» Experiences in Real Loss Assessment 10-years after implementing the ILI as decisive Key-PI in Austria

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» 23rd September 2019

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Water Loss 2019
Sep 22-24, 2019 Bucharest, Romania

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Experiences in Real Loss Assessment 10-years after implementing the ILI as decisive Key-PI in Austria

Joerg Koelbl & **Allan Lambert**

(Austria, presenter) (UK, co-author)

Southeast Europe Regional Conference
Water Loss 2019
Bucharest, 23 September 2019

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Consulting Engineers for Water Management and Environmental Engineering

WLR & A
ANALYZE YOUR WATER LOSS

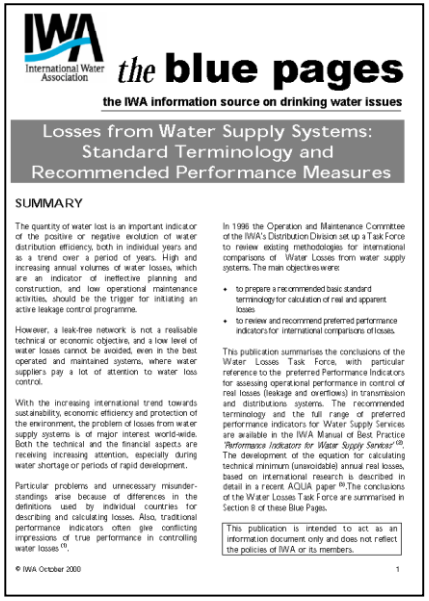
HISTORY

INFRASTRUCTURE LEAKAGE INDEX (ILI)

IWA BLUE PAGES (2000)

Losses from Water Supply Systems: Standard terminology and Recommended Performance Measures

- IWA Water Balance
- Infrastructure Leakage Index (ILI)



IWA International Water Association

the **blue pages**

the IWA information source on drinking water issues

Losses from Water Supply Systems: Standard Terminology and Recommended Performance Measures

SUMMARY

The quantity of water lost is an important indicator of the positive or negative evolution of water distribution efficiency, both in individual years and as a trend over a period of years. High and increasing annual volumes of water losses, which are an indicator of ineffective planning and construction, and low operational maintenance activities, should be the trigger for initiating an active leakage control programme.

However, a leak-free network is not a realisable technical or economic objective, and a low level of water losses cannot be avoided, even in the best operated and maintained systems, where water suppliers pay a lot of attention to water loss control.

With the increasing international trend towards sustainability, economic efficiency and protection of the environment, the problem of losses from water supply systems is of major interest world-wide. Both the technical and the financial aspects are receiving increasing attention, especially during water shortage or periods of rapid development.

Particular problems and unnecessary misunderstandings arise because of differences in the definitions used by individual countries for describing and calculating losses. Also, traditional performance indicators often give conflicting impressions of true performance in controlling water losses [1].

In 1996 the Operation and Maintenance Committee of the IWA's Distribution Division set up a Task Force to review existing methodologies for international comparisons of Water Losses from water supply systems. The main objectives were:

- to prepare a recommended basic standard terminology for calculation of real and apparent losses
- to review and recommend preferred performance indicators for international comparisons of losses.

This publication summarises the conclusions of the Water Losses Task Force, with particular reference to the preferred Performance Indicators for assessing operational performance in control of real losses (leakage and overflows) in transmission and distributions systems. The recommended terminology and the full range of preferred performance indicators for Water Supply Services are available in the IWA Manual of Best Practice *'Performance Indicators for Water Supply Services'* [2]. The development of the equation for calculating technical minimum (unavoidable) annual real losses, based on international research is described in detail in a recent AQUA paper [3]. The conclusions of the Water Losses Task Force are summarised in Section 8 of these Blue Pages.

This publication is intended to act as an information document only and does not reflect the policies of IWA or its members.

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System Input Volume M^3/year	Authorised Consumption M^3/year	Billed Authorised Consumption	Billed Metered Consumption (including water exported)	Revenue Water
			Billed Unmetered * Consumption	M^3/year
		Unbilled Authorised Consumption M^3/year	Unbilled Metered Consumption	
			Unbilled Unmetered Consumption	
	Water Losses M^3/year	Apparent Losses M^3/year	Unauthorised Consumption	Non-Revenue Water**
			Metering Inaccuracies	
		Real Losses M^3/year	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	M^3/year

