Outsourcing of Water Loss Reduction Activities – the Malaysia Experience

Paper presented at the AWWA ACE, New Orleans, June 2002

Roland Liemberger, Bristol Water Services Ltd., Bristol, United Kingdom,
(roland@liemberger.cc)
Paul Fanner, Water Systems Optimization, Inc., Miami, Florida, U.S.A.

Abstract

Unaccounted-for Water (UfW), Non-Revenue Water (NRW) or simply water losses, the difference between water produced and water sold, has reached unacceptable levels in the majority of water utilities all around the world. Outsourcing of water loss reduction activities is often the only feasible solution. The paper describes the concept of 'Performance Based Water Loss Reduction' in general and provides detailed information on the world's largest NRW reduction contract – the Selangor NRW Reduction Project. The performance target of Phase 1 was to reduce NRW by 18,540 m3/day. The works were completed on time and the target has been over-achieved. Based on this success, Phase 2 of the Project has commenced in April 2000 with the aim of reducing NRW across the entire State of Selangor, by 200,000 m3/d over a 9 year period. After the first 2 years of the project, all targets have been substantially overachieved.

The project cost is Malaysian Ringgit 398 M (equivalent to US$ 105 M) with a pay-back period is 6.7 years. The Internal Rate of Return was calculated to be 33.2 % based on the assumption that the value of water equals the average tariff of RM 1.27 (equivalent to 0.33 US$). It can be concluded that Performance Based NRW Reduction Contracts are a feasible model for water utilities around the world.

Introduction

Throughout the world, many public water utilities suffer from high levels of Non-Revenue Water (NRW). In cases where the utility has surplus water resources, the high levels of NRW only have a negative impact on the utility's finances by increasing operating costs and reducing revenues. However, in cases where the utility has no surplus water resources, high levels of NRW can also result in water shortages during peak demand periods, reducing the level of service provided to customers. Reduced service to customers reduces customer's willingness to pay their bills, further reducing the utility's revenues.

Despite the negative impacts of high levels of NRW, many public water utilities find they are unable to bring the NRW under control. NRW reduction is not politically attractive, compared with developing new water resource schemes, and therefore is often given insufficient funding, resources and management support. Furthermore, it is often difficult for public sector water utilities to offer performance incentives to NRW staff to encourage the achievement of NRW targets.

To address these problems and offer water utilities an alternative approach to effectively reducing NRW, BWS has developed the concept of Performance Based NRW Reduction contracts. The concepts were developed in Malaysia to address the problems of water shortages faced in the State of Selangor, where BWS are now undertaking what is probably the world's largest contract of this type. This paper describes to approach used for this contract and the results achieved to date, which have consistently exceeded targets and expectations.

The Selangor Project

Selangor is one of the 11 States of Malaysia, home to more than 5 million people (more than 20% of Malaysia's total population). Part of this area is the Federal Territory of Kuala Lumpur, Malaysia's Capital. The Selangor Non-Revenue Water Reduction Project also includes Kuala Lumpur.

History

In 1997 the population of Kuala Lumpur experienced a serious water crises, caused by the El-Niño weather phenomenon (it simply didn't rain enough). It didn't take long for water shortages to occur and the main reason for them (besides the lack of rainfall) was highlighted by the media: the high level of water losses.

An estimated 40% of the water produced was not paid for, partly because of under-registration of consumption meters, but mainly because of leaks in the distribution network. Leakage was estimated to be around 200 million m3/year (or 25% of the total water production). If leakage could be reduced by only 50%, another 1.8 million people could be supplied and Kuala Lumpur wouldn't have had a water shortage.

A wide ranging debate on water loss reduction ensued, with the replacement of all aging asbestos cement pipes, several thousand kilometers being widely recommended. Clearly, all these proposals were unfeasible – they were too costly and had an extremely long implementation time. Furthermore, the replacement of mains only reduces leakage by a small amount, as most undetected leaks are found on small diameter pipes (service connections) and related joints and fittings.

Influenced by this discussion, BWS developed the approach of 'Performance Based NRW Reduction'. The concept was straight forward: 'No Cure-No Pay'. A project proposal was presented to the relevant Authorities - with an overall target of reducing NRW by more than 200,000 m3/day (73 M m3/year - 25% of the present losses) over a 10 year period.

As a first phase, a pilot project (duration 18 months) was executed. It was completed in March 2000) and all contractual targets were (over)achieved. Convinced by the success of the pilot project, the Client awarded a contract for a 9-year project with a loss reduction target of 198,900 m3/day. The project commenced in April 2000.

