DISTRIBUTION OF LEAKAGE IN UNITYWATER'S WATER SUPPLY INFRASTRUCTURE

TOP DOWN AND BOTTOM UP WATER BALANCES FOR UNDERSTANDING REAL LOSSES DISTRIBUTION

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ABSTRACT

Unitywater is a water distribution and retail utility in South East Queensland, Australia. It operates and maintains approximately 6,000 km of water mains servicing a population of over 700,000 people in the rapidly growing area north of the city of Brisbane. Real losses in the network have been estimated at 70 Litres/ service connection/day, though the rate varies markedly between the northern and southern regions. To better understand whether or not the calculated real losses were accurate, a review of the top-down water balance calculation was conducted. In addition, a bottom-up assessment was done to try and quantify the relative contributions to leakage from the various components of the network (i.e. reservoirs, trunk mains, reticulation mains, service connections etc). The top-down review resulted in a lower overall reportable real loss figure of 52 Litres/service connection/day, largely arising from the higher than expected under-registration of the retail meter fleet. The bottom-up assessment confirmed that the difference in leakage rates calculated for the northern and southern regions is real, and that service connections are the major contributor to these losses.
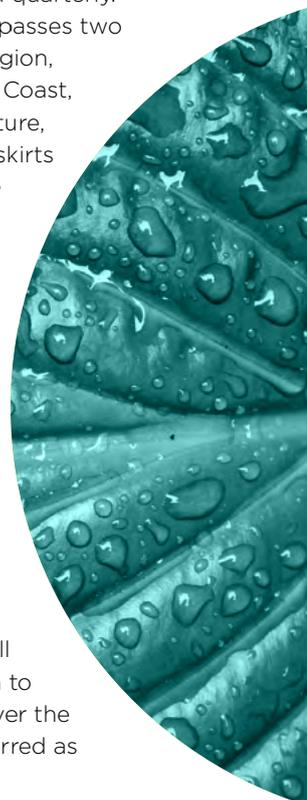
Key words: Water distribution network, distribution of leakage, water balance, component level assessment, apparent losses, real losses, metering accuracy, leak detection survey.

INTRODUCTION

Unitywater is a water distribution and retail utility in South East Queensland, Australia. It operates and maintains approximately 6,000 km of water mains servicing a population of over 700,000 people in the rapidly growing area north of the city of Brisbane. There are approximately 300,000 retail customers in the supply area and customers are metered and billed quarterly. Unitywater's water supply network encompasses two distinct regions, including the Northern Region, covering towns and cities on the Sunshine Coast, and the Southern Region covering Caboolture, Redcliffe and suburbs on the northern outskirts of Brisbane. These regions are comparable in terms of serviced population, network size, pipe materials and age, though network pressures are on average about 10 metres higher in the north. However, real losses measured in each region are significantly different – typically being about 90 L/conn/day in the Northern Region compared with 55 L/conn/day in the Southern Region. Overall, Real Losses across Unitywater's service area averages about 70 L/conn/day.

In accordance with its Corporate Strategic Plan, Unitywater has been pursuing initiatives to reduce leakage from an overall level of 70 L/service connection/day down to a target of 50 L/service connection/day over the next 10 years (service connections are referred as "conn" from here on).

The main driver for the leakage reduction is the rising bulk water unit price, which is at $2.68 per kilolitre in 2016. However, to help direct appropriate activities and to achieve this target it is necessary to better understand both;

◗ the top-down water balance calculation, in order to provide a greater level of confidence that the results, particularly at the regional level, reflect the level of real losses present in the network, and;

◗ the actual distribution of these real losses across the various infrastructure components of the water supply network.

To that end, over the last 3 years a review of the assumptions used in the top-down water balance calculation has been conducted to improve the level of certainty associated with the overall leakage result. In addition, a "bottom-up" or Component Analysis (IWA Task Force 2003) has been carried out to try and quantify the relative contribution to the overall leakage result by the various elements of the water supply network (i.e. reservoirs, trunk mains, reticulation mains, service connections, etc). This paper reports findings from these two assessments.

TOP-DOWN WATER BALANCE MODEL ASSESSMENT
IWA Top-Down Water Balance Model

Unitywater has adopted the International Water Association (IWA) top-down water balance model as the basis for determining Non-Revenue Water (NRW). According to the IWA top-down water balance approach, real losses (leakage) from a water supply network can be estimated by the equation provided below.

