# Best practice performance indicators: a practical approach

Water Loss

IWA TASK FORCE

● In this eighth article in a special series for *Water21* by the IWA Water Loss Task Force, **RONNIE MCKENZIE** and **ALLAN LAMBERT** highlight practical developments over the last decade with regards to performance indicators for non-revenue water and water loss components.

A clearly defined water balance is the first essential step in assessing volumes of non-revenue water and managing water losses in potable water distribution systems. In July 2000, the IWA Task Force on performance indicators and water losses published a standard international 'best practice' water balance, as shown in Figure 1. This water balance has since been recognised and adopted as international 'best practice' by a steadily increasing number of countries and water utilities throughout the world.

In addition to the standardised water balance, the task force also proposed several key 'best practice' performance indicators (PIs) for:

- non-revenue water
- water losses
- apparent losses
- real losses

Of particular significance is the use of the term 'non-revenue water' in place of the widely used 'unaccounted-for water', due to the scope for misinterpretation and manipulation associated with the latter term. It is only necessary to observe publications from around the world to see how the definitions and calculations of 'unaccounted-for water' vary from one country to another. The term 'non-revenue water' is clear and unambiguous, even to non-specialists.

While some healthy debate still continues around the world, the IWA approach of selecting different PIs for different purposes - financial, operational, and water resources – is a clear step forward. In each case, PIs have been recommended for both basic and detailed levels within each category (intermediate PIs have also been proposed in some cases but, to avoid confusing the issue even further, this article will concentrate on only a few of the key and most useful PIs relating to water losses and non-revenue water).

Some discussion on each of the PIs listed in Table 1 is provided below.

*Figure 1: The IWA's 'best practice' standard water balance*

**Figure 1 The IWA 'best practice' standard water balance**

| | | | | |
|---|---|---|---|---|
| System Input Volume (corrected for known errors) | Authorised consumption | Billed Authorised Consumption | Billed Metered Consumption (including water exported) | Revenue Water |
| | | | Billed Unmetered Consumption | |
| | | Unbilled Authorised Consumption | Unbilled Metered Consumption | Non-Revenue Water (NRW) |
| | | | Unbilled Unmetered Consumption | |
| | Water losses | Apparent Losses | Unauthorised Consumption | |
| | | | Customer Metering Inaccuracies | |
| | | Real Losses | Leakage on Transmission and/or Distribution Mains | |
| | | | Leakage and Overflows at Utility's Storage Tanks | |
| | | | Leakage on Service Connections up to point of Customer metering | |

**Non-revenue water: financial PI**

Although 'percentage by volume' has traditionally been widely used as a PI for many components of the water balance (including non-revenue water), it can be very misleading as it is strongly influenced by:

- differences and changes in the volume of consumption

**Table 1: Details of Selected Key PIs**

| Component | Type | Basic PI | Detailed PI |
|---|---|---|---|
| Non- Revenue Water | Financial | Volume of NRW as % of System Input Volume | Value of NRW as % of cost of running system |
| Real Losses | Water Resources | Volume of real losses as % of System Input Volume | |
| Real Losses (In each case, this PI is calculated per day when the system is pressurised to allow for the effect of intermittent supply) | System Operational | litres/service connection/day for systems with 20 or more services/km mains (32/mile) | The Infrastructure Leakage Index: defined as the Ratio of the Current Annual Real Losses to the Unavoidable Annual Real Losses = CARL/UARL This indicator is fully explained by Lambert et al,1999 |
| | | Use $m^3$/km mains/day for systems with fewer than 20 services/km of mains | |
| Apparent Losses | Operational | | $m^3$/service connection/year |
| Water Losses | Operational | $m^3$/service connection/year | |

## Table 2: Comparison of basic and detailed NRW financial PIs for a Canadian system

| NRW component | Volume as % of system input volume | Marginal cost ($/m³) | Value as % of annual system running cost |
|---|---|---|---|
| Unbilled authorised Consumption | 1.06 | 0.0440 | 0.08 |
| Apparent losses | 1.25 | 0.2550 | 0.57 |
| Real losses | 17.72 | 0.0447 | 1.41 |
| Non-revenue water | 20.03 | | 2.06 |

- intermittent supply
- the presence or absence of customer storage tanks [which usually result in significant under-recording of customer meters (Lambert, 2002)]

While 'percentage by volume' is still recommended as a basic financial PI for non-revenue water, and a basic PI for real losses from a water resources viewpoint, it should definitely not be used for assessing any aspect of operational performance management of water losses (other components of the water balance, and where possible the recommended PIs given in Table 1, should be used).

