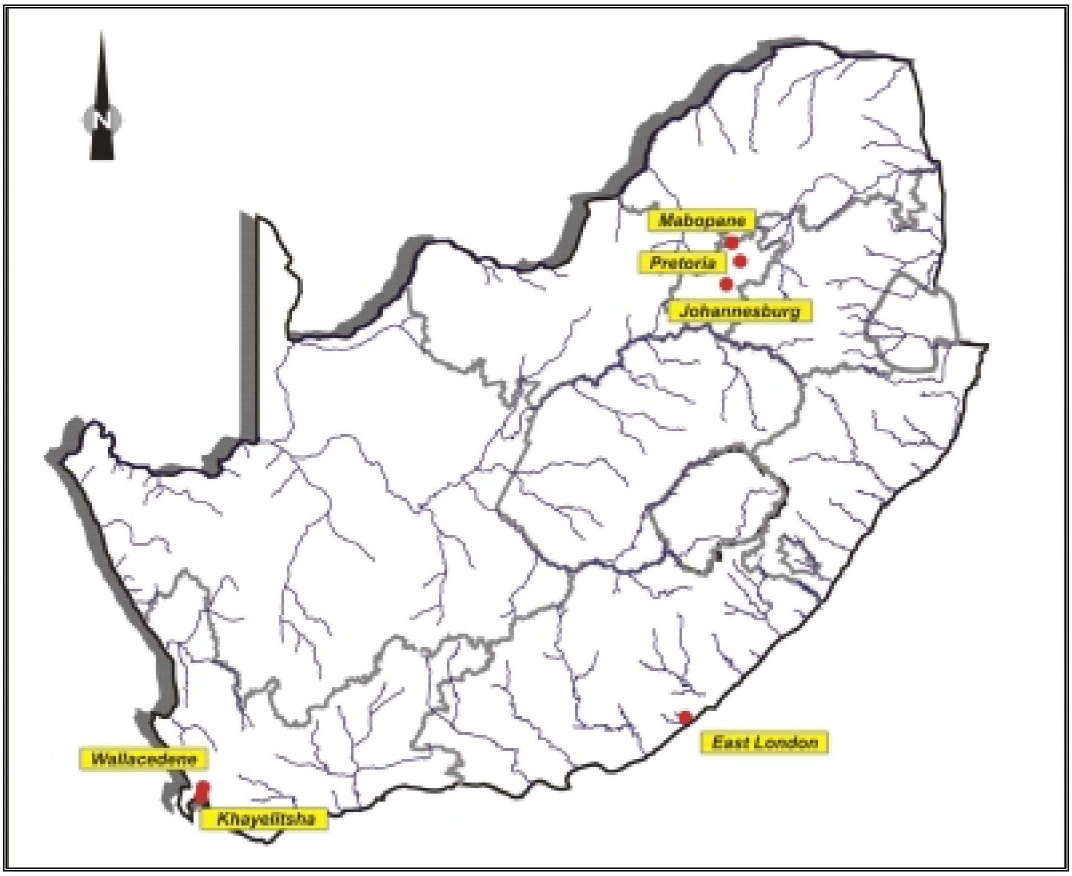


Figure 3.1 : Locality of pilot studies areas

The selected zones do not necessarily represent zones with the highest level of losses, but rather represent a range of typical zones that can be expected in most water supply systems. The existing PRESMAC model does not include flow-modulated analysis with the results only time–modulated control options were considered.

Details of the eight zones selected are summarised in the following paragraphs:

City of Tswane – Valhalla high-level zone

The Valhalla high-level zone is situated south of Thaba Tswane (Voortrekkerhoogte) supplying approximately 1 050 properties with a population of 4 300. The zone is supplied through two PRV's in series, directly from Rand Water bulk supply. The area is fully developed with an average consumption of 326 ℓ/head/day.

A time modulated controller was connected to the downstream PRV and the pressure was reduced from 45m to 36m between 22h30 and 05h00. The flow at the inlet and pressures at the critical point, lowest point, inlet point and average zone point were logged simultaneously.

City of Tswane – Meintjieskop

Meintjieskop PRV zone is situated north of the Union buildings and supplies approximately 1 250 properties with a population of 4 900. The zone is supplied through two PRV's in parallel from the Meintjieskop reservoir. The smaller PRV was closed for the duration of the study. The area is fully developed with an average consumption of 462 ℓ/head/day.

A time modulated controller was connected to the main supply and the pressure was reduced from 80m to 70m between 22h30 and 05h00. The flow at the inlet and pressures at the critical point, lowest point and inlet point and average zone point were logged simultaneously.

Rand Water ODI – Slovoville (Mabopane)

Slovoville is situated in the north-western corner of Mabopane and supplies approximately 1 900 properties with a population of 7 800. The zone has a single supply point and is fed from the Mabopane middle level reservoir. The area is a low cost housing area with an average consumption of 62 ℓ/head/day.

Initially the PRV was fully open and the inlet pressure increased to 83m at night. The PRV was set to 30m and a time-modulated controller was connected to the PRV. With the controller, the pressure was reduced to 20m between 22h30 and 05h00. The flow at the inlet and pressures at the critical point (also inlet point) and lowest point were logged simultaneously.

City of Johannesburg – Slovoville

Slovoville is situated in the west of Johannesburg and supplies approximately 1 600 properties with a population of 7 200. The zone has a single supply point from bulk supply mains feeding into a reservoir. The area is a low cost housing area with an average consumption of 60 ℓ/head/day.

Initially this zone had no PRV and the zone inlet pressure was generally in the order of 100m. A PRV was installed and set to 55m. A time-modulated controller was connected to the PRV and the pressure was further reduced to 35m between 22h30 and 05h00. The flow at the inlet and pressures at the critical point, lowest point and inlet point were logged simultaneously.

City of Johannesburg – Tshepisong

Tshepisong is situated in the west of Johannesburg, just north of Noordgesig, and supplies approximately 3 950 properties with a population of 19 800. The zone has two supply points from a Rand Water reservoir feed. The area is a low cost housing area with an average consumption of 120 ℓ/head/day.

Initially the PRV, on the one zone inlet, was not set and the inlet pressure increased to 93m. Both PRV's were set and the time-modulated controllers connected. The average inlet pressure was reduced from 73m to 63m between 22h30 and 05h00. The flow at the inlets and pressures at the critical point and inlet points (also lowest point) were logged simultaneously.

City of Oostenberg – Wallacedene

Wallacedene is situated north-east of Cape Town and supplies approximately 1 650 properties with a population of 8 400. The zone has a single supply point and is fed from the De Novo reservoir. The area is a low cost housing area with an average consumption of 178 ℓ/head/day.

Initially this zone had no PRV and the inlet pressure increased to 47m at night. A PRV was installed and a time-modulated controller connected. The inlet pressure was reduced from 35m to 20m between 22h30 and 05h00. The flow at the inlet and pressures at the critical point (also inlet point) and lowest point were logged simultaneously.

City of Tygerberg – Khayelitsha Zone C

Zone C is situated in the north-western corner of Khayelitsha and supplies approximately 3 725 properties. The zone has a single supply point and is fed through the Khayelitsha distribution network via the Blackheath reservoirs. The area is a low cost housing area with an average consumption of 180 ℓ/head/day.

A time-modulated controller was connected to the PRV and the pressure was reduced from 33m to 21m between 22h30 and 05h00. Since the zone is supplied via the Khayelitsha distribution network, friction losses in the system results in pressure problems during peak demand. The inlet pressure drops below the set PRV value with the result the PRV is fully open during peak demand.

Additionally to logging the pressures at the inlet point and critical point, both the potable water and sewer flows were logged.

City of East London - Mdantsane PRV6

Mdantsane PRV6 zone is situated approximately 20 km west of East London and supplies approximately 650 properties with a population of 3 240. The zone has a single supply point and is fed from a reservoir. The area is a low cost housing area with an average consumption of 76 ℓ/head/day.

A time modulated controller was connected to the main supply and the pressure was reduced from 52m to 40m between 22h30 and 05h00. The flow at the inlet and pressures at the critical point and lowest point were logged simultaneously.

3.2. SUMMARY OF BASIC INFORMATION

The basic information captured for each zone is detailed in **Appendix A**. The standard templates developed, can be used for similar projects, and provides a clear indication of the system operation, characteristics and condition. The basic information for the eight zones evaluated is summarised in **Tables 3.1** and **3.2**.

Table 3.1 : Summary of zone supply and demand conditions

Zone name	Number of supply points	Level of service	PRV condition
Valhalla	1	House connections – medium income	Set
Meintjieskop	1	House connections – medium income	Set
Slovoville (ODI)	1	House connections – low income	Open
Slovoville (Jhb)	1	House connections - low income	None
Tshepisong	2	House connections - low income	Set/Open
Wallacedene	1	House connections - low income	None
Khayelitsha	1	House connections - low income	Open
Mdantsane	1	House connections – low income	Set

Table 3.2 : Summary of zone basic information

Zone name	Number of properties	Number of connections	Length of mains (km)	Connection density (conn/km)	Population
Valhalla	1 013	1 013	31	33	4 300
Meintjieskop	1 239	1 239	28	44	4 900
Slovoville (ODI)	1 906	1 906	26	73	7 800
Slovoville (Jhb)	1 600	1 600	16	100	7 200
Tshepisong	3 947	3 947	39	101	19 800
Wallacedene	1 674	1 674	12	140	8 400
Khayelitsha	3 725	3 725	34	110	20 500
Mdantsane	648	648	10	65	3 240
Average	**1 750**	**1 750**	**22**	**80**	**8 460**
Total	**15 752**	**15 752**	**196**	**-**	**76 140**

From the initial field investigation, it was found that three of the existing seven PRV installations were not operational when the project commenced. Pressure reducing valves are mechanical devices, which require regular maintenance and checking if they are to serve effectively in any water distribution system. Pressure reducing valves operating ineffectively can result in large water losses, excessive zone pressures and increased frequency of burst pipes. It is important to ensure that the pressure zone is operating effectively at a fixed outlet pressure prior to installing a pressure controller.