As noted in the equation, each element of the top-down water balance equation is either measured, or assumed. Both processes have the potential to introduce errors and inaccuracy. In the absence of local data, the IWA water balance model provides guideline estimates based on available international data to assist water utilities to complete the water balance calculation (Lambart and Hirner 2000).

Real Losses =			
Water Imported	**Billed Authorised Consumption**	**Unbilled Authorised Consumption**	**Apparent Losses**
(Measured Volume from bulk supply meters)	(Measured Volume, which generate revenue; mostly retail meters)	(Assumed Volume according to IWA definitions)	(Assumed Volume according to IWA definitions)

Water Services Association of Australia (WSAA) (2014) recommended these estimates as:

1. Unbilled Authorised Consumption (e.g. maintenance flushing), estimated as 0.5% of the total water supplied to the scheme, and

2. Apparent Losses, consisting of;

   a. Unauthorised consumption (theft), estimated as 0.1% of the total water supplied in the scheme

   b. Customer metering inaccuracies estimated at 2% under-registration.

The limitation with such assumptions is that the actual Unbilled Authorised Consumption and Apparent Losses can vary significantly from community to community (Al-Omari 2011). As part of the review of the top-down calculation, each element of the above equation was examined to identify;

◗ where measurement data was being used, whether it was sufficiently accurate, and;

◗ where assumptions are being made, whether data is available that might allow those assumptions to be verified or modified.

A summary of this assessment is provided below;

Apparent Losses

Apparent losses are caused by water theft, data handling errors and retail meter inaccuracies. Apparent loss control in water supply systems is also not well developed as more emphasis has been on the estimation of real losses in the past (McKenzie and Seago, 2005; Fanner et al. 2007).

Water Theft

Evidence of theft is largely anecdotal, with an occasional large suspicious out-of-hours usage recorded in DMA flowmeters. The main contributors to theft are thought to be:

1. Filling of water carriers using unauthorised mobile hydrant standpipes. Evidence of this appears occasionally from DMA flow meter data tracked by TaKaDu.

2. Use of fire service connections (typically fire hose reels) for internal use of water for commercial premises (In Unitywater, the majority of fire flow connections are not metered and should only be used for emergencies)

Overall there was insufficient data available to make a sensible assessment of the amount of water lost over the year by theft.

There was however, nothing in the limited data available to suggest that losses via theft are excessive, and on that basis the figure in the WSAA guideline of 0.1% of the total water supplied will continue to be used in the top-down leakage calculation.

Retail Meter Inaccuracy

Unregistered flows through the retail meter fleet include;

◗ non-registered volumes below the rate at which the meter first starts recording, and

◗ under-registered volumes, being the meter inaccuracy of the flows that are being recorded

The total unregistered volume can be expressed as;

Unregistered volume = under-registration volume + non-registration volume (Mukheiber et al. 2012)

A fleet of water meters not only becomes less accurate with age and usage (Xin et al. 2014), but also less able to register low flows. Both these impacts result in higher apparent losses (Arregui et al. 2006). The impact of these unregistered volumes on the apparent losses for Unitywater is discussed below.

Under-registered volume

As part of developing a meter replacement strategy, Unitywater and Queensland Urban Utilities conducted a comprehensive program of testing meters to identify performance degradation curves for the existing retail meter fleet. A statistically representative sample was tested for each meter size, model and age (two-year age bands) across the meter fleet. Xin et al. (2014) concluded based on review of available literature that metering inaccuracies have been found to be significant components of apparent losses. The customer meter inaccuracies can be estimated by meter tests at different flow rates that represent typical customer water use rates and meter guidance manuals (WLCR 2007; Farley et al. 2008; Mutikanga et al. 2010).

To determine the accuracy of the meters, a ten-point flow rate test was used. These test results were combined with actual customer water use (flow rate) patterns to determine the effective decay of meter accuracy under operational conditions. By combining these two parameters it was possible to determine the overall accuracy of the existing retail meter fleet.

The testing program indicated that the overall error in the retail meter fleet is an under-registration of 5%. This is considerably more than the 2% currently used in the top down water balance calculations (Itron 2016). This finding has a significant impact on the level of reportable Real

Losses and is discussed in further sections.