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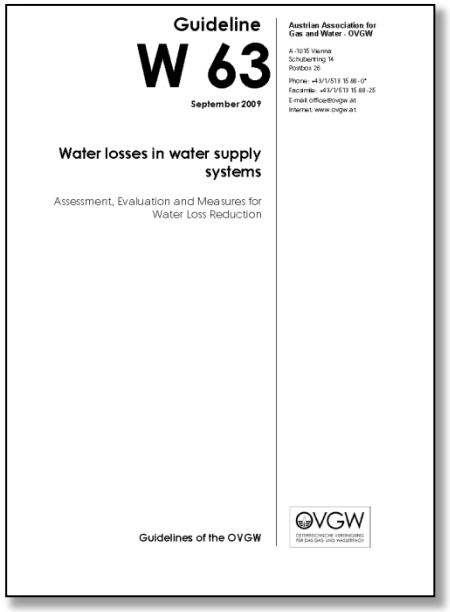
OVGW W 63 (2009)



Water Losses in Water Supply Systems: Assessment, Evaluation and Measures for Water Loss Reduction

- IWA Water Balance
- Clear statement against use of % as technical PI
- Infrastructure Leakage Index (ILI) as decisive PI
  - **Best indicator in terms of considering network parameters**
    - length of mains
    - number of connections
    - length of connections
    - pressure
- Class limits (A, B, C, D) same as World Bank Institute Bands (WBI)

WATER LOSS ASSESSMENT

According WBI classification scheme:

ILI	Class q_{AL}	Evaluation
till 2	A	**very little till little water losses**, further reduction could be counter productive; further analysis before any action should be executed.
2 to 4	B	**medium water losses,** potential for noticeable loss reduction existing, improvement in leakage control and infrastructure management.
4 to 8	C	**high water losses**, volume and reasons for losses have to be analyzed and attempts to reduce the volume of lost water has to be intensified.
greater than 8	D	**very high water losses**, volume and reasons for losses have to be analyzed, distinct leakage control and leakage reduction has to be executed immediately.

Source: OVGW W 63 (2009)

GOOD PRACTICES ON LEAKAGE MANAGEMENT WFD CIS W POM (2015)

Coordinated by

Cor Merks
(ARCADIS Nederland BV)

