Leakage reduction through pressure management in Khayelitsha: Two years down the line

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Abstract

The Khayelitsha Pressure Management Project has been well documented and widely publicised since it was commissioned towards the end of 2001. The project has received numerous national and international awards for technical excellence as well as for environmental awareness and community involvement. The initial water saved by the project was estimated to be in the order of 9 million m^3/yr representing approximately 40% of the original 22 million m^3/yr supplied to the area.

In many examples of WDM interventions, the initial savings achieved by the project are not always sustainable and the true savings several years later are often significantly lower than those originally achieved. It is for this reason that the project team and the Client responsible for the Khayelitsha pressure management project decided to produce a final paper documenting the results and actual savings two years after the completion of the installation.

The paper presents details of the initial savings suggested by the project team and compares them to the latest savings estimated by the Client. Problems associated with the installation experienced by the Client and consumers are discussed as well as any lessons learned by both the design team and the Client's team. It is through such feedback that future pressure management installations can be designed and commissioned with confidence in areas as large or even larger than Khayelitsha.

Introduction

Khayelitsha is one of the largest townships in South Africa and is located approximately 20 km from Cape Town on the Cape Flats. The area, which was previously a nature reserve, covers approximately 24 km^2 and now provides housing to approximately 450 000 people. There are approximately 43 000 serviced sites with both internal water supply and water borne sewage while there are a further 27 000 low-cost housing units which are supplied from communal standpipes. The area has been expanding continuously since the early 80's when the first settlements were established. The basic water distribution infrastructure is therefore relatively new and is considered to be in generally good condition.

Khayelitsha is supplied with potable water from Blackheath Reservoir situated at an elevation of 110 m through two large water mains supplying the area at an average pressure of approximately 80 m (8 Bar). A 1065 mm main supplies water from the north while a second 450 mm diameter pipe supplies the area from the west as can be seen in Fig. 1.

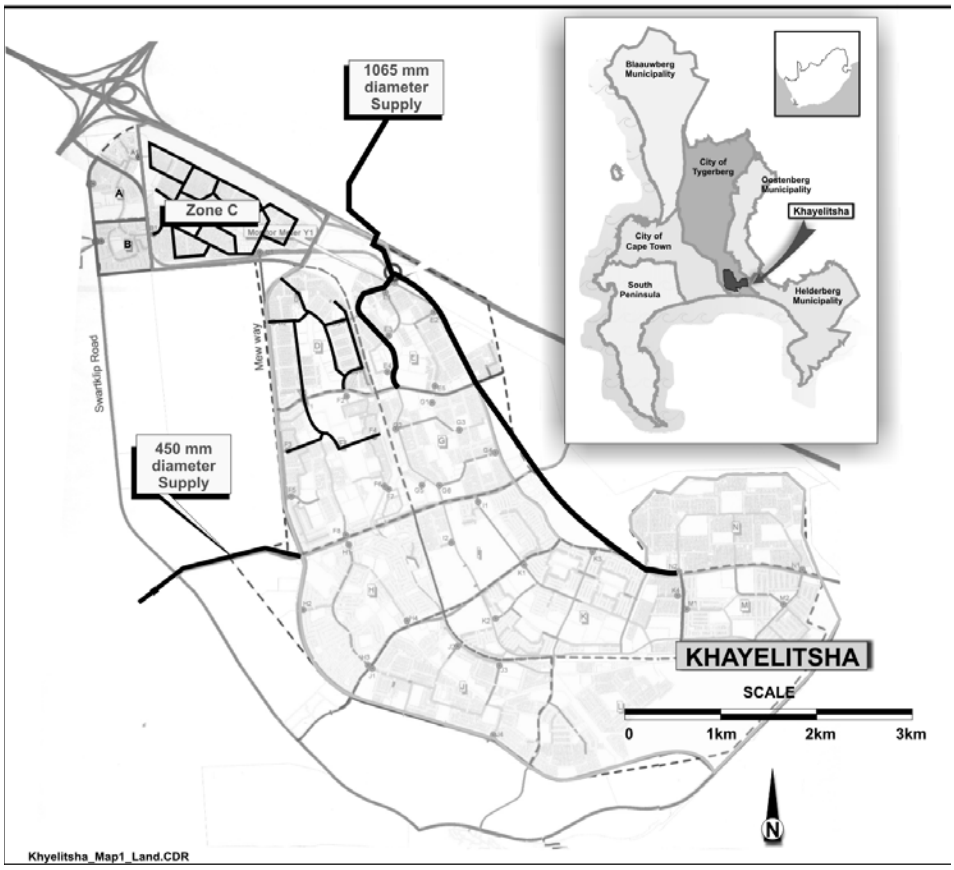

Figure 1
Location map for Khayelitsha

This paper was originally presented at the 2004 Water Institute of South Africa (WISA) Biennial Conference, Cape Town, South Africa, 2-6 May 2004.