It was also found during the initial field investigations that many zone boundary valves were open and the zones were not operating as intended. Zone valves should be clearly marked and only operated by authorised staff to ensure proper zone management. It is important to ensure that the selected pressure zone is discrete prior the implementing pressure management in order to obtain the desired control and quantify the savings achieved.

All of the selected zones have less than 2 000 properties except Tshepisong and Khayelitsha. It is therefore to be expected that the savings achieved will be relatively modest when compared to the savings that can be achieved from large zones. It should be noted that the purpose of the study was to demonstrate typical savings that can be expected in normal situations and not to create over optimisation and high expectations that can only be achieved in very specific circumstances.

3.3. SUMMARY OF INITIAL LOGGING RESULTS

The initial flow and pressure logging results are summarised in **Tables 3.3** and **3.4** respectively. Detailed graphs of the logging results are included in **Appendix A** for each pilot study.

Table 3.3 : Summary of initial flow loggings

Zone name	MNF (1) (m^3/h)	ADD (2) (m^3/h)	MNF/ADD (%)	ADD (ℓ/head/day)
Valhalla	14	68	21	326
Meintjieskop	63	149	42	462
Slovoville (ODI)	42	50	84	62
Slovoville (Jhb)	34	41	85	60
Tshepisong	82	161	51	120
Wallacedene	83	129	64	154
Khayelitsha	321	376	85	180
Mdantsane	14	22	65	76
Average	**82**	**125**	**66**	**180**
Total	**653**	**996**	**497**	**1 440**

Notes:
(1) MNF = Minimum night flow
(2) ADD = Average daily demand

As can be seen in **Table 3.3** the MNF/ADD relationship is very high for most of the zones indicating a high level of leakage in these zones. A typical value of between 20% and 40% is expected for a well managed system in the South African environment. Internationally the norm for a well managed zone is between 10% and 20%.

Table 3.4 : Summary of initial pressure loggings over a 24 hour period

Zone name	**Inlet pressure (m)**			**AZP (m)**			**Critical point (m)**		
	Min	**Avg**	**Max**	**Min**	**Avg**	**Max**	**Min**	**Avg**	**Max**
Valhalla	44	45	45	59	62	64	34	35	37
Meintjieskop	80	80	80	46	54	62	27	31	34
Slovoville (ODI)	59	71	83	76	89	102	59	71	83
Slovoville (Jhb)	83	92	102	66	76	90	56	68	84
Tshepisong	86	89	93	59	62	66	44	49	57
Wallacedene	32	39	47	38	45	52	32	39	47
Khayelitsha	18	33	44	13	29	43	6	25	41
Mdantsane	51	52	52	48	50	52	21	22	22
Minimum	**18**	**33**	**44**	**13**	**29**	**43**	**6**	**22**	**22**
Average	**57**	**63**	**68**	**51**	**58**	**66**	**35**	**43**	**51**
Maximum	**86**	**92**	**102**	**76**	**89**	**102**	**59**	**71**	**83**

Notes:
(1) AZP = Average zone pressure

The average daily demands (ADD) per property in Tshepisong, Wallacedene and Khayelitsha are very high considering the areas include mainly low cost housing units with no significant garden irrigation.

In Wallacedene, the zone does not have its own designated flow meter. The meter at the reservoir outlet was logged and the take-offs between the reservoir and zone inlet were subtracted. The take-offs could not be metered and an estimate was made.

Based on the flow logging results, it was found that most of the meters and pressure reducing valves were over-sized and operating outside their design specifications. Proper meter and pressure reducing valve sizing should always be undertaken before any form of pressure management is implemented to ensure effective operation.

As previously discussed in **Section 3.1**, the upstream pressure in Khayelitsha drops below the set PRV outlet pressure with the result that a fixed downstream pressure cannot be achieved. For the purposes of the analysis the average outlet pressure was used.

The fluctuating pressures at the critical point in Slovoville (ODI), Slovoville (Jhb), Tshepisong, Wallacedene and Khayelitsha between peak and off-peak demand periods make these zones ideal for pressure management. The effect of fixed outlet pressure management can also be seen in Valhalla, Meintjieskop and Mdantsane. The PRV's in these zones were set to provide stable pressures with little fluctuation.

3.4. SUMMARY OF PRESMAC RESULTS

The results from the PRESMAC model are summarised in **Tables 3.5** and **3.6**.

Table 3.5 : Summary of inlet pressure and leakage reduction

Zone name	Inlet pressure (m) (1)			Minimum night flow (m^3/h)			N1 value
	Before	After	Reduction	Before	After	Reduction	
Valhalla	45	36	9	14	11	3	2.2
Meintjieskop	80	70	10	63	53	10	0.8
Slovoville (ODI)	83	20	63	42	9	33	1.6
Slovoville (Jhb)	100	34	66	34	11	23	1.8
Tshepisong	92	63	29	82	46	36	1.3
Wallacedene	47	20	27	83	52	31	0.5
Khayelitsha	44	21	23	321	180	141	0.9
Mdantsane	52	40	12	14	13	1	0.4
Average/Total	**68**	**38**	**30**	**653**	**375**	**278**	**1.2**

Notes:

(1) Inlet pressure at time of minimum night flow

Table 3.6 : Summary of reduction in zone inflow (m^3/annum)

Zone name	Inflow without pressure management	Reduced distribution losses	Reduced consumption	Total reduction	Inflow with pressure management
Valhalla	592 395	6 219	368	6 586	585 809
Meintjieskop	1 307 795	19 970	823	20 793	1 287 002
Slovoville (ODI)	439 460	179 301	4 129	183 431	256 029
Slovoville (Jhb)	361 715	139 409	4 635	144 044	217 671
Tshepisong	1 411 090	202 423	11 858	214 281	1 196 809
Wallacedene	1 133 453	24 539	2 413	26 951	1 106 502
Khayelitsha	3 295 220	222 286	-6 355	215 931	3 079 289
Mdantsane	191 625	2 654	81	2 736	188 889
Average	**8 732 753**	**796 801**	**17 952**	**814 753**	**7 918 000**

The N1 value is based on a single step due to time and budget constraints. A more accurate N1 value would be obtained if the three-step pressure test is performed as discussed in the PRESMAC users guide (WRC, 2001).

An average inlet pressure reduction of 10m in the Valhalla, Meintjieskop and Mdantsane zones resulted in a 14m^3/h reduction in MNF. The fixed outlet pressure in these zones was already at the limit (to supply peak demand) and the additional savings could be achieved though the implementation of time-modulated pressure management. The leakage and pressures in these zones were well managed and there was relatively little benefit to be gained through further pressure management.

The leakage and pressures in Slovoville (ODI), Slovoville (Jhb), Tshepisong, Wallacedene and Khayelitsha, however, were not under control. An average inlet pressure reduction of 42m resulted in a leakage reduction of 264m^3/h. Fifty-three percent of this was achieved in Khayelitsha alone which has high leakage levels and fluctuating pressures. It should be noted that the Khayelitsha zone represents only a small portion of Khayelitsha and the remaining area was the subject of a full-scale pressure management project (completed in April 2002).

The effect of pressure management can also be seen on the sewer flow logging undertaken in Khayelitsha. The sewer minimum night flow reduced by approximately 100m^3/h through the introduction of pressure management. This indicates a high level of internal plumbing leakage which is to be expected in many low income areas (refer to graphs in **Appendix A**).

Through proper pressure control, the average annual zone inflow for the eight pilot zones was reduced by approximately 10%. The savings refer only to the reduction in background leakage and do not include savings achieved through the reduction in number of bursts. In many cases the burst savings can be as high (or higher) than those associated with the background leakage.

Although the inlet pressure was reduced by an average of 30m, all zones still had sufficient pressure at the critical point. An improved level of service was therefore provided through the reduced burst frequency.

3.5. PRESMAC VERSUS ACTUAL LOGGING RESULTS

In order to gain confidence in the use of the PRESMAC model the, values obtained by the model were compared with the actual logged values. The comparison is summarised in **Table 3.7.**

Table 3.7 : Modelled versus actual logging results

Zone name	MNF (m^3/h)		ADD (m^3/h)		Inlet point (m)		Critical point (m)	
	Model	Actual	Model	Actual	Model	Actual	Model	Actual
Valhalla	11	11	67	46	36	36	28	29
Meintjieskop	55	53	147	126	70	70	24	24
Slovoville (ODI)	12	9	30	27	20	21	20	21
Slovoville (Jhb)	9	11	25	29	35	35	17	31
Tshepisong	47	46	138	117	63	62	26	11
Wallacedene	75	52	127	110	20	20	20	20
Khayelitsha	171	180	351	306	21	21	19	12
Mdantsane	13	13	21	30	40	40	11	11
Average	**44**	**42**	**101**	**88**	**34**	**34**	**18**	**18**
Total	**393**	**375**	**906**	**791**	**305**	**305**	**165**	**159**

The 5% difference in the total minimum night flow between the model and actual results can be attributed to the error in the N1 value calculation. By following the three-step pressure test an accurate N1 value will be obtained resulting in better results. The correlation is less for the average daily demand since the demand pattern for a supply zone varies on a daily basis due to climate, seasonal and migration patterns. The actual demand is, however, 15% lower than the modelled demand confirming that the model errs to the conservative side.

The values predicted by the model are proportional to the input parameters and emphasis should be placed on obtaining accurate data. The PRESMAC model provides an accurate indication of the likely savings that can be achieved through the proposed pressure reduction. It is, however, recommended that the settings are optimised during the actual implementation. The SABS 0306 :1999 Code of Practice (SABS, 1999) suggests that in some areas, pressures can be reduced to as low as 15m and still deliver an adequate supply of water. The pressures in Slovoville (ODI), Slovoville(Jhb) and Wallacedene could therefore be reduced even further.

