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SUSTAINABLE DEVELOPMENT OF WATER RESOURCES, WATER SUPPLY AND ENVIRONMENTAL SANITATION

A Case Study on Leakage Management in Sandakan, Malaysia

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With population growth, global warming and rapid development, water has become or will become a scarce resource. It is predicted within 20 years, almost a third of the world's population will have insufficient supply of water. There is an increasing awareness around the world that careful management must be applied when handling this valuable resource. As such prevention of water from leaking in the distribution system has become a major concern for water utilities world-wide. This paper details some of international best practices available in determining, comparing and managing water leakages in distribution system, and how they are being applied in managing leakages in Sandakan, since the project commenced in year 2003.

Introduction

In April 2003, Jabatan Air Sabah (Sabah Water Board, a State owned Government agency and sole distributor for water in the Sabah State, Malaysia) awarded the Sandakan NRW Reduction Project to a Malaysian company, Salcon Engineering Berhad (Salcon), with the aim to reduce real losses in the distribution system and to alleviate the water supply shortage problem. This was achieved by expanding the existing active leakage control activities and replacing the worst mains that required replacement. The timescale for the project was 30 months, from April 2003 to October 2005.

IWA water balance and performance indicators

Non- Revenue Water, more commonly known as NRW, is the difference between the volume of water put into a distribution system and the volume of water billed to customers. NRW consists of three components: real losses, apparent losses, and unbilled authorized consumption. Standard water balance adopted by IWA Water Loss Task Force (WLTF) was used to undertake a top down water audit to determine the various components of NRW in the Sandakan water supply system at the beginning of the project. The 95% confidence limits were added to the calculation. The water balance is

Table 3. IWA Standard Water Balance & Terminology (Year 2003 Data)

System Input Volume 28,408ML 100%	Authorised Consumption 14,477ML 51%	Billed Authorised Consumption	Billed Metered Consumption	Revenue Water
			Billed unmetered Consumption	
		Unbilled Authorised Consumption	Unbilled Metered Consumption	Non-Revenue Water (NRW) 13,939ML 50%
			Unbilled unmetered Consumption	
	Water Losses 13,931ML 49%	Apparent Losses	Unauthorised Consumption	
			Customer Meter Inaccuracies and Data Handling Errors	
		Real Losses 19,940ML 38%	Leakage on Transmission & Distribution Mains	
			Leakage and Overflow at Reservoirs and Elevated Tanks	
			Leakage on Service Connections up to Metering Points	

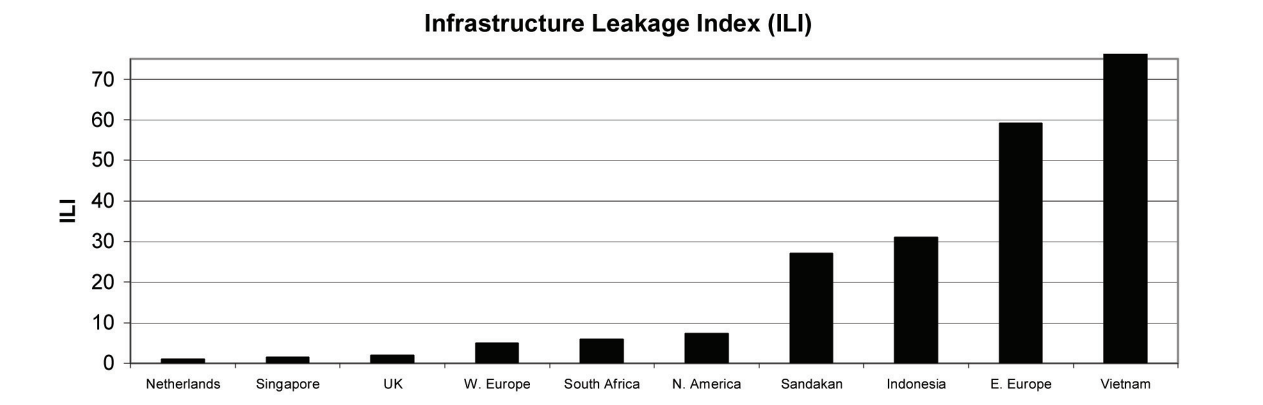

Figure 1. Comparison of ILI from Different Countries

illustrated in Table 1. Real losses comprise of water leaking from mains, service connections, reservoirs, and reservoir over-flow. Apparent losses include unauthorized consumption, metering inaccuracies and data handling errors. Unbilled authorized consumption is normally a small component of NRW, includes items such as fire-fighting, mains flushing, filling of water tankers etc.