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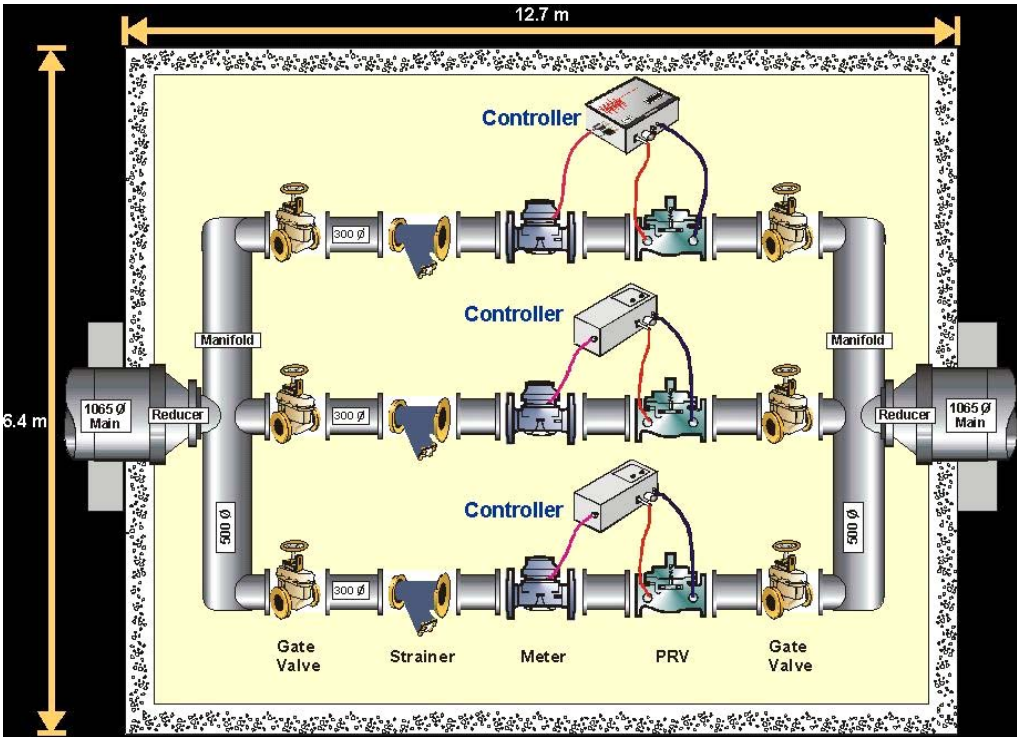