4. CONCLUSIONS AND RECOMMENDATIONS

It is clear from the eight pilot studies undertaken that pressure management is an effective measure of water demand management. Pressure management has substantial benefits which include:

- improved level of service;
- reduced level of distribution network leakage;
- reduced level of domestic leakage in areas with poor internal plumbing;
- reduced consumption, beneficial in areas with low levels of cost recovery;
- reduced number of bursts and subsequent disruption in the supply; and
- reduced costs to the authority and customers.

Pressure management can also have additional benefits, which are unfortunately not always easy to quantify and often excluded from the calculations. Additional benefits include :

- reduced capacity required of water treatment works;
- prolonged life of the water distribution system;
- reduced capacity required of sewer treatment works; and
- by installing a pressure controller with an integral logger the benefit of constant monitoring is obtained. Through constant monitoring increases in the minimum night flow can be identified, bursts in the system, open zone valves and general performance of the controller.

It is recommended that a systematic approach, as discussed in this report, be followed when implementing pressure management. This will in most cases result in greater successes and subsequent savings.

Basic considerations

Pressure management can be applied to all zones with varying success. In selecting a suitable zone, zones with the following characteristics tend to be the most suitable :

- zones with more than 1 000 properties;
- zones with fluctuating inlet pressures (supplied from rising main, bulk service provider, etc.);
- zones with fluctuating pressures at the critical point;
- zones with high MNF/ADD relationships (> 50%); and
- zones with no industrial use or high rise buildings with sprinkler fire systems.

Implementing pressure management

When implementing pressure management the selected zone should have the following characteristics :

- the zone must be discrete with all zone valves closed. The desired pressure management effect will not be achieved if the zone is not discrete. It is recommended that zone valves are properly marked and checked at regular intervals;
- a flow meter is required to calculate the volume of water entering the system and subsequent savings/losses. The meter must be properly sized to measure the flow correctly, especially during low flow conditions;
- a pressure reducing valve is required the provide pressure control with the electronic pressure control device. Prior to starting pressure control, it must be ensured that pressure-reducing valve is stable and properly sized. Oversized valves will be unstable at low flows, resulting in cavitation, pressure surges and destruction to the pipe work. It is recommended that a pro-active pressure reducing valve maintenance programme be developed as opposed to a re-active programme.

Pressure management analysis

The PRESMAC model can be used with confidence to illustrate the potential saving that can be achieved through pressure management. The predicted savings calculated by the model will in most cases be conservative compared to the actual savings achieved. It is also recommended that the controller settings be optimised during the actual implementation in order to achieve maximum results.

It should be noted that the results from the model are proportional to the quality of the information entered. It is recommended that basic information is checked and entered correctly. The logging results should be checked for errors and should be representative of a typical day.

Management and monitoring

As one of the key initiatives to reduce unaccounted-for water, it is essential that the pressure management installations operate as intended. The correct performance of the pressure management installations is critical in terms of:

- return on the capital investment;
- savings in reduced water losses; and
- future pressure management installations.

The management of the controller installations requires commitment and technical expertise, which can only be developed over time. It is often useful to continually monitor the performance of an installation through logging. If continuous logging is not possible then a programme of regular logging should be implemented where each installation is monitored at 6-monthly intervals. Water Service Providers should invest in providing sufficient training and transfer of technology in the operation and maintenance of the pressure management zones and installations. It is recommended that training is provided in following aspects :

- system characterises and operation;
- controller operations and maintenance;
- basic principles of pressure management;
- night flow analysis;
- logging of pressures and flows;
- interpreting logging results; and
- meter and pressure reducing valve operation and maintenance.

5. REFERENCES

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APPENDIX A

Results from the pressure management pilot studies

PRESSURE ANALYSIS : BASIC INFORMATION

General

Name of Water Undertaking: **City of Pretoria**
Name of Water Supply Zone: **Valhalla high level zone**
Reference number: **WRC 1**

Condition of distribution network

(tick appropriate box)

Material	uPVC	Steel	[✓ AC]	HDPE	Polypropylene
	mPVC	GRP	Concrete	Other (Specify)	
Age (Years)	0-5	5 to 10	10 to 20	[✓ 20 to 40]	40 +
Mains Losses	V. High	High	Average	Low	V Low
	100 l/km/hr	80 l/km/hr	[✓ 40 l/km/hr]	20 l/km/hr	10 l/km/hr
Mains burst frequency (number)		per week		per month		per annum
Connection losses	V. High	High	Average	Low	V Low
	10 l/conn/hr	6 l/conn/hr	[✓ 3 l/conn/hr]	2 l/conn/hr	1 l/conn/hr
Connection repair frequency (number)		per week		per month		per annum
Property losses (installations)	V. High	High	Average	Low	V Low
	100 l/prop/hr	5 l/prop/hr	[✓ 1 l/prop/hr]	0.5 l/prop/hr	0.1 l/prop/hr
Illegal connections	V. High	High	Average	Low	[✓ V Low]
Type of housing	Affluent	High Income	[✓ Med Income]	Low Income	Informal

Basic information

Length of mains(km)	30.82
Number of connections	1 500
Number of properties	1 500
Estimated population	6 000

Water use

	%
Urban	98
Industrial	0
Commercial	2
Other	0

Small non-domestic night users

Number: 0
Average use: 0 litres/hour

Large non-domestic night users

Total use: 0 m^3/h

PRV & Flow meter characteristics

PRV details

	Make	Model	Size (mm)
Inlet 1	2 x Cla-val	90-G	150
Inlet 2			
Inlet 3			

Flow Meter

	Make	Model	Size (mm)
Inlet 1	Meinecke	WP	150
Inlet 2			
Inlet 3			
Outlet 1			
Outlet 2			

Zone Boundary Conditions

Condition	Address	Comments

PRESSURE ANALYSIS : BASIC INFORMATION

General

Name of Water Undertaking: **City of Pretoria**
Name of Water Supply Zone: **Meintjieskop**
Reference number: **WRC 2**

Condition of distribution network

(tick appropriate box)

Material	[✓ uPVC]	Steel	[✓ AC]	HDPE	Polypropylene
	mPVC	GRP	Concrete	Other (Specify)	
Age (Years)	0-5	5 to 10	10 to 20	20 to 40	[✓ 40 <]
Mains Losses	V. High	High	Average	Low	V Low
	100 l/km/hr	80 l/km/hr	[✓ 40 l/km/hr]	20 l/km/hr	10 l/km/hr
Mains burst frequency (number)		per week		per month	per annum
Connection losses	V. High	High	Average	Low	V Low
	10 l/conn/hr	6 l/conn/hr	[✓ 3 l/conn/hr]	2 l/conn/hr	1 l/conn/hr
Connection repair frequency (number)		per week		per month	per annum
Property losses (installations)	V. High	High	Average	Low	V Low
	100 l/prop/hr	5 l/prop/hr	[✓ 1 l/prop/hr]	0.5 l/prop/hr	0.1 l/prop/hr
Illegal connections	V. High	High	Average	Low	[✓ V Low]
Type of housing	Affluent	High Income	[✓ Med Income]	Low Income	Informal

Basic information

Length of mains(km)	28.38
Number of connections	1 239
Number of properties	1 239
Estimated population	4 900

Water use

	%
Urban	100
Industrial	0
Commercial	0
Other	0

Small non-domestic night users

Number: 0
Average use: 0 litres/hour

Large non-domestic night users

Total use: 0 m^3/h

PRV & Flow meter characteristics

PRV details

	Make	Model	Size (mm)
Inlet 1	Claval	90-G01	50
Inlet 2	Claval	90-G01	200
Inlet 2 (bypass)	Claval	90-G01	100

Flow Meter

	Make	Model	Size (mm)
Inlet 1	Meinecke	WPD	200
Inlet 2			
Inlet 3			
Outlet 1			
Outlet 2			

Zone Boundary Conditions

Condition	Address	Comments
PRV	Stand R155, cnr Soutpansberg Ave & Parker Str	
C&P	Stand 1/1403, Twenty-eight Ave	
C&P	Stand R/1401, Twenty-seventh Ave	
C&P	Stand 1/1399, Twenty-sixth Ave	
C&P	Stand 1/1397, Twenty-fifth Ave	
???	Stand 6/2146, Eighteenth Ave & Momberg Str	
C&P	Stand 12, cnr Bodel Str & Fifteenth Ave	
CV	Stand R/18, cnr Chaimberlain Str & Fourteenth Ave	

PRESSURE ANALYSIS : BASIC INFORMATION

General

Name of Water Undertaking: **Rand Water ODI**
Name of Water Supply Zone: **Slovoville (Mabopane)**
Reference number: **WRC 3**

Condition of distribution network

(tick appropriate box)

Material	[✓ uPVC]	Steel	AC	HDPE	Polypropylene
	mPVC	GRP	Concrete	Other (Specify)	
Age (Years)	0-5	[✓ 5 to 10]	10 to 20	20 to 40	40 +
Mains Losses	V. High	High	Average	Low	V Low
	100 l/km/hr	80 l/km/hr	[✓ 40 l/km/hr]	20 l/km/hr	10 l/km/hr
Mains burst frequency (number)		per week		per month	per annum
Connection losses	V. High	High	Average	Low	V Low
	10 l/conn/hr	6 l/conn/hr	[✓ 3 l/conn/hr]	2 l/conn/hr	1 l/conn/hr
Connection repair frequency (number)		per week		per month	per annum
Property losses	V. High	High	Average	Low	V Low
(installations)	100 l/prop/hr	5 l/prop/hr	[✓ 1 l/prop/hr]	0.5 l/prop/hr	0.1 l/prop/hr
Illegal connections	V. High	High	Average	[✓ Low]	V Low
Type of housing	Affluent	High Income	Med Income	[✓ Low Income]	Informal