Quoting NRW and leakage as % of System Input is a very misleading indicator. Performance indicators most commonly used by IWA, i.e. volume of real losses/connection/day) and Infrastructure Leakage Index – ILI (Farley and Trow, 2003) were used to calculate and compare with international data sets.

The ILI for Sandakan system in year 2003 was calculated to be 27, and the real loss was 666 litre/connection/day. Figure 1 shows the comparison of ILIs with different parts of the world.

Real losses reduction

The measures taken by various water authorities to curb real losses may range from simple but ineffective Passive Leakage Control, responding only to reported leaks, to the latest strategy of applying the leakage management activities, such as the four fundamental leakage management activities (shown in Figure 2) introduced by the UK Leakage Control Initiative. All these four activities were implemented in the Sandakan NRW Reduction project.

Active leakage control (ALC)

The function of active leakage control or ALC is to suppress the level of leakage by actively detecting unreported leaks/burst and repairing them, and continuous monitoring of the leakage level in the water distribution system (WRc, 1994). ALC was implemented in Sandakan by applying the following methodology:

Zoning

The zoning concept is introduced to monitor the flow of water from source to consumer. The zonal monitoring system enables the engineer to understand and operate a complicated network by dividing them into smaller areas. This allows precise prediction of demands, better leakage management and control. Such a subdivided area is commonly known as a District Meter Area or DMA. Ideally, each of the DMA will contain 500 to 2000 properties, and is fed via a single main.

The objective of establishing DMAs is to identify, measure and control real losses within each DMA. Given that leakage runtime is arguably the most important contributing factor to real losses, early awareness and detection of leakage is critical in reducing real losses. Once established, a functional DMA with appropriate flow meter and pressure transducer coupled with data logger, can provide the information required to identify unreported bursts rapidly as they occur.

DMA determination should be planned in view of practicality, continuity and sustainability as the principle criteria. In Sandakan, a total of 56 numbers of DMAs were commissioned. The DMAs were comparatively small, compared to those set up in other systems. It is due to the critical demand, supply and pressure problems that exist. On average, each DMA contains about 500 properties.

Leakage Monitoring

Leakage monitoring with DMA, is known for its efficiency and cost effectiveness worldwide. It can be applied to all

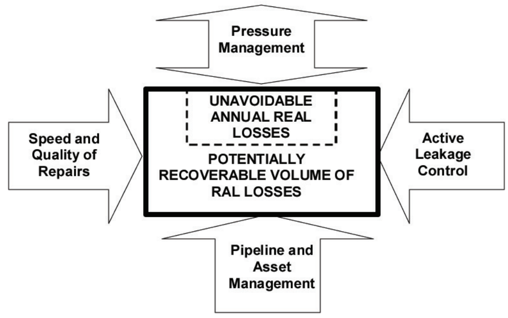

Figure 2. The 4 fundamental activities of leakage control

types of networks, even in systems with supply deficiency like the Sandakan system.

The advancement of flow and pressure measuring and logging techniques and equipment enables continuous measurement of total daily inflow and minimum night flow, MNF, at close intervals. Under normal circumstances, MNF occurs at the time window from 2:00am to 4:00am in Sandakan. Within this period of time, the legitimate consumption is at the lowest, and leakage is at the maximum.

By deducting the legitimate night consumption of domestic consumers, which is estimated at 8 l/property/ hour, and any large consumers (data obtained from data logging or direct reading), the remainder may be assumed as the system losses. The MNF may vary from area to area due to their differences in nature, say residential or commercial, and from different time of the year, eg. Moslem Fasting month. It is worth mentioning here that in Sandakan, more than half of the DMAs did not have diurnal profiles, due to suppression of flow as a result of insufficient supply. Under such circumstances, the total inflow of these DMA was used for water loss analysis instead of MNF.