Figure 2
Schematic layout of the 1065 mm diameter installation

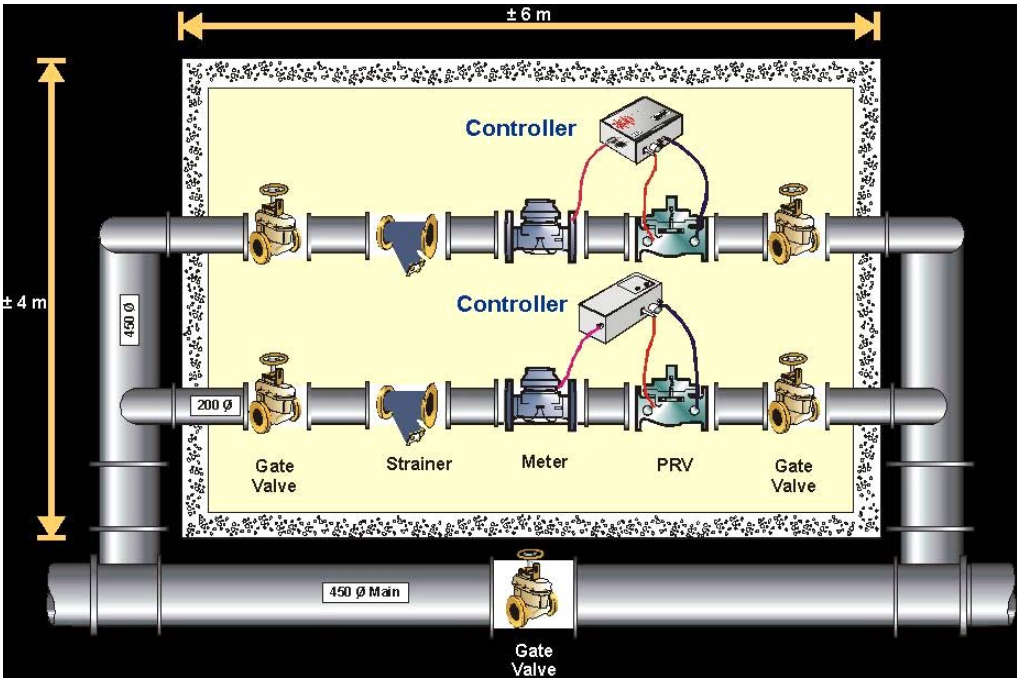

Figure 3
Schematic layout of the 450 mm diameter installation

Background to the Khayelitsha pressure management installation

As the Khayelitsha township has grown, so too has the overall water consumption as well as the leakage from the system. At the beginning of 2000, the water supplied to Khayelitsha was measured to be almost 22 million m^3/a. From the analyses of the minimum night flow into the area (1 600 m^3/h) it was estimated that the leakage and/or wastage in the area was in the order of 70% to 80% of the water supplied. Furthermore from the analyses of the sewer flows originating from the area during the period of minimum night flow, it was confirmed that most of the water being wasted in the area was lost through the internal household plumbing fixtures – the minimum night sewer flow was measured to be approximately 1 300 m^3/h representing more than 80% of the minimum night flow supplied to the area. To place these figures in perspective, the minimum night flow supplied to the area was sufficient to fill an Olympic sized swimming pool every hour.

To address the leakage/wastage problem in Khayelitsha it was not practical to employ the normal leakage reduction measures usually promoted by various organizations. Such measures often involve leak detection and repair programmes to find and repair any leaks evident on the main water reticulation system. In the case of Khayelitsha this form of water demand management was not

Figure 4
Internal view of a portion of the 1065 mm diameter chamber

appropriate since most of the leaks were inside the properties In such cases, another common 'remedy' often proposed involves retrofitting of the plumbing fittings in each property to eliminate leaking toilets and taps. While this has proven successful in some cases, it has also been found in many other cases that the savings are not sustainable and that the leakage levels have returned to pre-retrofitting levels in a matter of a year or two (or even less).

To address the problem of high internal plumbing leakage, it is important to understand the underlying problem after which appropriate action can be taken. In the case of Khayelitsha, the underlying problem was the high system pressure which led to high internal leakage since the taps and toilets were not designed to operate under such high water pressure for prolonged periods. Even high quality plumbing fittings will eventually leak if they are subject to excessive pressure for years on end as was the case in Khayelitsha where the high pressures had been experienced for between 10 and 20 years. Before trying to repair the individual taps and toilets, it is first necessary to reduce the overall system pressure to appropriate levels where the plumbing fittings can operate properly for many years.

The Khayelitsha pressure management project was therefore proposed and implemented in 2001 to improve the level of service to the Khayelitsha community by reducing the excessive water pressure and pressure fluctuations in the reticulation system. By reducing the system pressure, the internal plumbing leakage was reduced to levels which surprised even the most optimistic network engineer. The savings were so high that they completely contradicted any modelled projections based on the latest pressure leakage concepts and the project has highlighted several interesting issues which should be considered when tackling similar projects elsewhere.

Scope of the project

In order to implement pressure management, it is normally a reasonably simple procedure to install a standard pressure reducing valve. In the case of Khayelitsha, however, the situation was neither straightforward nor simple due to the size of the two supply pipes into the area. The Project Team decided that the most practical approach would be to cut into the two water mains and commission two installations, each with several sections of small diameter pipe and the appropriate sized pressure reducing valves. In this regard it was decided to install three 300mm diameter sections in the 1065 mm diameter main and two 200 mm diameter sections in the 450 mm diameter main as shown in Figures 2 and 3. It was also decided to introduce advanced pressure control which involves the commissioning of specially imported electronic controllers used to reduce the system pressure even further during off peak periods.

Project implementation

Despite many problems, some of which were anticipated, the installations were finally commissioned towards the end of 2001 and have been operating continually since then. The completed installation is shown in Figure 4 and has been recognised both locally and internationally as the most significant advanced pressure management installation worldwide.