The detailed financial PI for non-revenue water is based on the 'percentage by value' of the water, rather than the 'percentage by volume'. A simple example of a typical calculation is provided in Table 2, which highlights the differences between the two PIs for non-revenue water.

**Real losses: water resources PI**

The basic water resources PI recommended in a previous feature of *Water21* (Lambert, 2003) is 'real losses by volume' = volume of real losses as a percentage of system input volume

No further work has been done on this PI by the Water Losses Task Force since 2000. As previously mentioned, percentages by volume are strongly influenced by differences and changes in consumption. If improvements to this PI are to be considered, it would be useful to assess whether or not the 'real losses' become available for re-use.

**Real losses: operational PI**

The IWA Best Practice Report (Alegre *et al*) clearly states that 'percentages by volume' are unsuitable for assessing the efficiency of operational management of real losses. This conclusion has been endorsed by many organisations throughout the world, including Ofwat in England/Wales, the national regulator in Malta, AWWA in North America, WSAA in Australia, NZWWA in New Zealand, and DWAF in South Africa.

As comparatively few systems have less than 20 service connections per kilometre, 'litres per service connection per day' is the preferred basic operational PI for most distribution systems. This basic PI is the best of the 'traditional' PIs but has certain limitations, as it does not allow for the following:

- density of connections (per kilometre of mains)
- length of service pipe between the main and the customer meter
- average pressure (leakage rates vary approximately linearly with pressure for systems with mixed pipe materials)

To address these deficiencies, a detailed operational PI for real losses was developed and is referred to as the infrastructure leakage index (ILI). This relatively new PI is the ratio of the current annual real losses (CARL) to the unavoidable (technical minimum) annual real losses (UARL) and is discussed in detail by Lambert et al, 1999.

The ILI measures how effectively a utility is managing real losses under the current operating pressure regime. However, it is important to note that this does not imply that the pressure management is optimal - it is usually possible to reduce the volume of real losses (but not the ILI) by improved active pressure management. This 'twin track' approach to leakage management directly addresses comments that the ILI somehow favours water utilities operating at high pressures and discriminates against those that implement strict pressure management measures.

Once again, this is the subject of considerable debate. However, the speed at which water utilities throughout the world have adopted the ILI as their preferred PI for real losses is clear testament to its value in the water industry. The ILI has in fact been the subject of many workshops and is included in many water balance models, including BENCHLEAK (McKenzie and Lambert, 2002), BENCHLOSS (McKenzie et al, 2000), BENCHLOSSNZ (Lambert and McKenzie, 2002), AQUALIBRE (Liernberger and McKenzie), FASTCALC (see reference), as well as many other similar models developed and used throughout the world by various water utilities or water distribution specialists.

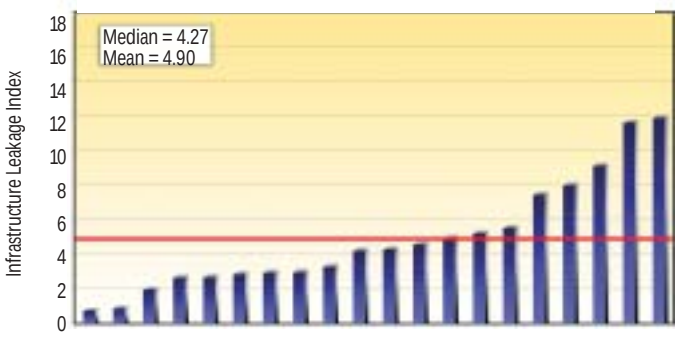
Since the ILI was first introduced in 1999, it has been calculated in an increasing number of countries, as shown in Figure 2. Theory and experience both show that it can be used with confidence for comparisons at international, national, state and within-system levels, for systems with:

- more than 5000 service connections
- more than 25m pressure, on average, throughout the system
- more than 20 service connections per kilometre of mains.