Basic information

Length of mains(km)	26.18
Number of connections	1 906
Number of properties	1 559
Estimated population	7 795

Water use

	%
Urban	82
Industrial	0
Commercial	18
Other	0

Small non-domestic night users

Number	0	
Average use	0	litres/hour

Large non-domestic night users

Total use	0	m^3/h

PRV & Flow meter characteristics

PRV details

	Make	Model	Size (mm)
Inlet 1	Bermad		150
Inlet 2			
Inlet 2 (bypass)			

Flow Meter

	Make	Model	Size (mm)
Inlet 1	Meinecke	WP	300
Inlet 2			
Inlet 3			
Outlet 1			
Outlet 2			

Zone Boundary Conditions

Condition	Address	Comments

PRESSURE ANALYSIS : BASIC INFORMATION

General

Name of Water Undertaking: **City of Johannesburg**
Name of Water Supply Zone: **Slovoville**
Reference number: **WRC 4**

Condition of distribution network

(tick appropriate box)

Material	[✓ uPVC]	Steel	AC	HDPE	Polypropylene
	mPVC	GRP	Concrete	Other (Specify)	
Age (Years)	0-5	[✓ 5 to 10]	10 to 20	20 to 40	40 +
Mains Losses	V. High	High	Average	Low	V Low
	100 l/km/hr	80 l/km/hr	[✓ 40 l/km/hr]	20 l/km/hr	10 l/km/hr
Connection losses	V. High	High	Average	Low	V Low
	10 l/conn/hr	6 l/conn/hr	[✓ 3 l/conn/hr]	2 l/conn/hr	1 l/conn/hr
Property losses (installations)	V. High	High	Average	Low	V Low
	100 l/prop/hr	5 l/prop/hr	[✓ 1 l/prop/hr]	0.5 l/prop/hr	0.1 l/prop/hr
Illegal connections	V. High	High	Average	[✓ Low]	V Low
Type of housing	Affluent	High Income	Med Income	[✓ Low Income]	[✓ Informal]

Mains burst frequency (number)		per week		per month	213	per annum
Connection repair frequency (number)		per week		per month	213	per annum

Basic information

Length of mains(km)	16.18
Number of connections	1 600
Number of properties	1 600
Estimated population	7 200

Water use

	%
Urban	100
Industrial	0
Commercial	0
Other	0

Small non-domestic night users

Number	0	
Average use	0	litres/hour

Large non-domestic night users

Total use	0	m^3/h

PRV & Flow meter characteristics

PRV details

	Make	Model	Size (mm)
Inlet 1	Clayton	90G-01	100
Inlet 2			
Inlet 3			

Flow Meter

	Make	Model	Size (mm)
Inlet 1	Meinecke	WS	150
Inlet 2			
Inlet 3			
Outlet 1			
Outlet 2			

Zone Boundary Conditions

Condition	Address	Comments

PRESSURE ANALYSIS : BASIC INFORMATION

General

Name of Water Undertaking: **City of Johannesburg**
Name of Water Supply Zone: **Tshepisong**
Reference number: **WRC 5**

Condition of distribution network

(tick appropriate box)

Material	[✓ uPVC]	Steel	AC	HDPE	Polypropylene	
	mPVC	GRP	Concrete	Other (Specify)		
Age (Years)	0-5	[✓ 5 to 10]	10 to 20	20 to 40	40 +	
Mains Losses	V. High	High	Average	Low	V Low	
	100 l/km/hr	80 l/km/hr	[✓ 40 l/km/hr]	20 l/km/hr	10 l/km/hr	
Mains burst frequency (number)		per week		per month	213	per annum
Connection losses	V. High	High	Average	Low	V Low	
	10 l/conn/hr	6 l/conn/hr	[✓ 3 l/conn/hr]	2 l/conn/hr	1 l/conn/hr	
Connection repair frequency (number)		per week		per month	213	per annum
Property losses	V. High	High	Average	Low	V Low	
(installations)	100 l/prop/hr	5 l/prop/hr	[✓ 1 l/prop/hr]	0.5 l/prop/hr	0.1 l/prop/hr	
Illegal connections	V. High	High	Average	[✓ Low]	V Low	
Type of housing	Affluent	High Income	Med Income	[✓ Low Income]	[✓ Informal]	

Basic information

Length of mains(km)	39.04
Number of connections	5 947
Number of properties	5 947
Estimated population	29 255

Water use

	%
Urban	100
Industrial	0
Commercial	0
Other	0

Small non-domestic night users

Number	0	
Average use	0	litres/hour

Large non-domestic night users

Total use	0	m^3/h

PRV & Flow meter characteristics

PRV details

	Make	Model	Size (mm)
Inlet 1	Roll Seal	790-01	150
Inlet 2	Roll Seal	790-01	150
Inlet 3			

Flow Meter

	Make	Model	Size (mm)
Inlet 1	Meinecke	WP	150
Inlet 2	Meinecke	WP	150
Inlet 3			
Outlet 1			
Outlet 2			

Zone Boundary Conditions

Condition	Address	Comments

PRESSURE ANALYSIS : BASIC INFORMATION

General

Name of Water Undertaking: **City of Oostenberg**
Name of Water Supply Zone: **Wallacedene**
Reference number: **WRC 6**

Condition of distribution network

(tick appropriate box)

Material	uPVC	Steel	AC	HDPE	Polypropylene
	mPVC	GRP	Concrete	Other (Specify)	
Age (Years)	0-5	5 to 10	10 to 20	20 to 40	40 +
Mains Losses	V. High	High	Average	Low	V Low
	100 l/km/hr	80 l/km/hr	[✓ 40 l/km/hr]	20 l/km/hr	10 l/km/hr
Connection losses	V. High	High	Average	Low	V Low
	10 l/conn/hr	6 l/conn/hr	[✓ 3 l/conn/hr]	2 l/conn/hr	1 l/conn/hr
Property losses (installations)	V. High	High	Average	Low	V Low
	100 l/prop/hr	5 l/prop/hr	[✓ 1 l/prop/hr]	0.5 l/prop/hr	0.1 l/prop/hr
Illegal connections	V. High	High	Average	[✓ Low]	V Low
Type of housing	Affluent	High Income	Med Income	[✓ Low Income]	Informal

Mains burst frequency (number) ____ per week ____ per month ____ per annum

Connection repair frequency (number) ____ per week ____ per month ____ per annum

Basic information

Length of mains(km)	12.49
Number of connections	7 600
Number of properties	7 600
Estimated population	27 000

Water use

	%
Urban	88
Industrial	0
Commercial	12
Other	0

Small non-domestic night users

Number 0
Average use 0 litres/hour

Large non-domestic night users

Total use 0 m^3/h

PRV & Flow meter characteristics

PRV details

	Make	Model	Size (mm)
Inlet 1	Bermad	720	200
Inlet 2			
Inlet 3			

Flow Meter

	Make	Model	Size (mm)
Inlet 1	Meinecke	WP	
Inlet 2			
Inlet 3			
Outlet 1			
Outlet 2			

Zone Boundary Conditions

Condition	Address	Comments
PRV	Stand 14018, La Boheme Rd	
CV	Stand 14455, Boesak Rd	
CV	Stand 13031, cnr Swelleni Str & Botfontein Rd	
CV	Stand 13037, cnr La Boheme Rd & Botfontein Rd	

PRESSURE ANALYSIS : BASIC INFORMATION

General

Name of Water Undertaking: **City of Tygerberg**
Name of Water Supply Zone: **Khayelitsha - Zone C**
Reference number: **WRC 7**

Condition of distribution network

(tick appropriate box)

Material	[✓ uPVC]	Steel	AC	HDPE	Polypropylene
	mPVC	GRP	Concrete	Other (Specify)	
Age (Years)	0-5	5 to 10	10 to 20	20 to 40	40 +
Mains Losses	V. High	High	Average	Low	V Low
	100 l/km/hr	80 l/km/hr	[✓ 40 l/km/hr]	20 l/km/hr	10 l/km/hr
Connection losses	V. High	High	Average	Low	V Low
	10 l/conn/hr	6 l/conn/hr	[✓ 3 l/conn/hr]	2 l/conn/hr	1 l/conn/hr
Property losses (installations)	V. High	High	Average	Low	V Low
	100 l/prop/hr	5 l/prop/hr	[✓ 1 l/prop/hr]	0.5 l/prop/hr	0.1 l/prop/hr
Illegal connections	V. High	High	Average	[✓ Low]	V Low
Type of housing	Affluent	High Income	Med Income	[✓ Low Income]	Informal

Mains burst frequency (number) ____ per week ____ per month ____ per annum

Connection repair frequency (number) ____ per week ____ per month ____ per annum

Basic information

Length of mains(km)	33.99
Number of connections	1 674
Number of properties	1 674
Estimated population	8 370

Water use

	%
Urban	100
Industrial	0
Commercial	0
Other	0

Small non-domestic night users

Number	0	
Average use	0	litres/hour

Large non-domestic night users

Total use	0	m^3/h

PRV & Flow meter characteristics

PRV details

	Make	Model	Size (mm)
Inlet 1	Bermad		250
Inlet 2			
Inlet 3			

Flow Meter

	Make	Model	Size (mm)
Inlet 1	Meinecke		
Inlet 2			
Inlet 3			
Outlet 1			
Outlet 2			

Zone Boundary Conditions

Condition	Address	Comments

PRESSURE ANALYSIS : BASIC INFORMATION

General

Name of Water Undertaking: **City of East London**
Name of Water Supply Zone: **Mdantsane - PRV 6**
Reference number: **WRC 8**

Condition of distribution network

(tick appropriate box)