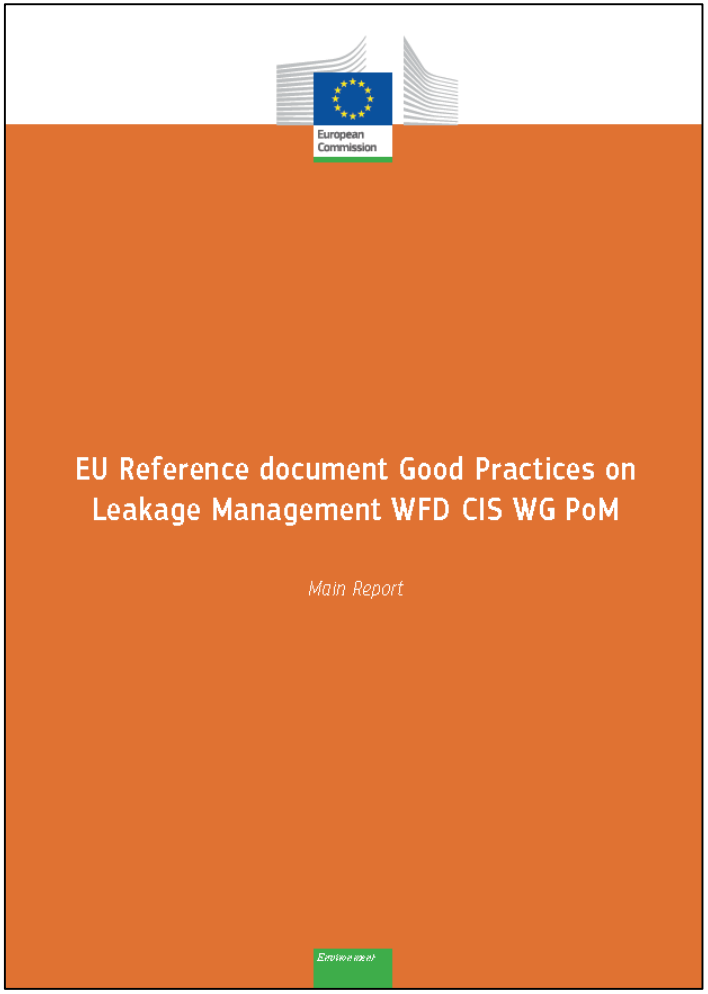
In cooperation with

IWA Water Loss Specialist Group

Institutions of EU member states

Main Report

Case Study Report



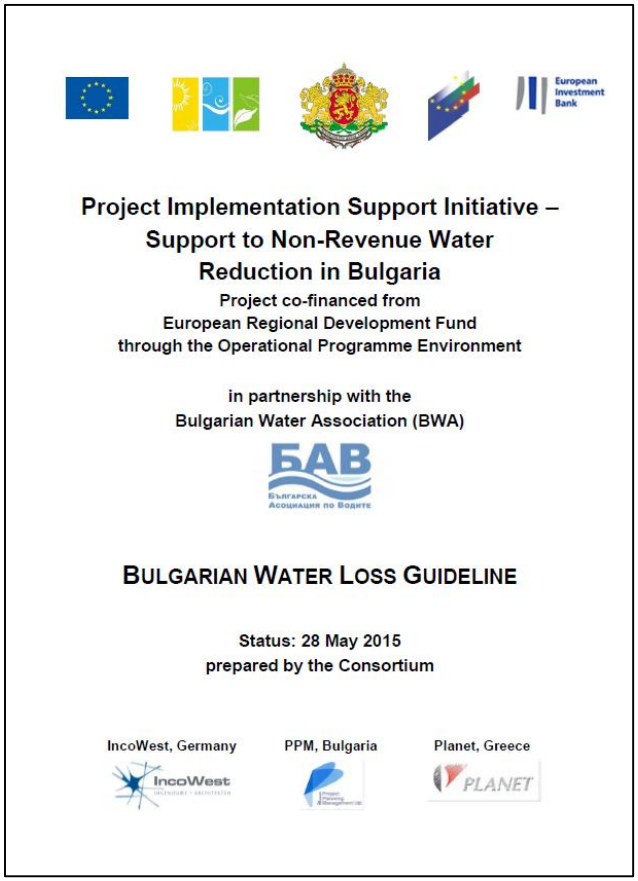
https://circabc.europa.eu/sd/a/1ddfba34-e1ce-4888-b031-6c559cb28e47/Good%20Practices%20on%20Leakage%20Management%20-%20Main%20Report_Final.pdf

GOOD PRACTICES ON LEAKAGE MANAGEMENT WFD CIS W POM (2015)

Parameter or Context Information	Units of measurement	Performance Indicator and Context Information Descriptions				
		Very Low	Low	Moderate	High	Very High
Infrastructure Leakage Index ILI		< 1,5	1,5 to < 2,0	2,0 to < 4,0*	4,0* to < 8,0*	8* or more
Average System Pressure	Metres	< 30	30 to < 40	40 to < 50	50 to < 60	60 or more
Mains repairs	per 100 km/year	< 7	7 to < 10	10 to < 15	15 to < 20	20 or more
Mains - average time to repair	Days	< 1	1 to < 2	2 to < 4	4 to < 8	8 or more
Service Connection repairs	per 1000 services/year	< 3	3 to < 4	4 to < 7	7 to < 10	10 or more
Services - average time to repair	Days	< 2	2 to < 4	4 to < 8	8 to < 16	16 or more
Active Leakage Control	% checked annually	< 10%	10% to < 30%	30% to < 70%	70% to < 90%	90% or more
Rate of Rise of Unreported Leakage	litres/service conn/day, in a year	< 20	20 to < 40	40 to < 80	80 to < 160	160 or more
Assessed Value of leakage	Euro/m^3	< 0,10*	0,10 to < 0,25*	0,25 to < 0,50*	0,50 to < 1,00*	1,0* or more
Use of Energy	kWhr/m^3	< 0,25*	0,25 to < 0,50*	0,50 to < 1,0*	1,0 to < 2,0*	2,0* or more
	* Limits for these parameters are provisional and subject to further checking and/or review					

Table 6 – Additional PIs and context indicators (Lambert et al, 2014).

BULGARIAN WATER LOSS GUIDELINE (2015)



Project Implementation Support Initiative –
Support to Non-Revenue Water
Reduction in Bulgaria

Project co-financed from
European Regional Development Fund
through the Operational Programme Environment

in partnership with the
Bulgarian Water Association (BWA)

БАВ
Българска Асоциация по Водите

BULGARIAN WATER LOSS GUIDELINE

Status: 28 May 2015
prepared by the Consortium

IncoWest, Germany PPM, Bulgaria Planet, Greece

IWA Water Balance

Set of Performance Indicators for

- real loss, NRW, failure rates

ILI as decisive PI

- Low/Middle Income Country ILI range = 2 x High Income Country

ILI range	Leakage Performance Category
Less than 3	A1
3 to < 4	A2
4 to < 6	B1
6 to < 8	B2
8 to < 12	C1
12 to < 16	C2
16 to < 24	D1
24 and more	D2