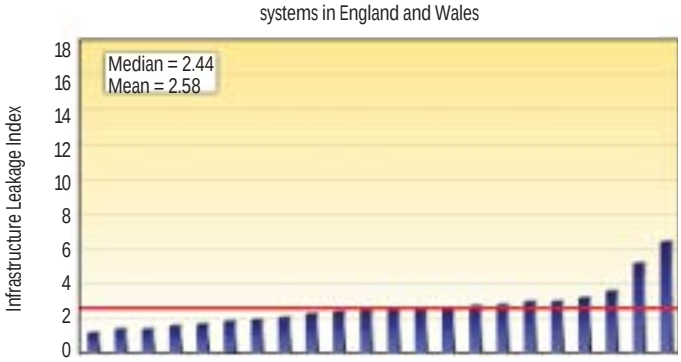
**Apparent losses: operational PI**

The operational PI for water losses (the sum of real and apparent losses) and apparent losses in the 2000 PIs report (Alegre *et al*) was $m^3$/service connection per year (to provide consistency with the basic PI for real losses). However,

Infrastructure Leakage Index values for 20 supply systems in North America / Canada




Infrastructure Leakage Index values for 22 supply systems in England and Wales



numerous international applications of the water balance since 2000 have identified a need for more specifically focused practical operational PIs for unbilled authorised consumption (UAC), and the components of apparent losses (AL). When auditing and comparing volumes attributed to UAC and AL, it is necessary to check that these components are not excessive.

A practical approach undergoing further testing by the performance indicators team of the task force is to use 'percentage of water supplied' as a PI for checking the unbilled authorised consumption (metered and unmetered), and the unauthorised consumption. The most meaningful practical PI for the remaining component of apparent losses – mainly customer meter error – is likely to be 'percentage (+/-) of registered metered consumption', as this is the usual basis for presenting results from systematic testing of randomly selected customer meters.

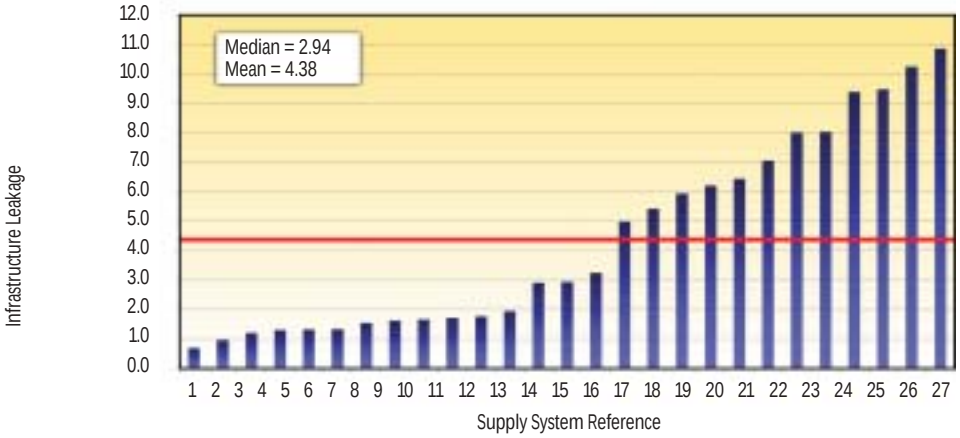
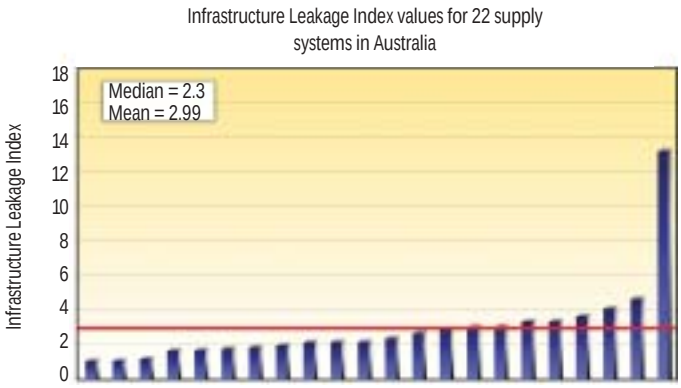
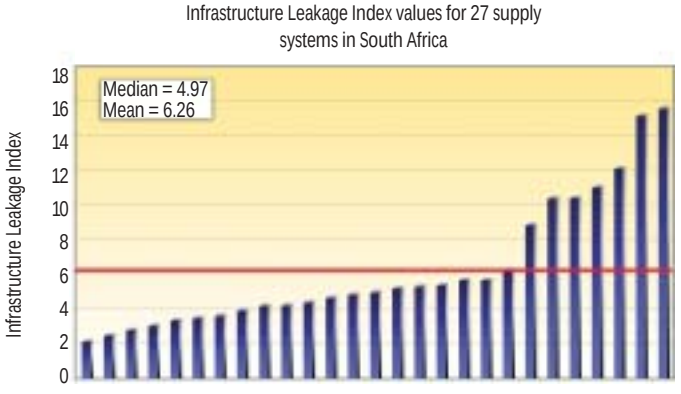