Material	uPVC	Steel	AC	HDPE	Polypropylene
	mPVC	GRP	Concrete	Other (Specify)	
Age (Years)	0-5	5 to 10	10 to 20	20 to 40	40 +
Mains Losses	V. High	High	Average	Low	V Low
	100 l/km/hr	80 l/km/hr	[✓ 40 l/km/hr]	20 l/km/hr	10 l/km/hr
Mains burst frequency (number)		per week		per month	per annum
Connection losses	V. High	High	Average	Low	V Low
	10 l/conn/hr	6 l/conn/hr	[✓ 3 l/conn/hr]	2 l/conn/hr	1 l/conn/hr
Connection repair frequency (number)		per week		per month	per annum
Property losses (installations)	V. High	High	Average	Low	V Low
	100 l/prop/hr	5 l/prop/hr	[✓ 1 l/prop/hr]	0.5 l/prop/hr	0.1 l/prop/hr
Illegal connections	V. High	High	Average	Low	[✓ V Low]
Type of housing	Affluent	High Income	Med Income	[✓ Low Income]	Informal

Basic information

Length of mains(km)	10.14
Number of connections	648
Number of properties	648
Estimated population	3 240

Water use

	%
Urban	100
Industrial	0
Commercial	0
Other	0

Small non-domestic night users

Number	0	
Average use	0	litres/hour

Large non-domestic night users

Total use 0 m^3/h

PRV & Flow meter characteristics

PRV details

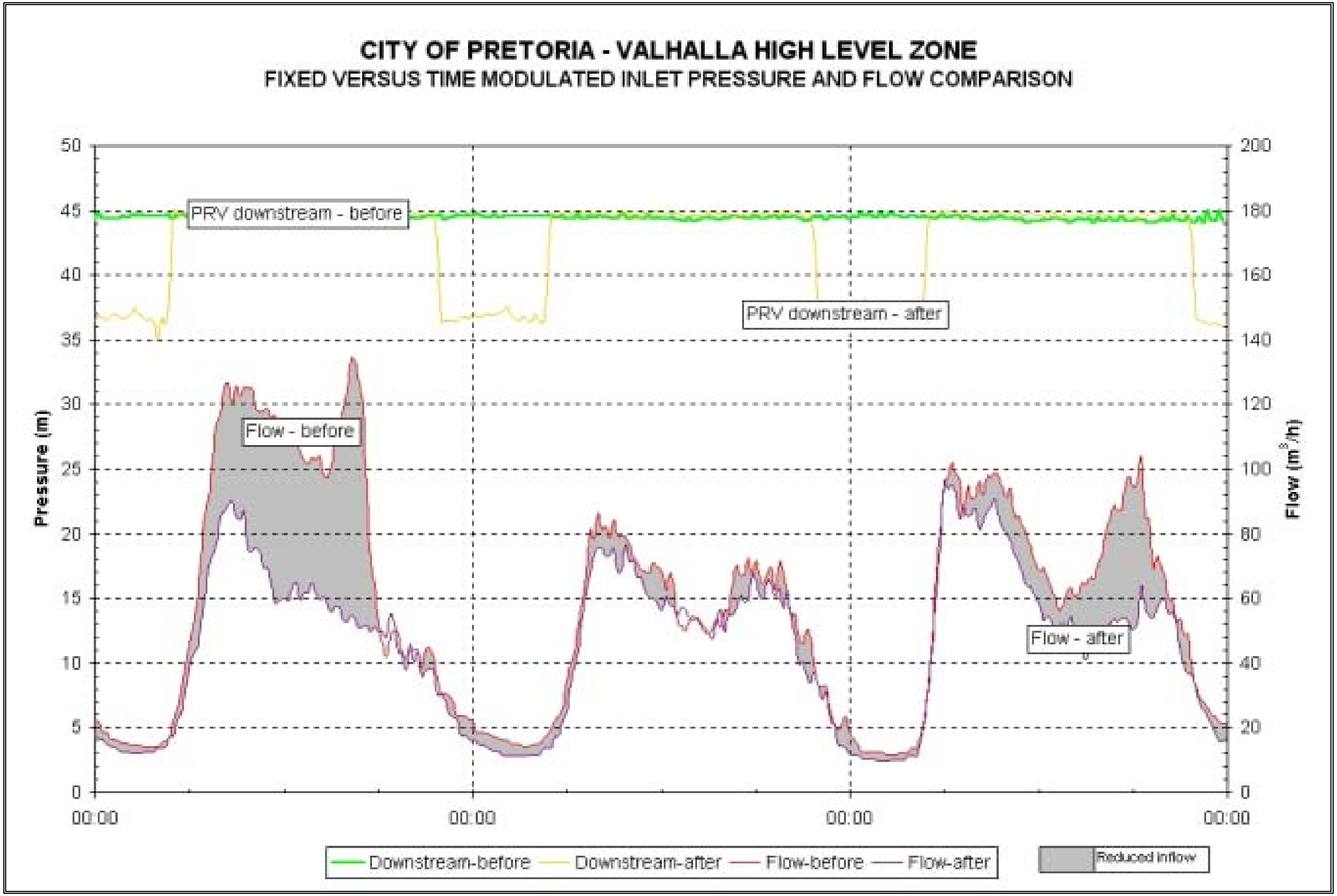
	Make	Model	Size (mm)
Inlet 1	Baker		80
Inlet 2			
Inlet 3			