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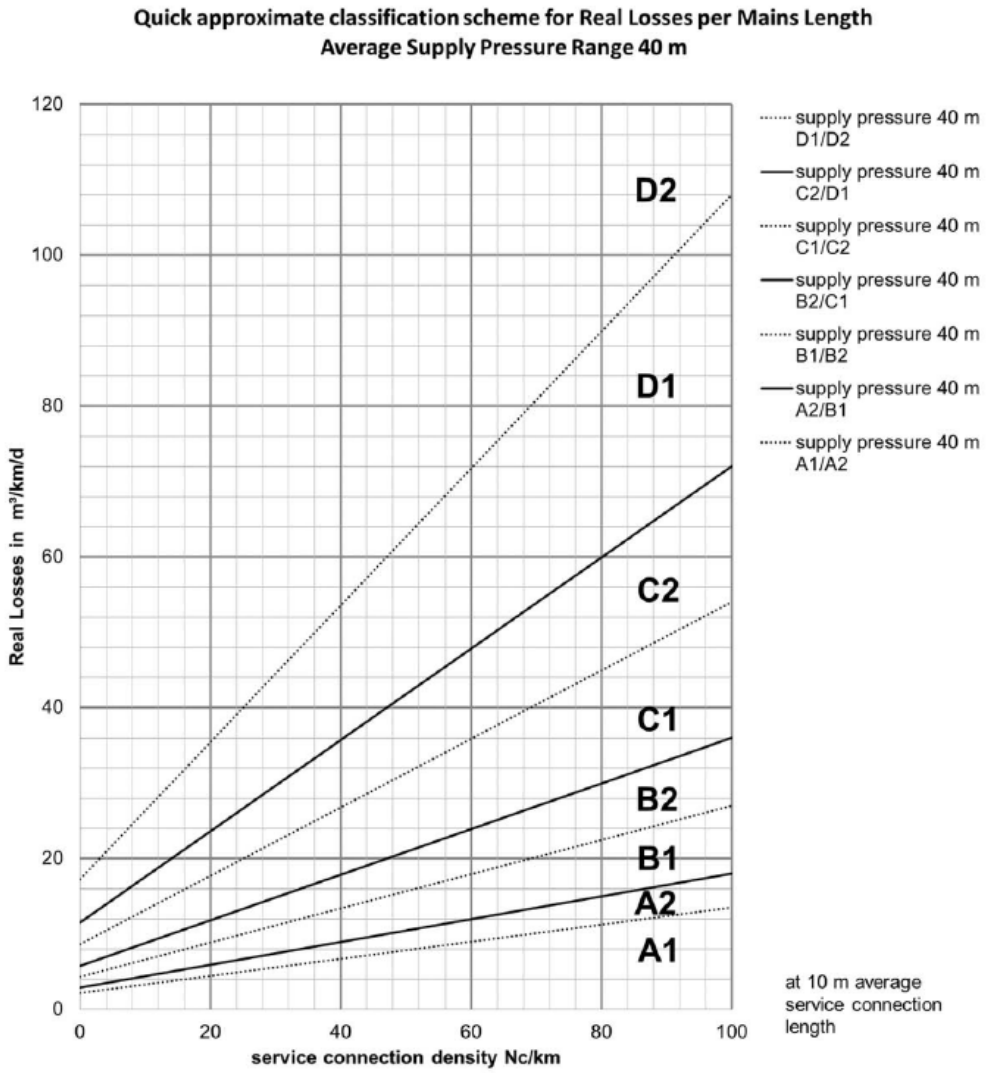
BULGARIAN WATER LOSS GUIDELINE (2015)