Leakage Detection

From the analysis of DMA flow and pressure data, DMAs with leakage level that exceeded the Economic Leakage Level (ELL) were identified, leak detection team was deployed into these areas to search for leaks.

Leak detection teams would employ either one or a combination of the following techniques to detect leaks:

- Visual inspection and sounding on pipe work and fittings
- Using cluster of sound loggers to localize the leaks
- Using electronic equipment such as leak noise locator or leak noise correlator to detect invisible leaks.

Speed and quality of repairs

When a leak was detected and located, it was repaired as soon as possible to minimise the volume of water lost. Apart from speed, it was important to ensure that all repairs were carried out with approved materials, competent workmen, and under proper supervision.

Pressure management

It has been proven in laboratory and field-tests that the rate of leakage and burst frequency is a function of pressure applied. As such, pressure management is considered as the cheapest and most effective means of reducing leakage, and it is best undertaken in conjunction with established DMAs depending on the topography of the area.

In Sandakan, pressure-reducing valves (PRV) were installed at the inlet or within the DMA, to prevent the increment of zonal pressure after leak repair and reduce excessive pressure in the zone. The effectiveness of a pressure management scheme implemented at Tmn Rimba in

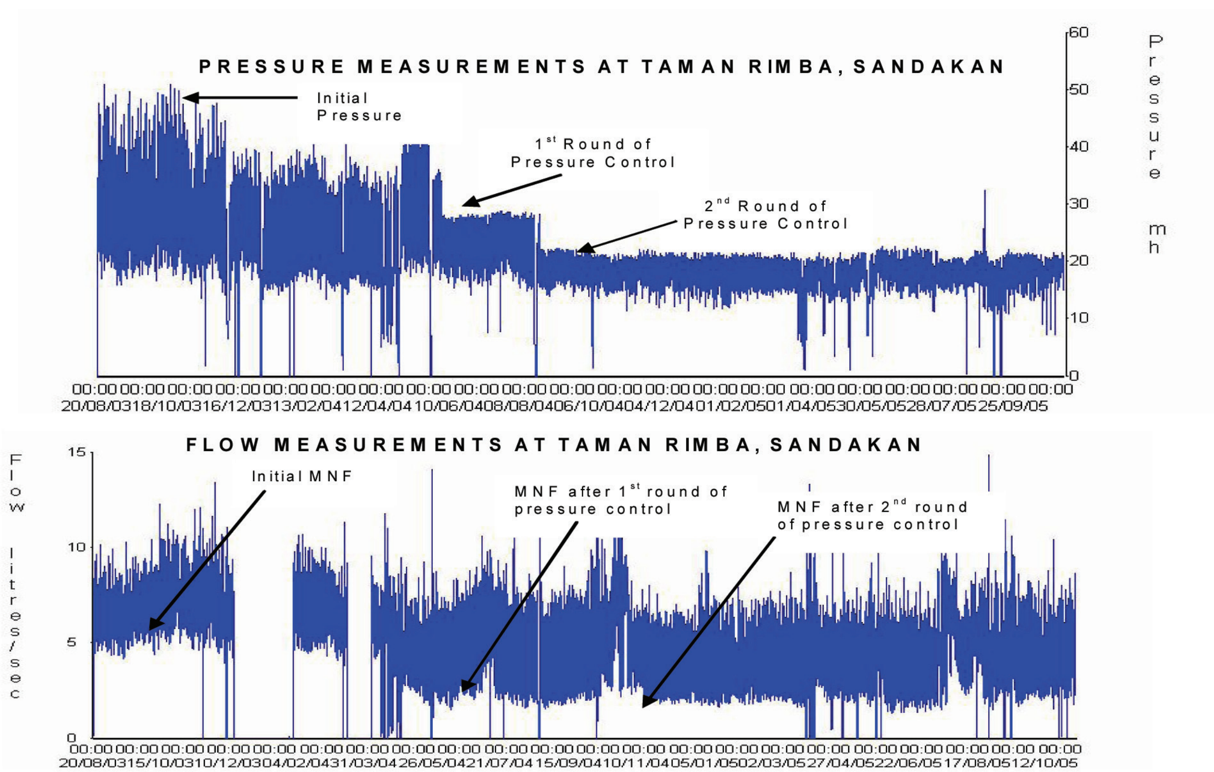

Figure 3. Result of Pressure Management in Taman Rimba, Sandakan

Sandakan is illustrated in Figure 3. MNF reduced as a result of pressure reduction.