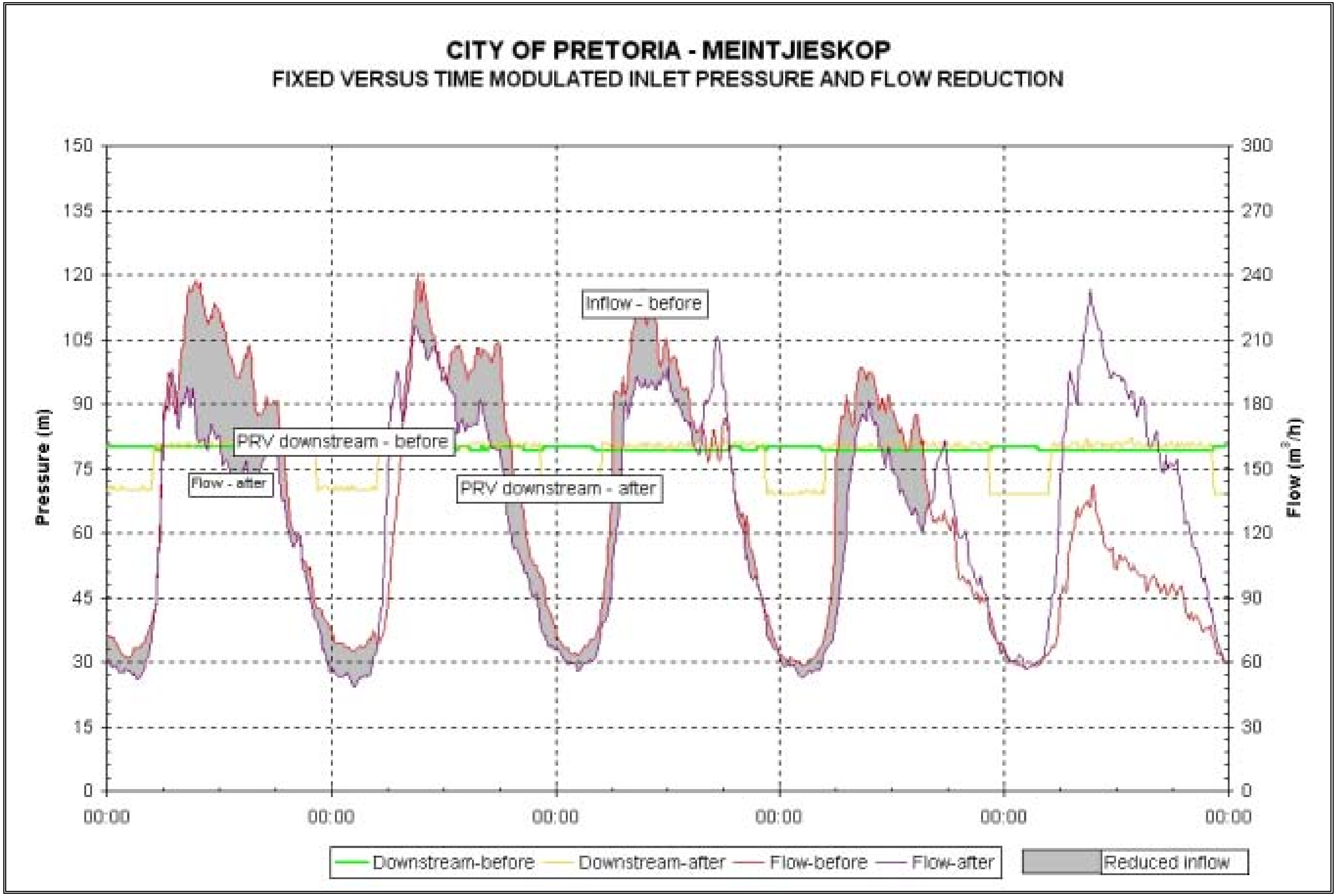
Flow Meter

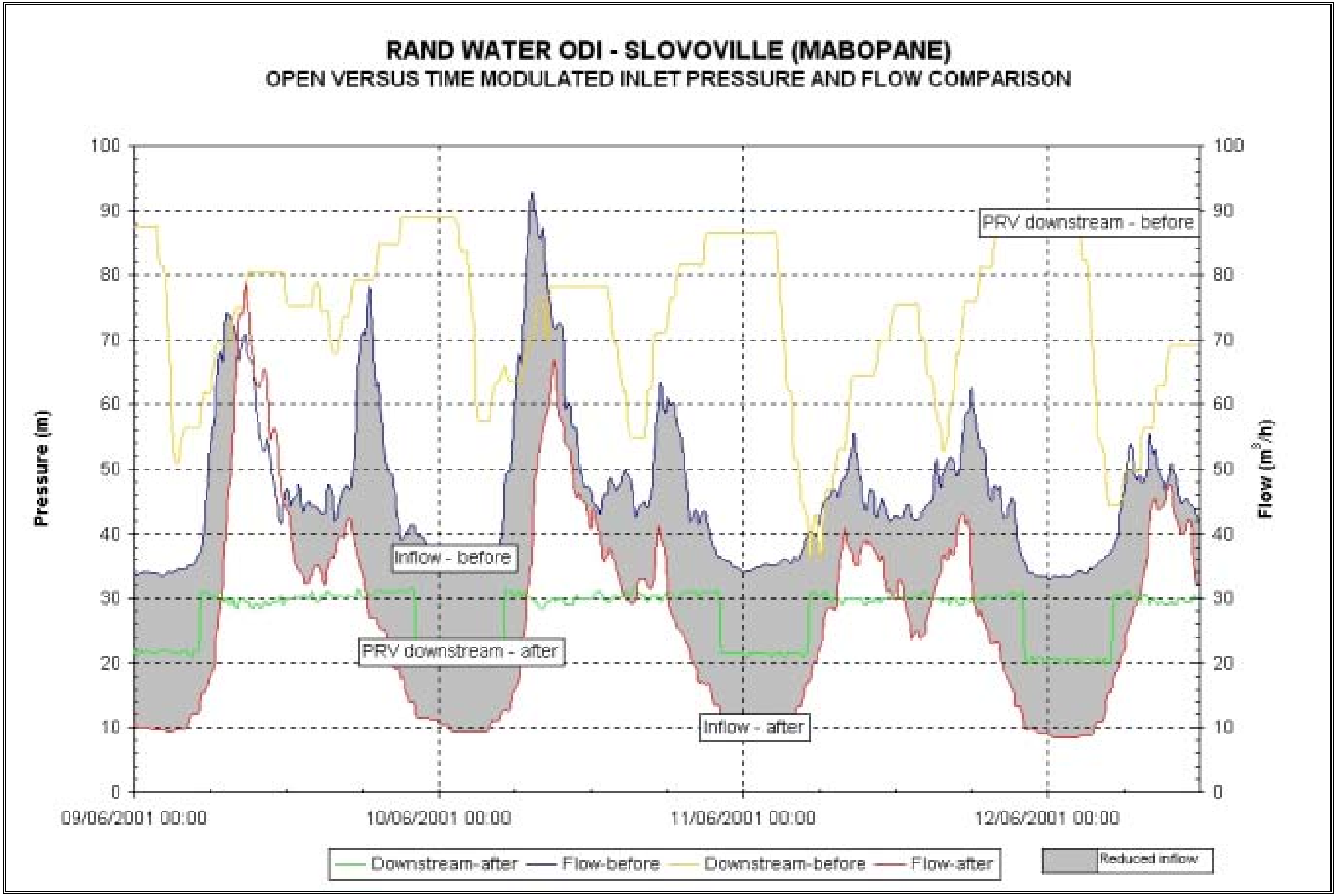
	Make	Model	Size (mm)
Inlet 1	Meinecke	WP	80
Inlet 2			
Inlet 3			
Outlet 1			
Outlet 2			

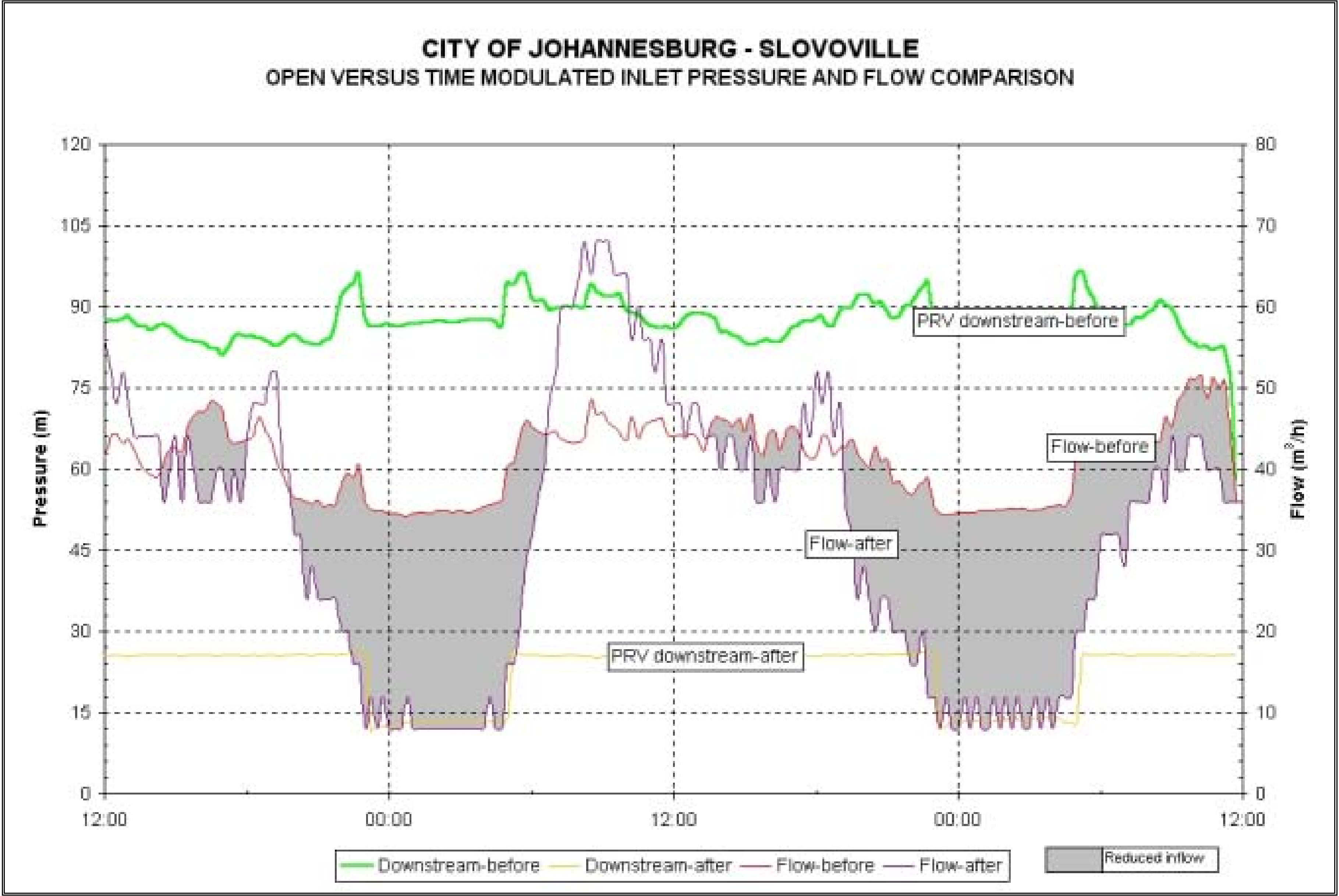
Zone Boundary Conditions

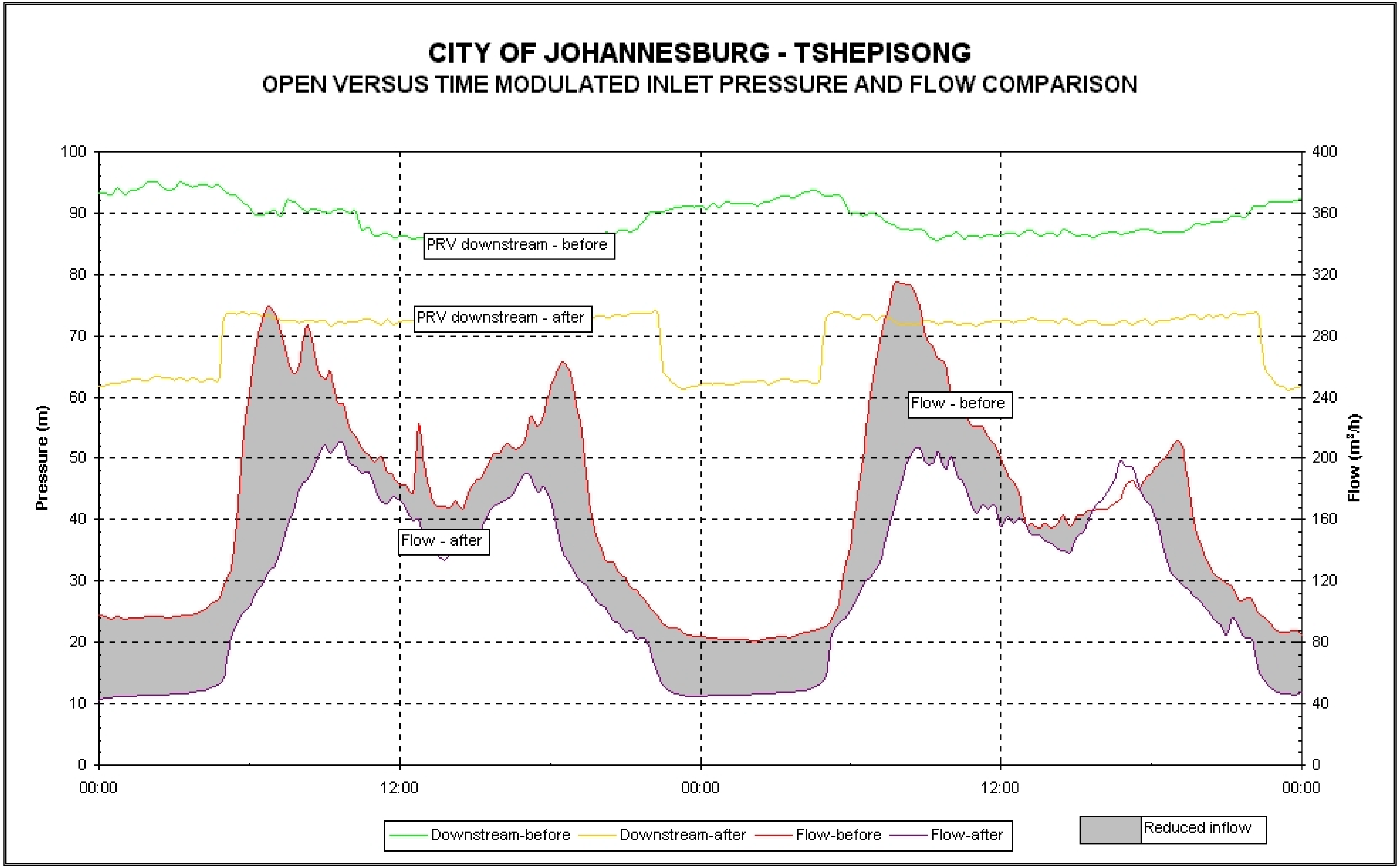
Condition	Address	Comments
PRV & Meter	Stand 2859, Lilian Nqoyi Village	