Project Scope

The scope of the projects includes the reduction of

(i) real losses (leakage) and

(ii) apparent losses (meter under-registration)

Whilst leakage reduction is of the utmost importance because of the limited water resources of the State of Selangor, the reduction of apparent losses will automatically lead to an increase of revenues for the water utility.

The project can be best described as a Turn-Key NRW reduction contract, with no additional cost for the Client. The activities covered by the lump-sum price include:

- planning, design, engineering
- mapping
- leak detection, pressure management
- supply of equipment, fittings, repair materials
- repair works

- other required civil, mechanical and installation works
- domestic meter replacement
- staff training

Performance Targets

Phase 1 (Pilot Project):

The performance target for phase 1 was to reduce NRW by 18,540 m3/day with sub-targets for both real loss reduction (> 10,450 m3/day) and meter accuracy improvement (> 6,400 m3/day). These targets had to be achieved by the end of the project (month 18).

Phase 2:

The performance targets for phase 2 follow the phase 1 approach. The overall target is to reduce NRW by 198,900 m3/day with sub-targets for both real loss reduction (> 97,500 m3/day) and meter accuracy improvement (> 81,450 m3/day). These are the main project targets which have to be achieved at the end of year 9.

To assure a continuous monitoring process, the concept of annualized targets was introduced and consequently targets have been set from year 1 to 9, as detailed in Table 1 below:

End of Year	Annual Performance Target (Annualized[1] Volume of Savings Accrue) [Mm^3]	Cumulative Savings (Annualized[1] Volume of Savings Accrue) [Mm^3]
1	2.65	2.65
2	17.46	20.11
3	32.41	52.52
4	43.65	96.17
5	52.88	149.05
6	60.24	209.29
7	67.95	277.24
8	72.17	349.41
9	72.60	422.01

Table 1: Phase 2 Annualized Saving Targets

Methodology

Real Loss Reduction

Experience gained in England and Wales during the last 10 years has shown that network zoning is the most efficient way to get deteriorating, leaking distribution networks under control. Hence this concept has been used from the beginning in the Selangor Project.

As a first step, areas with expectedly high leakage are identified and small network zones (NRW zones) are established. These zones have to be hydraulically discreet with one inflow point only. Often boundary

[1] Annualized Volume = Average Daily Saving at end of Year x Number of Calendar Days in the Year

valves have to be replaced or valves have to be installed in new locations. The NRW zones consist of several kilometers of mains and between 500 and 2000 service connections.

A water meter and a pressure reducing valve are installed at the inflow point of each zone. After a first baseline measurement (see Progress Monitoring below), leak detection and repair activities are carried out. In general, leaks on mains are repaired and leaking service connections are entirely replaced, including the tapping point (pipe saddle). High quality repair materials and fittings are used to ensure sustainability.

All kinds of leak detection equipment are used, ranging from simple, self-manufactured 'listening sticks' to ground microphones, leak noise correlators and leak noise loggers.

Pressure management is another important issue. Wherever the situation allows, operating pressures are reduced to acceptable minimum levels. In other cases, where zone pressure is already low, the pressure control device is used to maintain pressure at a certain level and to prevent pressure increases caused by leak repairs (which reduce friction losses by reducing flow rates).

Apparent Loss Reduction

It is a general principle of the Selangor Water Authority to meter all domestic and non-domestic customers. However, they don't have a regular meter replacement policy. Customer meters are very often far too old and therefore inaccurate. It has been shown that after five years, Selangor's domestic meters tend to substantially under-register - but many of the meters are more than 7, 10 or even 20 years old.

The approach taken is simple: Based on the water meter data base, meters with a high potential to under-register are selected for replacement. Selection criteria include age, type of meter, customer complaints, billing irregularities and similar. Once selected, these meters are replaced with new meters.

Progress Monitoring

Progress monitoring is of course an essential part of a performance based contract. Thus a methodology acceptable to both Client and Contractor had to be developed.

In order to monitor the real loss reduction achievements the following procedure([1]) was established:

1. Baseline measurements are to be undertaken for each of the zones prior to any water loss reduction activities. The inflow to the zone is measured for 7 days. At the beginning and the end of this period, all consumption meters in the zone are read too. The difference between inflow and metered consumption is non-revenue water (NRW).

2. After the implementation of all loss reduction activities (including pressure management) these measurements have to repeated for another 7 day period. The difference between NRW(start) and NRW(end) is the achieved real loss reduction per zone [m3/d]. Results of all zones are summed up to calculate the contract performance achievement.