Pipeline and asset management

Pipeline and asset management involves maintenance, rehabilitation, and renewal of defective mains and service connections. The rehabilitation and upgrading of a network system is deemed necessary when it experiences excessive frequency of pipe bursts or insufficient hydraulic capacity resulting in poor supply. Similarly, in a water supply system, it is a fundamental requirement to have a mapping system that enables proper record keeping and data retrieval, such as the Geographical Information System (GIS). It will be an added advantage if there is a calibrated network model, which can simulate its hydraulic behaviour accurately. Both GIS and network model were available and updated for the Sandakan water supply system.

The general condition of the mains, service connection, tanks, and reservoirs are significant factors that will affect the leakage level. When the network has experienced high burst frequency and poor hydraulic performances, it will become too costly to maintain, and has to be rehabilitated or replaced. Rehabilitation and upgrading of pipeline is a costly affair, and require proper consideration and planning. In order to justify the decision in the pipe replacement scheme in Sandakan, the following factors had been considered:

- Burst frequencies
- Pipe materials, such as the aged AC pipes
- The requirement to lower the level of leakage and elevate hydraulic performance
- The availability of finance and other resources.

In Sandakan, about 15% of the old mains were replaced during the course of this project. About 3600 numbers of communication pipes (10% of total legal connections) located along the mains that underwent replacement were also replaced at the same time.

However it is important to realize that with pipe replacement alone, without proper monitoring, maintenance, and pressure management, NRW will eventually rise to the level of leakage before the pipe replacement program. Hence it is vital to implement a holistic NRW control program.

Project performance

After implementation of leakage reduction activities mentioned above, at the end of the project period, the performance of the system was evaluated as follows:

- Volume of water saved : 15.38 Million Litre / Day
- ILI = 17
- Real losses : 376 litres/connection/day
- % of NRW : 35% of Input Volume

In consideration that good results have been achieved in this project, JAS has awarded Phase 2 of the NRW reduction program in February 2006 to Salcon, with the aim to increase the coverage of DMAs, reduce apparent losses, increase level of pressure management, pipe replacement and increase efforts on training and technology transfer.

Continuity and sustainability

Once the targets have been met, the key issue is then the maintenance of leakage level at the sustainable level. All aspects of leakage management requires constant effort if leakage is to be kept in a reduced state. Leakage never goes away, it is something which requires constant attention, or else its levels would rise or even surpass the level before the leakage reduction program, wiping out much of the work and investment. Hence it is essential that the following be considered:

- A link between realistic objectives and resource strategies. Ensuring appropriate staffing levels to carry out the required works
- Some of the project staff to transfer to the water utility at the completion of the project
- Staff education and ongoing training. Training of staff in new skills and techniques features highly in developing a leakage management strategy and to ensure long-term sustainability. In the Sandakan Project, JAS staffs were seconded to the project team to be trained on-the-job.
- Appropriate funding for operation and maintenance to carry out speedy and quality repairs as well as continuous pipe renewal program
- Assessing and monitoring performance

NRW reduction is a continuous battle and the effort should be maintained to keep the NRW level at an acceptable and sustainable level.

Conclusions

In the past, NRW control and management has been sidelined in the daily operations of the water distribution network. Today, diminishing resources, increasing demand and the need for higher level of consumer services has put NRW control back in the limelight. As recognised internationally, it should be treated as a major component of day-to-day water distribution network operations.

In the Sandakan NRW Reduction Project, the latest methodology in leakage control has been implemented with promising results. As indicated by the performance of this project, with proper planning and implementation, the level of NRW can be lowered and sustained at a justifiable level by any water utilities companies.

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