*Figure 2: ILI results for 27 systems from 20 countries. (Figures courtesy Allan Lambert and IWDC Ltd)*

**Other ongoing initiatives**

Consideration is being given to possible revision of the definition of 'number of service connections' in complex situations, including aspects such as fire service connections and fire hydrants separated from the main by lateral connections. These and other aspects will be discussed as part of a task force workshop planned for the IWA Marrakech symposium in September 2004. ●




**References**


*Alegre H, Hirner W, Baptista JM, Parena R, July 2000. Performance indicators for water supply services. IWA Manual of Best Practice. ISBN 9002222723*

*Brothers, K, May 2003. A practical approach to water loss reduction. Water21 magazine. (www.iwapublishing.com/template.cfm?name=w21jun03)*

*Fastcalc: water balance and Pis software with 95% confidence limits. Customised versions to date for Australia, Brazil, Canada, Italy, Morocco, UK and US. For further details contact AOandJGLambert@aol.com*

*Lambert A, 2002. International report on water loss management and techniques. Water Science and Technology: Water Supply, Vol 2 No 4 pp1-20.*

*Lambert A, August 2003. Assessing non revenue water and its components: a practical approach. Water21 magazine (www.iwapublishing.com/template.cfm?name=w21aug03).*

*Lambert A, Brown TG, Takizawa M, Weimer D, December 1999. A review of performance indicators for real losses from water supply systems. AQUA, Vol 48 No 6. ISSN 0003-7214*

*Lambert A, McKenzie R, 2002. Benchmarking of water losses in New Zealand (incorporating the user manual for the BenchlossNZ software: version 1A)'. User New Zealand Water & Wastes Association Manual ISBN 1-877134-35-X; ISBN for CD is 1-877134-39-2. water@nzwwa.org.nz*

*Liemberger R, McKenzie R, April 2003. Aqualibre: a new innovative water balance sSoftware. IWA and AWWA conference on efficient management of urban water supply, Tenerife. For further details contact mckenzie@global.co.za or roland@liemberger.cc*

*McKenzie R, Lambert A, August 2000. Benchmarking of water losses in Australia: Benchloss user guide. Report prepared for the Water Services Association of Australia.*

*McKenzie R, Lambert A, January 2002. Development of a simple and pragmatic approach to benchmark real losses in potable was distribution systems in South Africa: Benchleak. Report TT159/01 published by the South African Water Research Commission. ISBN 1 86845 773 7*


**Authors' note**

The scope of this series of articles 'A practical approach to water loss reduction' was outlined in a previous issue of *Water21* (Brothers, 2003) by Ken Brothers, Chair of the Water Losses Task Force (WLTF). This article outlines the latest developments in WLTF thinking on best practice performance indicators (PIs) for non-revenue water, real losses, unbilled authorised consumption and apparent losses.

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