In order to monitor apparent loss reduction achievements, the average reading of the old meter (over a 12 months period) is compared to a three month average reading of the newly installed meter. The difference between the two readings is used to calculate the apparent loss reduction achievement.

Selected Results

Figure 1 to Figure 3 below show data from a small zone (11 km distribution mains, 1900 service connections). Initially, daily inflow was around 4,387 m3 - 67% of the total inflow was lost (leakage = 1,535 litres/connection per day). After leak detection and repair and a moderate pressure reduction, the daily inflow dropped to 2,076 m3 with only 19% of the water lost (211 liters/connection per day). These savings, 2,311 m3 per day, or more than 840,000 m3/year, would be enough to supply an extra 15,000 people!

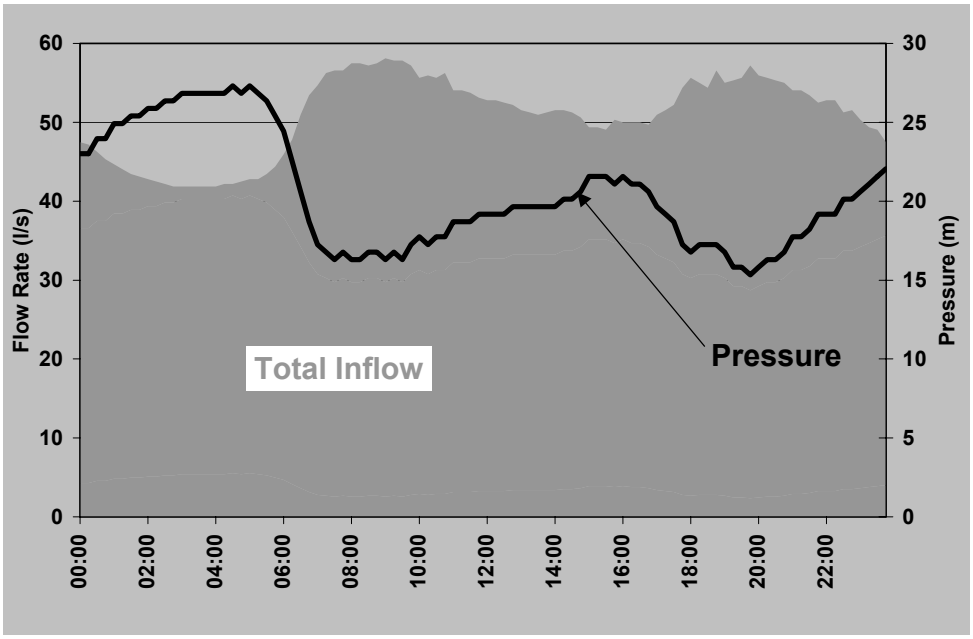

Figure 1: Inflow and related pressure

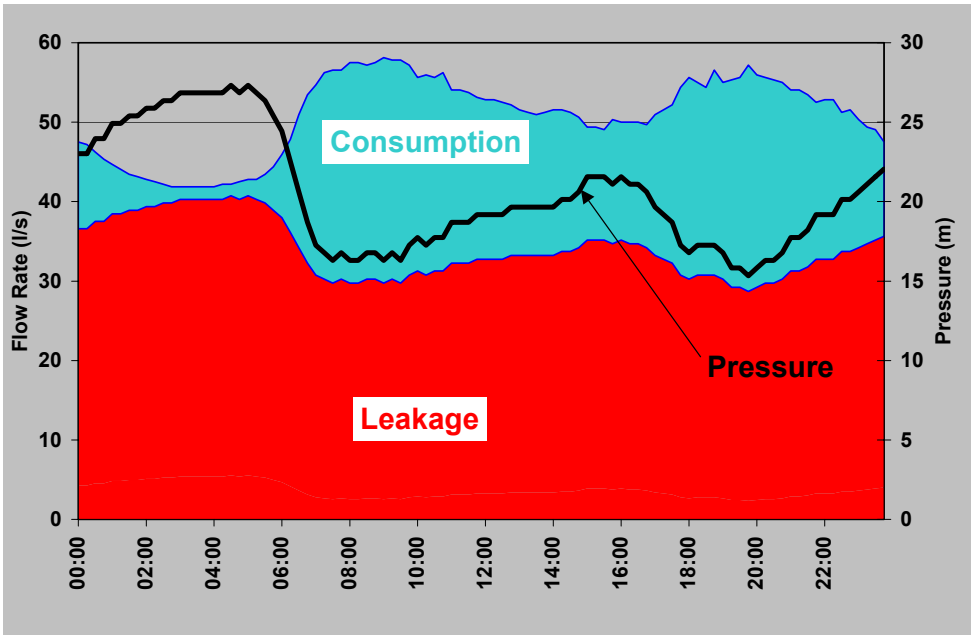

Figure 2: Inflow split into Leakage and Consumption (before repair)