Non-registered volume

Mechanical water meters have a minimum registration flow rate (Qs) below which flows are not able to measured (Britton et al., 2013). Mukheiber et.al. (2012) established that Qs for a new (DN20) meter is up to 3 L/hr, and for older meters with 3000 KL usage, up to 7 L/hr.

Note, these low flow rates are not necessarily caused by internal leaks, with at least some element associated with low flows generated at the end of tap and toilet cistern operation (Arthuraliya et al. 2012). Nevertheless these flows are unrecorded in the property meter, but are recorded collectively across the scheme in bulk meters. They would therefore appear as leakage in the top-down assessment.

Mukheiber et al. (2012) developed a sliding scale for non-registration of 20 mm meters based on meter testing from three Melbourne utilities. This investigation established that the average non-registered flow, as a percentage of total consumption, was 1.0% for new meters, and 3.5% for aged meters with 3000 KL usage.

However, whilst this data does indicate the potential significance of non-registered volumes, it does not directly relate to Unitywater meter fleet. At the moment therefore, non-registration of meters has not been quantified in the assessment of Apparent Losses for Unitywater.

Unbilled Authorised Consumption

Unbilled Authorised Consumption is the legitimate use of water (e.g. mains flushing) which may or may not be metered, but which does not generate any revenue.

According to the IWA water balance (Lambart and Hirner 2000), Unbilled Authorised Consumption can be divided into two sub-components; Unbilled Metered Water, and Unbilled Unmetered Water. Investigations were carried on both sub-components to estimate actual volumes.

Unbilled Metered Water

For Unitywater, Unbilled Metered Water relates to water consumed at Unitywater's own facilities. These facilities include, offices, pumping stations, reservoirs, sewerage treatment plants, depots, etc. Over the last 5 years, all water supplies to these facilities have been fitted with meters which are read each quarter. Recorded volumes are included in the top-down water balance calculation.

Unbilled Unmetered Water

Unbilled Unmetered Water is more difficult to identify. This sub-component includes water used for operational and maintenance purposes. A detailed investigation was carried out for two water supply scheme areas (Noosa and Redcliffe with 17,300 and 21,000 service connections respectively) to estimate the volume of water used for unbilled unmetered activities. Estimates were derived for the volume of water used for following activities;

1. Routine flushing and scouring of mains.
2. Special activities, such as hydrant tests for network model calibration, Unidirectional flushing, etc.
3. Normal construction activities (such as new connections, relocation of small diameter mains, valve replacement, flow meter cut-ins etc).
4. Major capital works (trunk main diversions, decommissioning of reservoirs etc).
5. Fire Fighting (Water used for firefighting activities by (QFES) Queensland Fire and Emergency Services.

An estimate of the volume of water associated with these activities was derived based on an analysis of DMA flow meter data, SCADA data, work-orders in Maximo, network intervention plans and Queensland Fire and Emergency Service records. The major source of unbilled unmetered water established were major capital works in the network. Over the two scheme areas, the average value of unbilled authorised consumption was estimated at 0.3% of the total volume supplied. This value, marginally lower than the WSAA guideline of 0.5%, was adopted for the whole

of the Unitywater service area. This value is significantly lower than Water Loss Control Committee Review (WLCR 2007), which estimated unbilled authorised consumption as 1.25% of the system input volume based on the findings of numerous water audits worldwide.

Billed Authorised Consumption

The Billed Authorised Consumption is the amount of water measured from customer meters. These meters are read quarterly with an almost uniform distribution of meter reads throughout the year. To interpolate the total retail consumption for a specific period (e.g. the start and end date over a quarter or financial year), a meter lag analysis is performed. The procedure adopted by Unitywater for systematic meter read data handling and meter lag correction was audited by an external subject matter and data specialist (Delloite 2015). Other than some minor procedural modifications, the data handling and meter lag process used was found to be appropriate.

Water Imported

Unitywater is supplied with potable water from a separate bulk water supply authority (Seqwater) through 37 metered offtakes. All bulk flow meters are electromagnetic and range in age from 2-15 years old. There are a total of 102 bulk flow meters across the bulk supply network supplying various distribution and retail entities, including Unitywater, within South East Queensland.