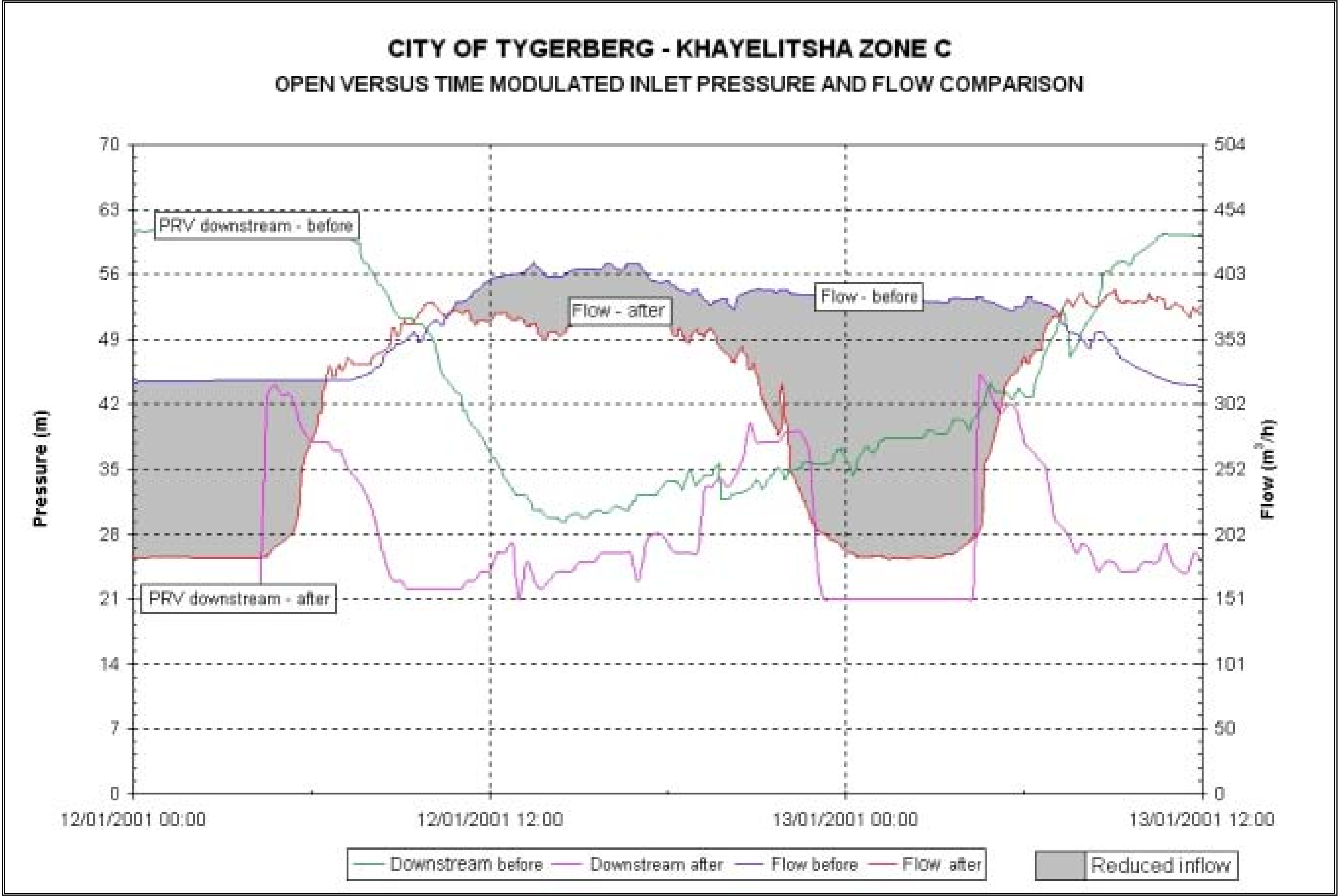

CITY OF PRETORIA - VALHALLA HIGH LEVEL ZONE
FIXED VERSUS TIME MODULATED INLET PRESSURE AND FLOW COMPARISON
Pressure (m)
Flow (m³/h)
50
45
40
35
30
25
20
15
10
5
0
200
180
160
140
120
100
80
60
40
20
0
00:00
00:00
00:00
00:00
PRV downstream - before
PRV downstream - after
Flow - before
Flow - after
Downstream-before
Downstream-after
Flow-before
Flow-after
Reduced inflow

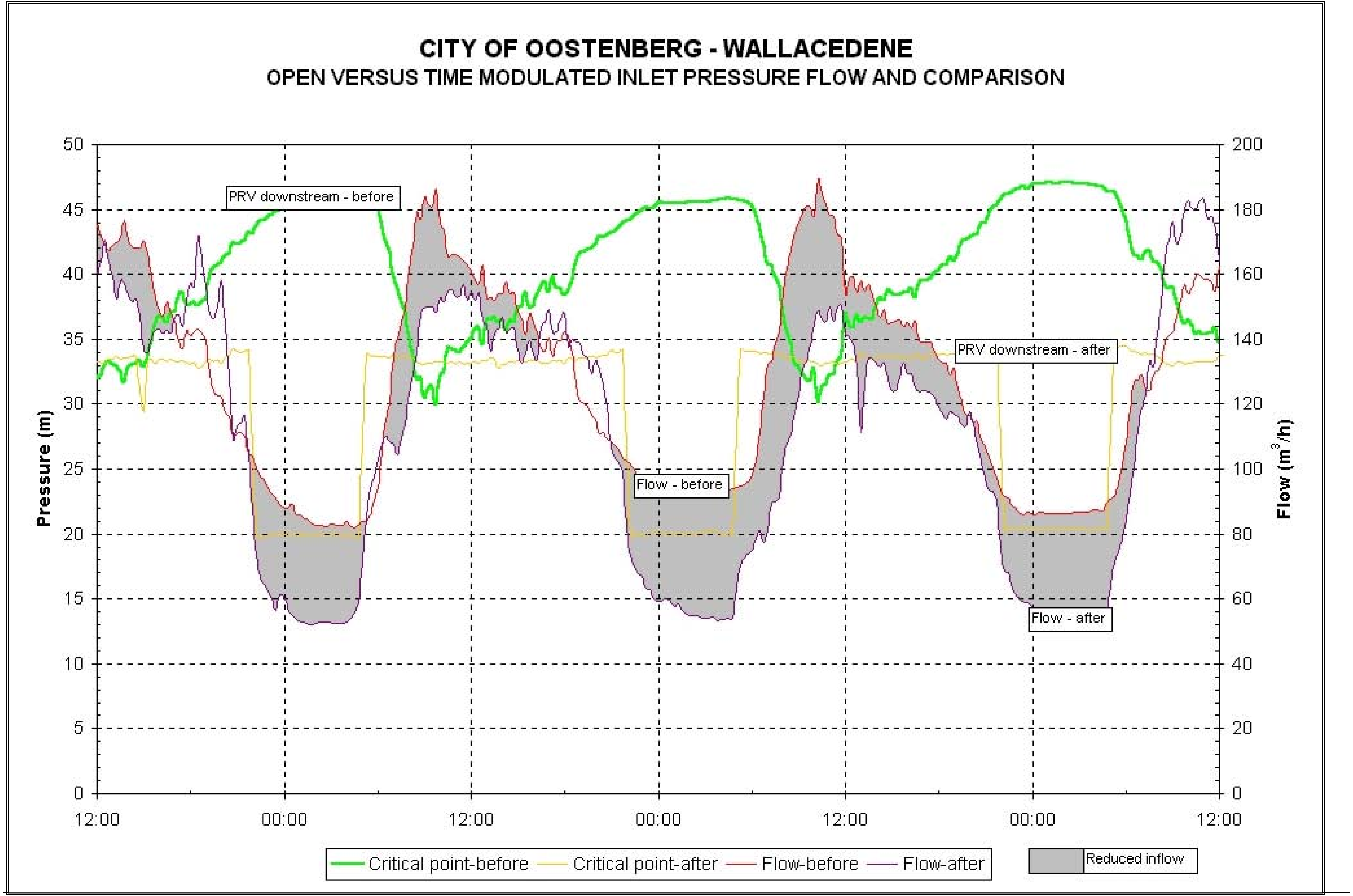

CITY OF PRETORIA - MEINTJIESKOP
FIXED VERSUS TIME MODULATED INLET PRESSURE AND FLOW REDUCTION
Pressure (m)
150
135
120
105
90
75
60
45
30
15
0
Flow (m^3/h)
300
270
240
210
180
150
120
90
60
30
0
00:00
00:00
00:00
00:00
00:00
00:00
Inflow - before
PRV downstream - before
Flow - after
PRV downstream - after
Downstream-before
Downstream-after
Flow-before
Flow-after
Reduced inflow