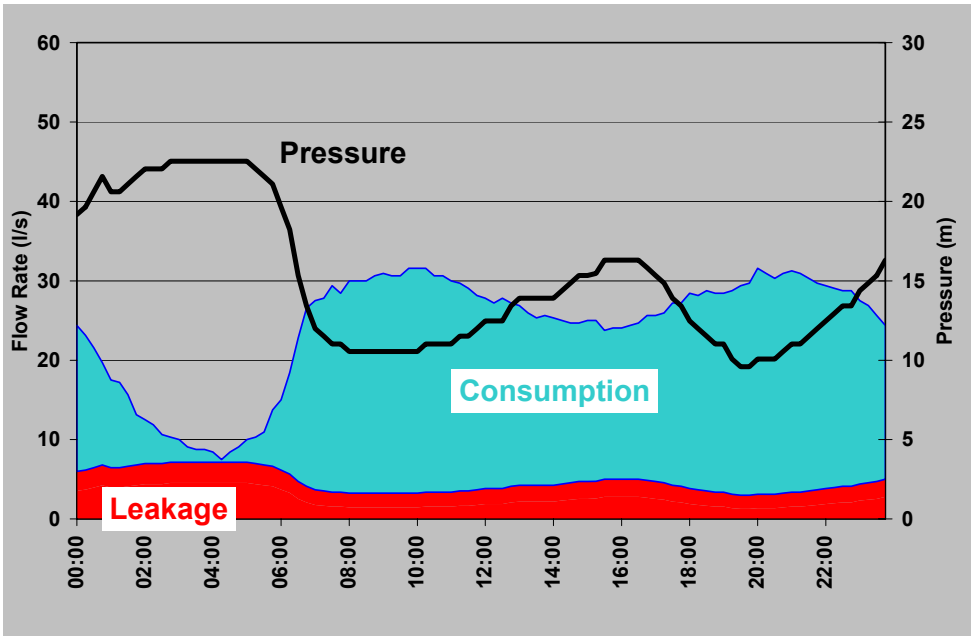

Figure 3: The situation after leak repair and a slight pressure reduction

Performance Achievements

Although Phase 1 was a small pilot project, the achievement of the performance targets was important as it (i) proved that the concept works and (ii) was a precondition for the second phase of the project. Table 2 below provides details:

Component	Target [m3/d]	Achieved [m3/d]	Ratio of Achievement [%]
Physical Loss Reduction	10,450	11,429	**109**
Meter Accuracy Improvement	6,400	9,212	**144**
Illegal Connections		257	
Total NRW Reduction	18,540	20,898	**113**

Table 2: Selangor Phase 1 Target Achievement

Phase 2 is now (June 2002) in its third year. During the first two years all targets were overachieved. Figure 4 below shows the annualized performance targets and the actual performance achievements during years one and two.