Recently, an in-situ calibration of seven bulk flow meters was carried out using laser doppler technology (developed by OPTOLUTION Messtchnik) to measure flow velocities across the pipe profile at specific flow rates. The test reports showed the accuracy of the 7 tested bulk flow meters ranged from +2.96% to -8.1% (Savage 2016).

For reasons of practicality and cost, bulk meter calibration testing was only carried out on a small sample of meters, and only at two flow rates. It is not valid to extrapolate the limited results across the entire bulk meter fleet for the range of operational flows. Due to this uncertainty, the bulk volume as invoiced by Seqwater to Unitywater continues to be used as the total bulk import to the network. Nevertheless, the level of accuracy within the bulk meter fleet is now known to be a significant uncertainty in the overall top-down water balance calculation.

Calculation of Real Losses Using Updated Information

The review of the top-down calculation has provided a more accurate assessment of both the Apparent Losses, and Unbilled Authorised Consumption. The outcomes of this assessment can now be included in the top-down calculation.

The previous 2014-15 water balance calculations estimated Unitywater's network real losses at about 70 L/conn/day. The impact of top-down assessment, and in particular changes to assumptions regarding Unbilled Authorised Consumption and Apparent Losses (customer metering inaccuracy) results in a marked reduction in the level of reportable real losses. The real losses are estimated as 51.9 L/conn/day with 5% meter under registration. In large part, this occurs because water previously considered to be leakage is now known to be passing unrecorded through the retail meter fleet. The top-down review suggests Unitywater's real losses are much lower than previously thought, and relatively low by national and international standards (BoM 2016; EPA 2010). The impact of this is that the lower the absolute level of real losses, the more difficult and expensive further significant reductions are likely to become.

This increases the need for leakage reduction measures to be targeted in those areas, and at those components of the water supply network that are contributing most to the leakage problem.

Unitywater's Northern Region has always reported significantly higher losses than the Southern Region. There has however, always been an underlying concern as to whether or not the higher losses are indeed real, or an artefact of the data and top-down calculation. To try and answer this question, a bottom-up component level assessment has been carried out to determine if losses in the North are worse, and if so, why?

BOTTOM-UP ASSESSMENT TO IDENTIFY DISTRIBUTION OF REAL LOSSES IN THE NETWORK

Water Supply Network Components

A bottom-up analysis was carried out to identify how real losses calculated using the IWA top down analysis might be distributed amongst the various components of the water supply network. These components include:

◗ Reservoirs
◗ Trunk Mains
◗ Reticulation Mains
◗ Service Connections
◗ Internal Property Leakage

For a bottom-up analysis, it is important to introduce the concept of BABE (Breaks and Background Estimation), developed in the nineties (Lambert 1994) to model physical leakage from network. There are three components of BABE:

1. *Reported leakage (visible):* Events that are reported to water utilities by the public or by employees.

2. *Unreported leakage (detectable):* Leaks, which are reported by regular or planned Active Leakage Detection (ALD) or other techniques.

3. *Background leakage (undetectable):* Individual small events that will continue to flow undetected until they get gradually worsen to the point that they can be detected. These individual small events cannot be detected by ALD due to technology limitation, pipe material and pipe depth.

The available data and the estimated leakage for each component is canvassed below.

Reservoirs

Unitywater has SCADA alarm systems that notify and record reservoir overflows. From these SCADA records, no reservoir overflows occurred in the water balance year.

The other source of leakage from reservoirs is from base, wall joints and waterstops. Unitywater has a reservoir inspection programme in place and 44 reservoirs out of the total 114 reservoirs were subject to detailed inspections over the 2013 to 2015 period. Only one reservoir was found with an estimated leakage 5.0 L/m, which is equivalent to 0.03 L/conn/day. It is likely that some minor leaks are present in the remaining un-inspected reservoirs. The possibility of a major leak from the remaining reservoir is thought to be limited, as such leaks usually become evident via routine operational inspections. Assuming minor leaks are present in the remaining uninspected reservoirs the total real losses from the reservoirs can be extrapolated as 0.1 L/conn/day as reported leakage. In short, the available data suggests reservoir leakage is likely to represent only a very minor portion of the total overall leakage losses from the water supply system.

Trunk Mains

Trunk mains are defined as major water supply mains above 300mm diameter and are normally not part of the reticulation District Metered Areas (DMAs). The larger supply trunk mains occasionally run through difficult and sometimes remote terrain with overgrown vegetation.