Many high ranking officials have visited the installation including the Director General from DWAF, The Minister of the Environment from Norway, the Water Conservation Manager from Queensland Auatralia as well as many other prominent water conservation specialists. The project team including the Client (City of Cape Town) has been recognised for its efforts by various organizations and it received the national SAICE and IMESA awards for technical excellence as well as the Michael Flynn award in Australia. Clearly the project has been well received and appears to be highly successful. The issue addressed in this paper concerns whether or not the project remains successful two years down the line and what lessons have been learned by the project team that can assist others who may be considering similar initiatives elsewhere in South Africa.

Initial savings

In order to evaluate the success of the Khayelitsha pressure management project two years after commissioning, it is necessary to compare the initial savings with those being achieved in 2004. The baseline from which the savings have been calculated was the

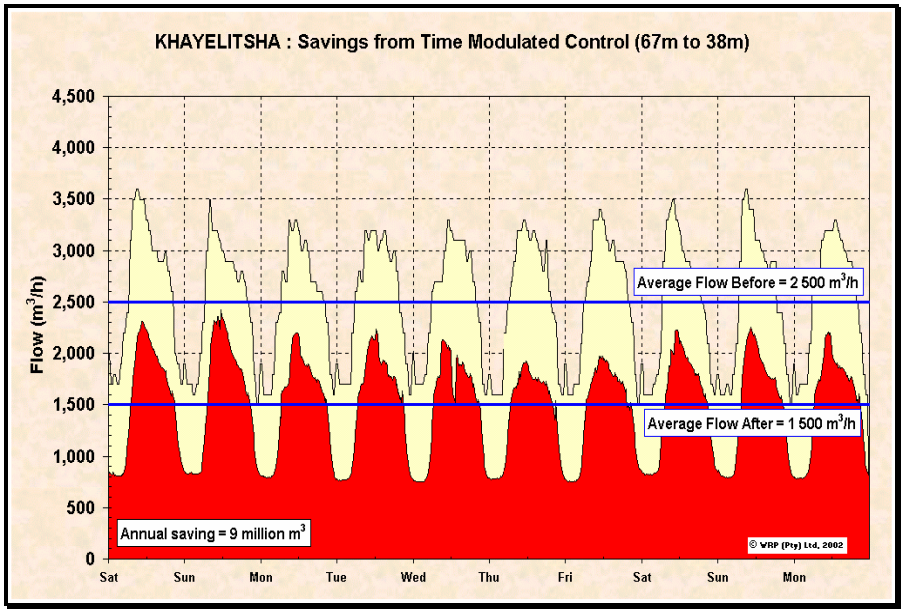

Figure 5
Savings achieved from the installation (Nov. 2001)

level of leakage in April 2000 when the project was first identified by the project team and presented to the Client. The water supply situation in April 2000 had an average flow of 2 500 m^3/h (representing an annual water demand of 22 million m^3/h of which approximately 75% was wastage) with a Minimum Night Flow of over 1 600 m^3/h.

The pressure control involved using pressure reducing valves equipped with electronic controllers to provide further pressure reduction during periods of low demand. This form of pressure control is termed Advanced Pressure Control and requires considerable experience and care to ensure that it is implemented properly. The results from the project shortly after commissioning at the end of 2001 are shown in Figure 5 from which it can be seen that the minimum night flow was lowered to 750 m^3/h with the average daily flow dropping from 2 500 m^3/h to 1 500 m^3/h. The total annual savings achieved by the installation as estimated by the City of Cape Town were in the order of 9 million m^3/h or 40% of the water originally supplied to the area.

It is important to note that at no time during the pressure management activities, was the pressure at any point in the system lowered below the minimum level experienced during normal peak demand periods.

Savings after 2 years

As mentioned previously, the savings achieved by many water demand management interventions are short lived and cannot be sustained for any significant period after completion of the project. Follow up assessments are rarely undertaken to check if the water demand management measures are still providing savings many months or years after completion of the projects. This is considered a serious oversight since the sustained savings are of great importance to the water utility when estimating future water demands which in turn influence bulk water resource developments.

In the case of the Khayelitsha pressure management installation, the annual water used in the project area has been monitored continually by the City of Cape Town and the project therefore offers an ideal case study to assess the sustainability of pressure management as a means to reducing wastage and/or leakage. In this regard, discussions were held with the Client in February 2004 and the logging results analysed by the original project team.