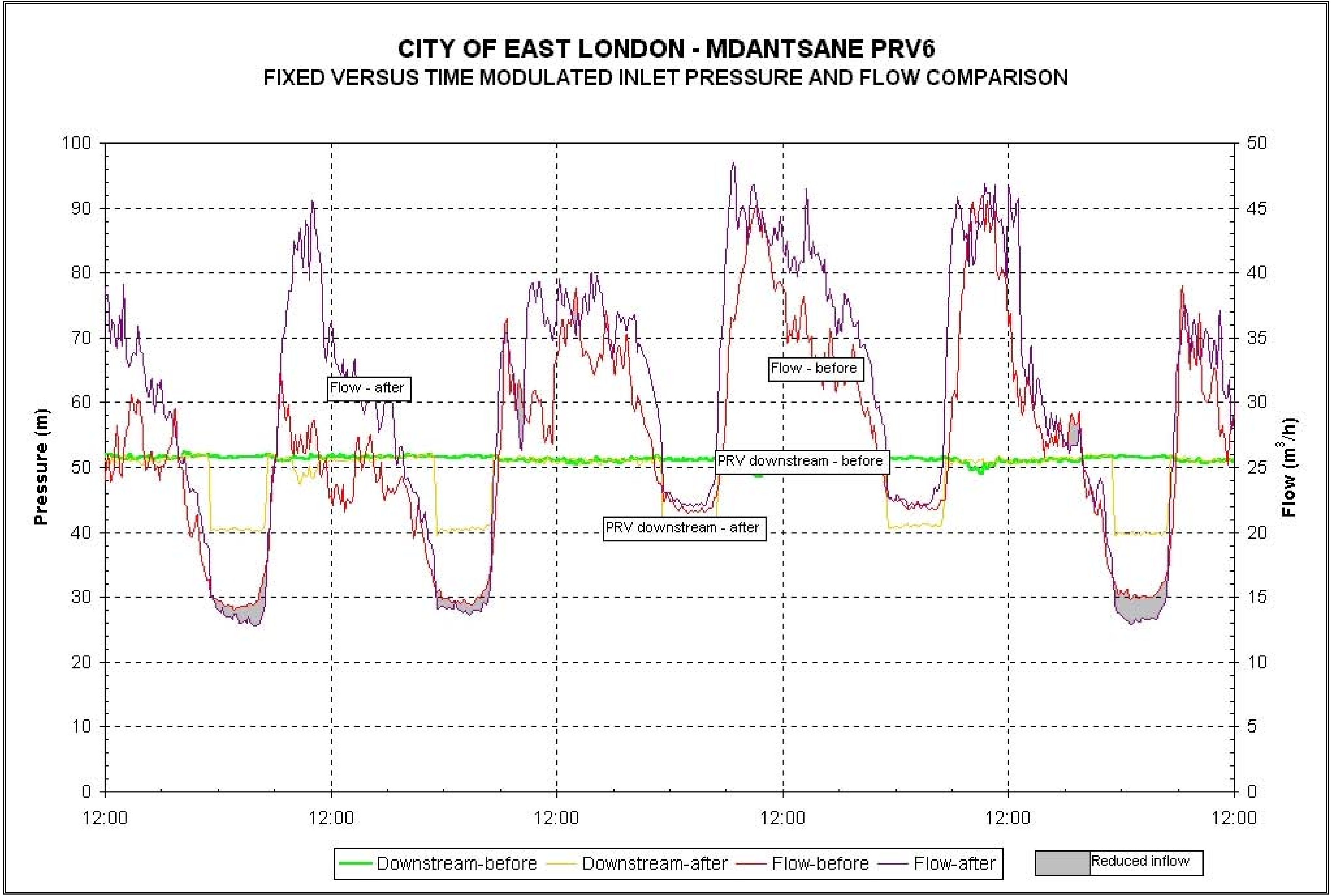

RAND WATER ODI - SLOVOVILLE (MABOPANE)
OPEN VERSUS TIME MODULATED INLET PRESSURE AND FLOW COMPARISON
Pressure (m)
Flow (m³/h)
0
10
20
30
40
50
60
70
80
90
100
09/06/2001 00:00
10/06/2001 00:00
11/06/2001 00:00
12/06/2001 00:00
PRV downstream - before
Inflow - before
PRV downstream - after
Inflow - after
Downstream-after
Flow-before
Downstream-before
Flow-after
Reduced inflow


CITY OF JOHANNESBURG - SLOVOVILLE
OPEN VERSUS TIME MODULATED INLET PRESSURE AND FLOW COMPARISON
Pressure (m)
120
105
90
75
60
45
30
15
0
Flow (m^3/h)
80
70
60
50
40
30
20
10
0
12:00
00:00
12:00
00:00
12:00
PRV downstream-before
Flow-before
Flow-after
PRV downstream-after
Downstream-before
Downstream-after
Flow-before
Flow-after
Reduced inflow


CITY OF JOHANNESBURG - TSHEPISONG
OPEN VERSUS TIME MODULATED INLET PRESSURE AND FLOW COMPARISON
Pressure (m)
Flow (m³/h)
100
90
80
70
60
50
40
30
20
10
0
400
360
320
280
240
200
160
120
80
40
0
00:00
12:00
00:00
12:00
00:00
PRV downstream - before
PRV downstream - after
Flow - before
Flow - after
Downstream-before
Downstream-after
Flow-before
Flow-after
Reduced inflow


CITY OF TYGERBERG - KHAYELITSHA ZONE C
OPEN VERSUS TIME MODULATED INLET PRESSURE AND FLOW COMPARISON
Pressure (m)
Flow (m³/h)
70
63
56
49
42
35
28
21
14
7
0
504
454
403
353
302
252
202
151
101
50
0
12/01/2001 00:00
12/01/2001 12:00
13/01/2001 00:00
13/01/2001 12:00
PRV downstream - before
Flow - after
Flow - before
PRV downstream - after
Downstream before
Downstream after
Flow before
Flow after
Reduced inflow


CITY OF OOSTENBERG - WALLACEDENE
OPEN VERSUS TIME MODULATED INLET PRESSURE FLOW AND COMPARISON
Pressure (m)
Flow (m3/h)
50
45
40
35
30
25
20
15
10
5
0
200
180
160
140
120
100
80
60
40
20
0
12:00
00:00
12:00
00:00
12:00
00:00
12:00
PRV downstream - before
PRV downstream - after
Flow - before
Flow - after
Critical point-before
Critical point-after
Flow-before
Flow-after
Reduced inflow


CITY OF EAST LONDON - MDANTSANE PRV6
FIXED VERSUS TIME MODULATED INLET PRESSURE AND FLOW COMPARISON
Pressure (m)
Flow (m³/h)
100
90
80
70
60
50
40
30
20
10
0
50
45
40
35
30
25
20
15
10
5
0
12:00
12:00
12:00
12:00
12:00
12:00
Flow - after
Flow - before
PRV downstream - before
PRV downstream - after
Downstream-before
Downstream-after
Flow-before
Flow-after
Reduced inflow

APPENDIX B

Standard templates for basic information

PRESSURE ANALYSIS : BASIC INFORMATION

General

Name of Water Undertaking:
Name of Water Supply Zone:
Reference number:

Condition of distribution network

(tick appropriate box)

Material	uPVC	Steel	AC	HDPE	Polypropylene
	mPVC	GRP	Concrete	Other (Specify)	
Age (Years)	0-5	5 to 10	10 to 20	20 to 40	40 +
Mains Losses	V. High	High	Average	Low	V Low
	100 l/km/hr	80 l/km/hr	40 l/km/hr	20 l/km/hr	10 l/km/hr
Mains burst frequency (number)		per week		per month	per annum
Connection losses	V. High	High	Average	Low	V Low
	10 l/conn/hr	6 l/conn/hr	3 l/conn/hr	2 l/conn/hr	1 l/conn/hr
Connection repair frequency (number)		per week		per month	per annum
Property losses (installations)	V. High	High	Average	Low	V Low
	100 l/prop/hr	5 l/prop/hr	1 l/prop/hr	0.5 l/prop/hr	0.1 l/prop/hr
Illegal connections	V. High	High	Average	Low	V Low
Type of housing	Affluent	High Income	Med Income	Low Income	Informal

Basic information

Length of mains(km)
Number of connections
Number of properties
Estimated population

Water use

	%
Urban	
Industrial	
Commercial	
Other	

Small non-domestic night users

Number
Average use litres/hour

Large non-domestic night users

Total use m^3/h

PRV & Flow meter characteristics

PRV details

	Make	Model	Size (mm)
Inlet 1			
Inlet 2			
Inlet 3			

Flow Meter

	Make	Model	Size (mm)
Inlet 1			
Inlet 2			
Inlet 3			
Outlet 1			
Outlet 2			

Zone Boundary Conditions

Condition	Address	Comments

PRESSURE ANALYSIS : PRESSURE AND FLOW RESULTS

General

Name of Water Undertaking:

Name of Water Supply Zone:

Reference number:

Pressure settings

	Source Name (Reservoir/Tower)	Source TWL (m)	PRV Elevation (m)	Inlet Pressure (bar)
Supply 1				
Supply 2				
Supply 3				

	Address	Elevation (m)	Without PRV (bar)	Existing Settings (bar)	Proposed Settings (bar)
PRV 1					
PRV 2					
PRV 3					
	Average				

Critical Point					
Low Point					
AZ(N)P Point					

Pressure and flow data

Logged from: to

Hour	Pressure			Flow	
	Inlet Point	AZP	Critical Point	To zone	To Zone
	(m)	(m)	(m)	(m^3/hr)	(l/s)
0 - 1					
1 - 2					
2 - 3					
3 - 4					
4 - 5					
5 - 6					
6 - 7					
7 - 8					
8 - 9					
9 - 10					
10 - 11					
11 - 12					
12 - 13					
13 - 14					
14 - 15					
15 - 16					
16 - 17					
17 - 18					
18 - 19					
19 - 20					
20 - 21					
21 - 22					
22 - 23					
23 - 0					
Minimum					
Maximum					
Average					
Total					m^3