Physical inspection using ALD of these mains is often difficult. The total length of trunk mains in Unitywater's networks is estimated at about 800km.

Unreported Leakage from Trunk Mains

Unitywater carried out a trial using "SmartBall" technology in 2015, which involves inserting a small electronic ball within the water main. The ball flows with the water along the main and can record the location of possible leaks based on the acoustic signature of the leaking water. The results of the "SmartBall" trial have been extrapolated across the 800 km trunk main system with leakage losses from trunk mains estimated at 2.8 L/conn/day.

Reported Leakage from Trunk Mains

Trunk water main breaks are relatively rare in Unitywater's network. The main break data for the previous three years showed that most breaks occurred on the smaller diameter trunk mains. The water lost from these trunk main breaks was estimated using flow meter data tracked in the SCADA system or in TaKaDu. Using this data, the estimated total annual water lost from leaks and bursts from trunk mains is estimated as 0.3 L/conn/day.

The total contribution of trunk mains to reported and unreported leakage is therefore 3.1 L/conn/day.

Reticulation Mains

Reticulation mains are smaller mains of diameter 300 mm or less. These mains are likely to be part of a District Metered Area (DMA). This infrastructure includes a significant number of joints and fittings (such as valves and hydrants) where leakage can occur. The total leakage from this infrastructure has been assessed for the following;

1. **Reported Leakage:** Water lost from main breaks, failures and reportable leaks (referred to as "breaks"). These are the losses that are evident at the time to either customers or Unitywater's monitoring systems (i.e. Takadu), and which trigger an immediate reactive response. These losses can be quantified by assessing reported main break data in conjunction with issued work orders plus flow records in SCADA and Takadu; and,

2. **Unreported Leakage:** This unreported leakage is only detectable via ALD programs. These leaks are quantifiable using data provided by the ALD contractor, who provides an estimate of loss based on the acoustic signal of the leak.

Reported Leakage from Reticulation Mains

Overall, the number of reported reticulation main breaks in Unitywater's network is about 3-5 breaks/100km of network length/year. This is low compared with other large

water utilities in Australia (WSAA 2014) and no doubt reflects the relatively low age of the reticulation network.

Within the operational DMAs, the amount of water lost from main breaks was estimated using the time period for which the flow deviated from the normal trend of flow. These flow trends are monitored in TaKaDu and were flagged on the basis of the work orders generated in Maximo. The flow volumes representing the lost water due to main breaks was estimated within the established DMAs and this volume was extrapolated for the reticulation network across the network within non-established DMA areas. Using this information, the water lost from reticulation main breaks is estimated at 2.7 L/conn/day.

Unreported Leakage from Reticulation Mains

Hidden leaks from reticulation water mains and fittings are identified using ALD programs. The leakage detection work started in May-June 2014 and has involved inspecting approximately 3,400 km of reticulation water mains by end of January 2016. The length of mains inspected is approximately 60% of the total water mains in Unitywater distribution area and excludes bulk water supply trunk mains.

The leakage detection work involves walking along the reticulation mains with ground-listening devices and locating the leaks based on the audio signals for dripping or exuding water. Based on the audio signal, the leakage contractors are also able to provide an estimate of the rate of water leaking at each location in Litres/minute. The results from the ALD records were extrapolated for the whole network. Table 1 suggests that losses from hidden leaks amount to 6.3 L/conn/d, with hydrants the major contributor.

Table 1. Detected Water Leakage and Location of Leakage

Water Network	Leak Location	Detected Leakage (L/conn/day)
Reticulation Mains	Hydrants	2.8
	Valves	1.3
	Main	2.2
Sub-total		6.3

In summary, total leakage losses from reticulation mains, including losses from both reported (2.7 L/conn/d), and unreported (6.3 L/conn/d), equates to 9 L/conn/day.

Service Connections

As with reticulation mains, leakage losses through service connections are quantified from "breaks", being customer reported failures (generally reported) and leaks as identified by ALD (generally unreported).

Reported Leakage from Service Connection

Unlike reticulation main breaks/failures, an individual service connection failure does not generally result in a flow detectable through the local DMA meter or on TaKadu. As such, an estimate was compiled on how much water was lost from these breaks/failures based on the average time to report and repair, and the typical rate of flow emanating from these service connection failures.