The results of the analyses were very positive and show that the minimum night flow has remained virtually unchanged at 750 m^3/h although there has been a slight increase in overall water demand from the 13 million m^3/yr to almost 14 million m^3/yr. The static night flow demonstrates that the installation is maintaining the original savings in leakage while the small increase in annual consumption is attributed to the increase in population in the area (estimated to have increased by 10% over the past 2 years).

In summary, the latest results clearly demonstrate that the Khayelitsha pressure management installation is providing sustainable savings which will continue as long as the installation remains in operation.

In addition to the basic reduction in leakage evident from the minimum night flow, the Client has also indicated that there has been a significant reduction in major burst repairs. Unfortunately there are no reliable records on which to estimate the savings, however, the Client has noted that overtime payments have reduced significantly since the installation was commissioned. The cost savings associated with the reduced number of mains and connection pipe bursts have never been included in any financial calculations and thus the true savings are clearly higher than originally suggested.

Another benefit from the project that was never included in the financial assessment concerns the treatment of sewage from the area. When the project was initiated, the sewage treatment plant at Zandvliet was operating beyond its design capacity (65 Ml/day with a capacity of 55 Ml/day) and a R35 million upgrade was planned for 2003 to increase the capacity to 90 Ml/day. As a direct result of the pressure management installation, the sewage from Khayelitsha dropped by 20 Ml/day and the extension to the sewage treatment plant was postponed by at least two years. The savings in financial charges (based on interest less inflation) were never included in the project viability study and can be estimated conservatively at R2.5 million per year – almost equal to the full implementation costs of the pressure management installation.

Conclusions and recommendations

After two years of operation, the Khayelitsha pressure management installation continues to deliver the goods in the form of massive water savings. The savings have been maintained at the original

TABLE 1
Summary of savings from January 2002 to December 2003

Description	Basis of calculation	Volume saved	Value of saving (R million)
Direct water savings in 2002	Based on R3.09/ m^3	9 million m^3	27.8
Direct water saving in 2003	Based on R3.49/ m^3	9 million m^3	31.4
Delay to infrastructure – 2 years	7% of R35 million/yr		4.9
Maintenance and replacement	R250 000 per year		-0.5
Total saving over 2 year period			**63.6**

commissioning levels and there has been no visible deterioration in the performance of the installations. The annual savings as estimated by the Client are shown in Table 1 which clearly shows the significance of the project which cost R2.7 million to implement in 2001. It should be noted that an allowance has been made for maintenance which is significantly higher than the actual maintenance costs currently experienced by the Client. The figures shown allow for the replacement of all equipment every 10 years and are considered to be conservative in that they overestimate the maintenance and replacement costs.

On a final note, the success of such projects rests with the Client since without a full 'buy-in' the installations would cease to function within a matter of months. All pressure management installations require continual care and attention if they are to perform properly and produce the anticipated savings. In the case of Khayelitsha, the Client's representatives in the project area have taken full control of the two installations and are operating them as part of the overall system. The project team regards this support to be essential and the key to the long-term success and sustainability of this and other similar projects throughout South Africa. There are many other examples throughout the country where the Client has either not wished to manage the installation or has not been permitted to do so, in which cases the overall performance of the installations has been less than impressive!

Figure 6
Completed chamber in Khayelitsha

Acknowledgements

- The project described in this article is a true team effort involving many organisations and individuals. While it is not possible to mention everyone who played a role in the successful completion of the project, it is considered appropriate by the Project Team to mention a few individuals without whom the project could not have taken place. The authors would therefore like to thank the following:
- Councilors from the former City of Tygerberg and present City of Cape Town (in particular Alderman Sitonga: formerly Mayor of Tygerberg) for their support of the project at a political level and providing the Project Team with the opportunity of developing such a prestigious installation.
- Mr Charles Chapman, former Water Demand Management Manager for the City of Cape Town who actively supported the project from its inception.
- Mr Anic Smit from the City of Cape Town who together with the authors recognised the potential for reducing wastage in Khayelitsha and actively motivated for a major pressure management project in the area. This project is considered to be the first main step towards the long-term goal of providing a more sustainable water supply to all Khayelitsha residents.
- Mr Larry Cronje; (also from the City of Cape Town but based in Khayelitsha), for his continued support and enthusiasm throughout the project. As the Client's representative in Khayelitsha, his active involvement in the project contributed greatly to its success.