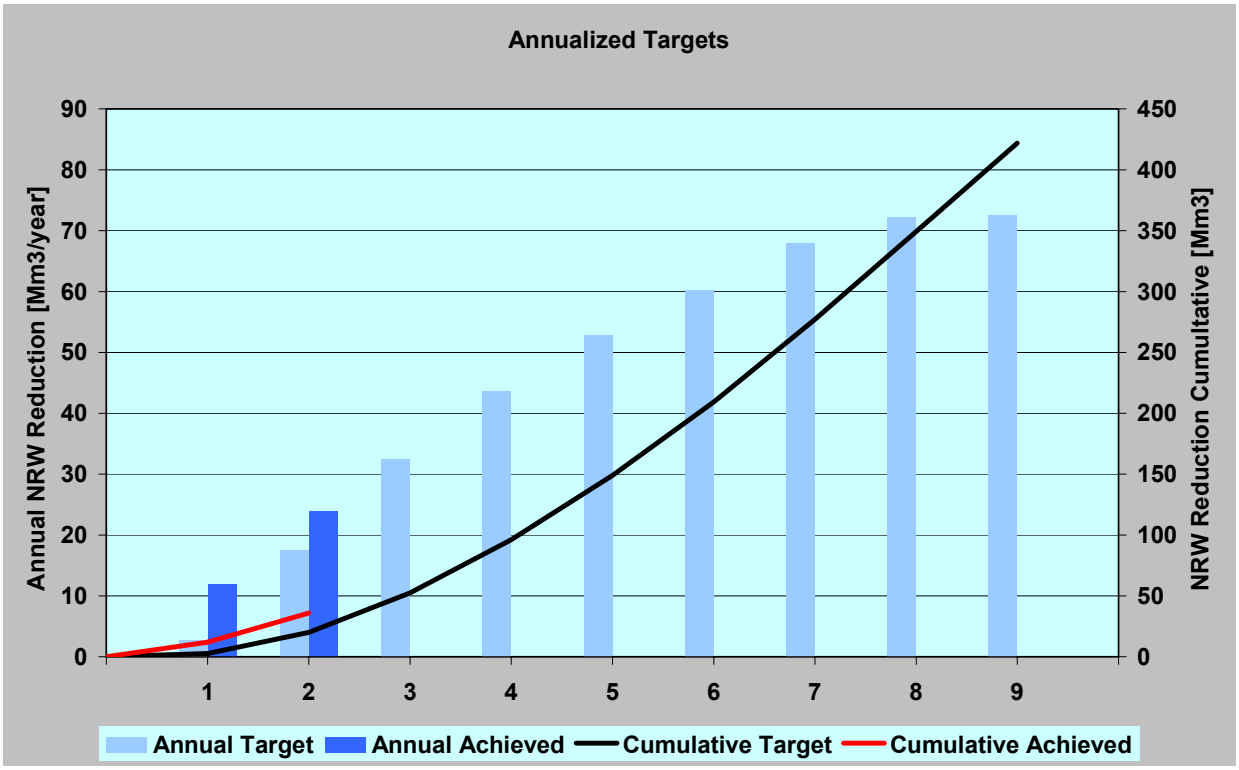

Figure 4: Annualized Performance Targets and Achievements

General Applicability of the Approach

During the last couple of years this concept has been promoted in several other countries. Proposals have been prepared for projects in the Middle East based on this approach. Wherever water resources are limited and/or raw water is expensive, the concept of performance based loss reduction is an ideal option for water utility managers to bring the NRW situation quickly under control and without any commercial risks.

Loss reduction will pay for itself and it is possible for the contractor to offer to fund the project, whilst the Client will pay the investments back according to the savings made. Depending on the marginal cost of water, the potential of additional sales and other influencing factors, payback periods of 5 to 8 years can be anticipated.

This concept would be ideally suited for utilities in the southern part of the United States, where the use of water resources is already reaching critical levels.

Steps to be taken

The following schedule outlines a possible project development time schedule.

Start: Initial discussions with the utility management, in order to assess the general feasibility of the approach and the specific needs of the Client. Analysis of any existing data.

Month 1: Based on this rapid assessment, submission of a concept paper.

Month 2: Invitation to submit a Proposal

Month 3: Technical Field Study (free of charge) in order to verify available data and carry out a few additional measurements. Establishment of a water balance according to IWA recommendations ([2,3])

Month 5: Submission of Draft Proposal

Month 6: Discussion of Draft proposal with the Client, preparation of detailed financing concept

Month 7: Submission of Final Proposal

Month 9: Contract Negotiations

after 10-12 months: possible contract start

Conclusions

Our experience in Selangor has demonstrated that Performance Based NRW Reduction contracts work well. They are effective in meeting desired NRW reduction targets and offer utilities an alternative proven approach to driving down NRW levels with short pay-back periods and no risk to the water utility.

This type of contract will prove to be particularly beneficial to utilities with water resource constraints, who are unable to bring NRW levels under control themselves, because the successful achievement of NRW reduction targets will often allow the utility to defer major capital investment in developing new water resources and treatment facilities.

We believe that this type of contract will be attractive to many utilities around the world and that it offers US water utilities in areas where water resources are constrained, particularly in the southern states another water conservation option.

References

(1) Liemberger R. (2001) Performance Target Based NRW Reduction Contracts – A new Concept Successfully Implemented in Southeast Asia. IWA World Water Congress, Berlin http://www.iwaponline.com/ws/00204/ws002040021.htm

(2) Alegre H., Hirner W., Baptista J.M. and Parena R. (2000) Performance Indicators for Water Supply Services. IWA Manual of Best Practice. ISBN 900222272

(3) Lambert A. and Hirner W. (2000): Losses from Water Supply Systems: Standard Terminology and Recommended Performance Measures. www.iwahq.org.uk/bluepages