Information has been gathered from field services about the nature of water lost from the incidents they have attended in the past. Very few service breaks are observed with water flowing unrestricted from the service connection pipe. The type of breaks in service connections are generally caused by pipe splits. Field service crews have developed a reference chart to estimate the water lost from the service main break based on the width and length of the split. The average water loss rate for splits varying in size from 1-6mm wide and 30-80mm long has been estimated as 0.3 L/s.

For estimation of water loss for these types of incidents, the average awareness and reporting time is considered as one day and average response and repair time has been estimated as 29 hrs based on work order history records.

On this basis, the water lost from service mains breaks/failures over the course of a year has been estimated as 3.22 L/conn/day.

Unreported Leakage from Service Connections

The ALD program identifies hidden leakage associate with service connection breaks in a similar fashion to leakage from reticulation mains. An assessment of the same ALD data covering 60% of Unitywater's network has been conducted to estimate the rate of hidden leakage from service connections. As shown in Table 2, the major source of hidden leakage within service connection was found as the pipe itself, marginally higher than losses through ferrules.

Table 2. Service Connections - Detected Water Leakage and Source of Leakage

Water Network	Leak Location	Detected Leakage (L/conn/day)
Ferrule to Internal Leaks	Ferrule	4.7
	Service Main	5.5
	Stopcock	0.7
	Meter	1.6
Total		12.5

In summary, total leakage losses from service connections, including losses from reported (3.2 L/conn/d), and unreported (12.5 L/conn/d) leakage, equates to 15.7 L/conn/day.

Internal Property Leaks

As part of the ALD programs, the ALD contractor also identified leaks downstream of the meter, i.e. leaks within the domestic plumbing. A summary of the ALD program data indicates leakage within customer properties amounts to 3.2 L/conn/day. However, the minimum leak rate identified by ALD is about 6 L/hr, which is likely to be above the registration level of the existing meters. Hence, internal property leaks identified by ALD are not included in the bottom-up analysis.

Summary of Real Losses in the Network

The real losses estimated for various component of the network with bottom up analysis are summarised in Table 3 and illustrated in Figure 1 below. Note, the results from the assessment are not definitive; they are simply a "best estimate" based on the data available at present.

To some extent, there will be some double-counting between reported and unreported leakage. ALD programs no doubt occasionally log visible leaks that have or would shortly be reported by customers. To some extent then, summing these two forms of leakage may marginally overestimate the likely losses.

As shown in Figure 2, a difference of 24 L/conn/day in the real losses was observed between the top down and bottom up approaches. This is quantified as Undetected Background Leakage according to the BABE concept.

It is important to note that the water balance analysis still includes some inherent data anomalies, which may result from; apparent losses such as the still undefined bulk metering error; errors that arise in extrapolating a result derived from data in one part of the network across the remainder of the network. In that sense, it could include a large as-yet undiscovered leak on a trunk main in a remote location.

Nevertheless the assessment illustrates that service connections appear to be the most significant contributor to leakage, followed by reticulation mains. Overall, approximately 56% of the explainable leakage with bottom-up assessment can be attributed to the performance of service connections.

A further breakdown of the assessment was conducted to see if these results differ between the northern and southern regions.
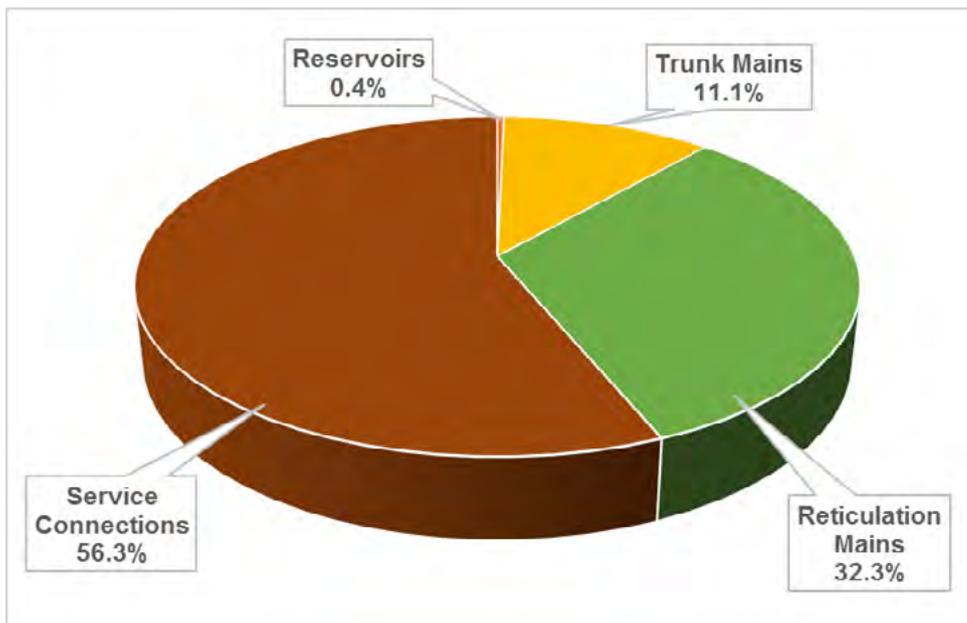
Leakage in the North versus South

Leakage in the Northern Region of Unitywater has typically been 1.5 – 2 times the rate in the Southern Region. This has been a consistent result arising from the top-down analysis over the last three years and comes despite the relative similarity in the networks within each region.

The data used in the bottom-up analysis was further broken down to allocate losses from individual types of assets (i.e. trunk mains, service connections etc)

between the Northern and Southern Region supply areas. In relation to some asset types – in particular – reservoirs and trunk mains - there is insufficient data to allow separate estimates between the two regions. However, as noted above, these two types of assets do not appear to be major contributors to leakage. For the other leakage contributors, being reticulation mains and service connections, sufficient data is available to allow a meaningful breakdown to be conducted.

Table 3. Distribution of Real Losses in the Water Supply Network

Water Supply Network Component	Reported Leakage (visible) L/conn/d	Unreported Leakage (detected) L/conn/d	Total Leakage L/conn/d
Reservoirs	0	0.1	0.1
Trunk Mains	0.3	2.8	3.1
Reticulation	2.7	6.3	9.0
Service Connections	3.2	12.5	15.7
Total Reported and Unreported Leakage with bottom up analysis	6.2	21.7	27.9
Total Leakage with top down analysis (L/conn/d)			51.9
Background Leakage-undetectable (L/conn/d)			24.0

Figure 1 pie chart values:
- Reservoirs 0.4%
- Trunk Mains 11.1%
- Reticulation Mains 32.3%
- Service Connections 56.3%

Figure 1. Real Losses from Various Components of Water Supply Network
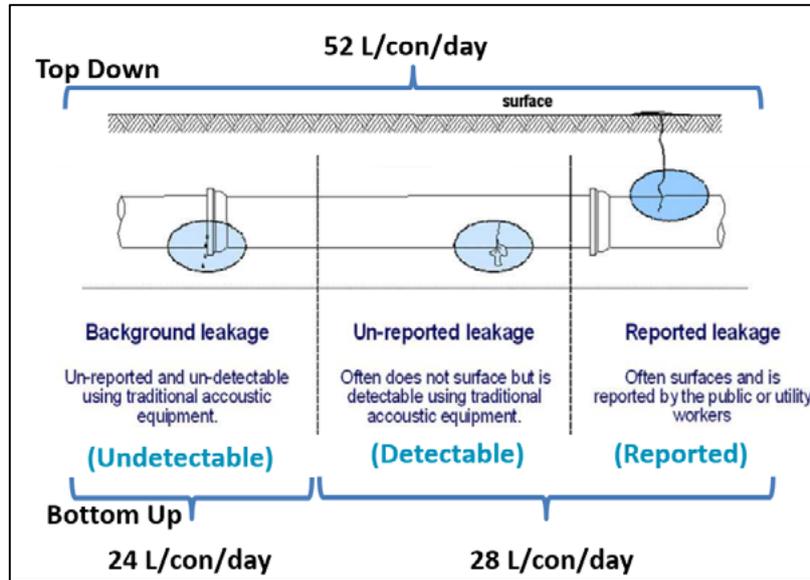
Figure 2. Top-down and Bottom-up Assessment Results

Table 4. Field Observations for Leakiness in the North and South Network

Item	North	South	Ratio North/South
RETICULATION			
Number of Reticulation Main Breaks/100km of main	3.45	2.84	1.21
Estimated volume leaks detected via ALD programs (L/conn/d)	7.4	5.5	1.35
SERVICE CONNECTIONS			
Number of Reported Service Main Breaks/1000 connections	28.4	14.1	2.01
Estimated volume leaks detected (L/conn/d)	18.8	8.5	2.21
ON-PROPERTY LEAKAGE			
% of total cost of the Water leakage rebates issued	72	28	2.57
Estimated volume leaks detected (L/conn/d)	5.5	1.8	3.06

The internal property leakage detected by ALD was also examined to identify if, in relative terms, such leakage might be worse in the North that the South. The data on rebates issued to customers was also examined. Unitywater provide a one-off capped rebate to property owners who have suffered a large unexpected increase in metered consumption arising from an undetected leak.

The data examined includes;

▶ Work flow data gathered about the number of repairs conducted on breaks in reticulation mains and service connection in the North and South, and

▶ ALD program data about the number (and rate) of hidden leaks detected in reticulation mains and service connections in the North and South, and

▶ Active Leakage Detection data about the number (and rate) of internal property leaks in the North and South, and

▶ Retail data about the number and value of rebates issued to customers with internal property leaks in the North and the South.

A breakdown of data for the two regions as well as the ratio illustrating the relative magnitude of the difference between the two regions is provided in Table 4.

Table 4 shows that losses in the North compared to the South do indeed appear to be higher. Reticulation Mains in the North "break" (1.21 times) more than the South, and do show higher levels (1.35 times) of hidden leakage. However, service connection breaks and hidden leakage are much higher again, more than twice the level in the North.

Service connections exhibit about 2.01 times the rate of reportable breaks, and about 2.21 times the rate of hidden leakage.

In addition internal property leaks in the North - as detected in ALD programs and mostly captured by property meters - is 3.06 times the rate experienced in the South. The value of issued rebates in the North is also 2.57 times those in the South. Whilst this data relates to larger detectable on-property leaks, it does suggest that low level leakage passing unrecorded through the property meter, is likely to be considerably worse in the North than the South.

CONCLUSIONS

A review of the assumptions used during the top-down water balance calculation of real losses has been conducted. The outcome is that reportable real losses within Unitywater's network reduce from about 70 L/conn/day to 52 L/conn/day. This reduced estimate is almost wholly attributable to the use of the actual 5% retail meter under-registration rather than the WSAA guideline figure of 2%.

The bottom up analysis shows that undetectable leakage in the Unitywater network is 24 L/conn/day. This figure could be higher to account for some double-counting between reported and unreported leakage.

The bottom up analysis nevertheless proved very informative. The bottom-up analysis suggests;

1. Service connections are the major contributor to leakage within the network

2. Real losses are worse in the North than the South, confirming the results of previous top-down assessments, and

3. Leakage from service connections in the North are much worse, 2-3 times, than in the South.

Other observations arising from the bottom-up assessment are the apparent consistent relationship between the rate at which pipes fail (break), and the amount of detectable leakage identified during leakage detection programs. This is perhaps intuitively obvious; the explanation being that detectable leakage ultimately evolves into pipe breaks and failures. Nevertheless the significance of this relationship is that if, as indicated by the bottom-up assessment, leakage is worse in the North and this is principally because service connection leakage is worse, and if detectable leakage is related

to the frequency of failure, then ALD programs should focus on areas in the North where customer reported service connection failures are common.

The revised top-down analysis provides an overall leakage rate of 52 L/conn/day, confirming that Unitywater's leakage problem is relatively low by national and international standards. Leakage reduction strategies therefore need to focus on areas where the problem is most acute. The bottom-up analysis suggests this focus should be on service connections in the North, and in areas where customer reported failure of service connections are frequent.

The high rates of leakage and breaks in the service connection pipework immediately upstream of the property meter, and the high rates of leakage/breaks (as evidence by rebates) for failed plumbing downstream of the meter are also thought likely to be both symptoms of a common cause. That common cause could be pressure. On average, water pressures are about 50 metres in the North compared with 40 metres in the South.

The outcomes from this bottom up assessment is that trials are now underway in relation to possible pressure management in selected areas in the North, and the replacement of service connections in areas particularly prone to failure. ALD programs are also being focussed in those area where service connection failures are common. Assessment for economical level of leakage is also underway.

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