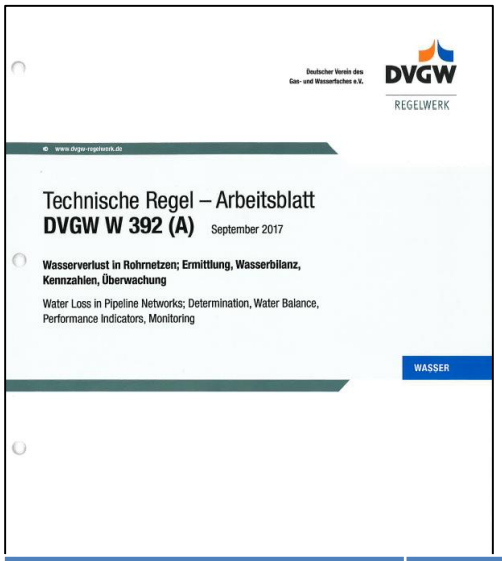


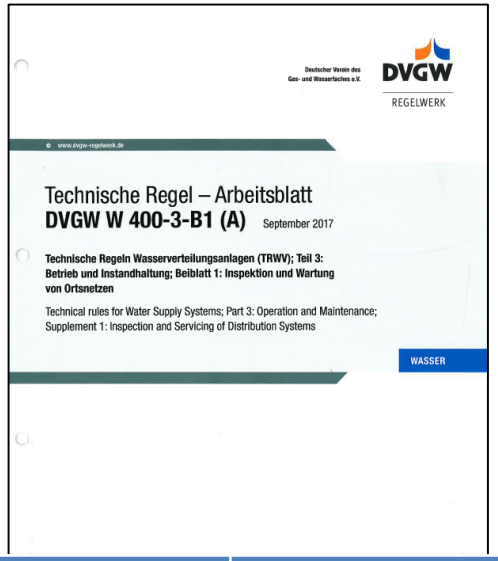
Alternative Assessment scheme for:

m³/km/d

Several graphs for different pressure ranges

GERMAN W 392 (A) & W 400-3 B1 GUIDELINES (2017)





IWA Water Balance

Real Losses

- **ILI is preferred KPI**
- **$m^3/km/h$ (q_{VR}) traditional**

ILI classification scheme in W 400-3, shows ALC interval for ILI and qvr

Water loss according W 392 (A)	Classification	Failure rate (mains)		
		low	moderate	high
ILI ≤ 2	**low**	selective measures	every 6 years	every 3 years
2 < ILI ≤ 4	**moderate**	every 3 years	every 2 years	annually
ILI > 4	**high**	annually	comprehensive measures	comprehensive measures

All good?

LEARNINGS FROM AUSTRIA - ILI

Still limited acceptance of ILI

Classification scheme for ILI works well

for systems with >3000 connections

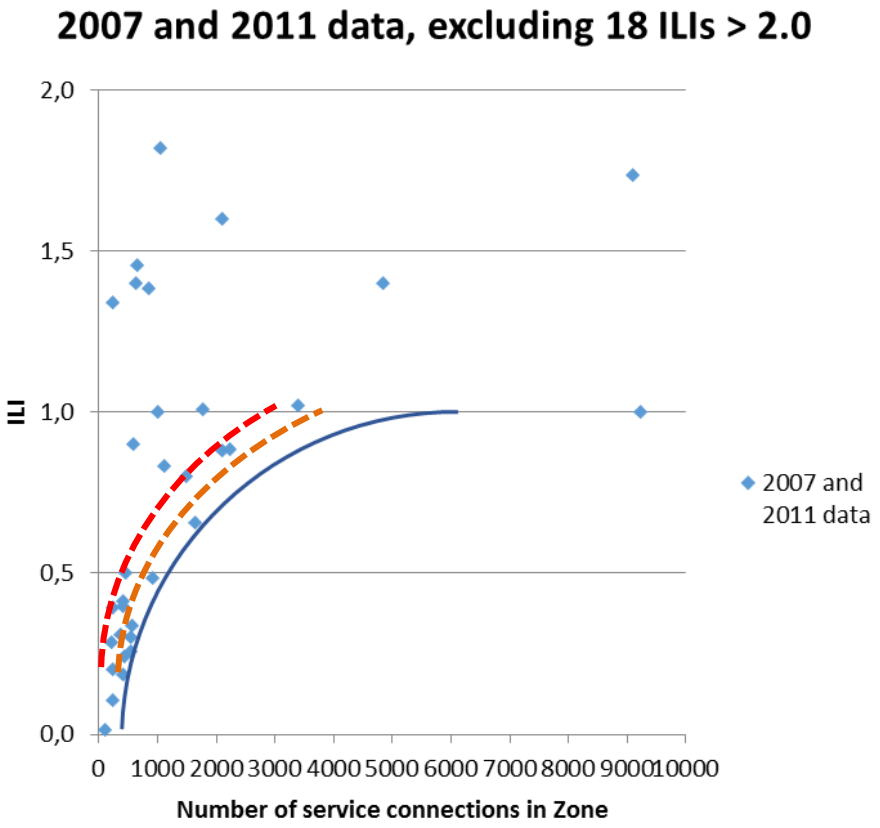
But smaller systems (<3000 service connections) can be in Band A with ILI << 1.0 at average pressure of 50 metres

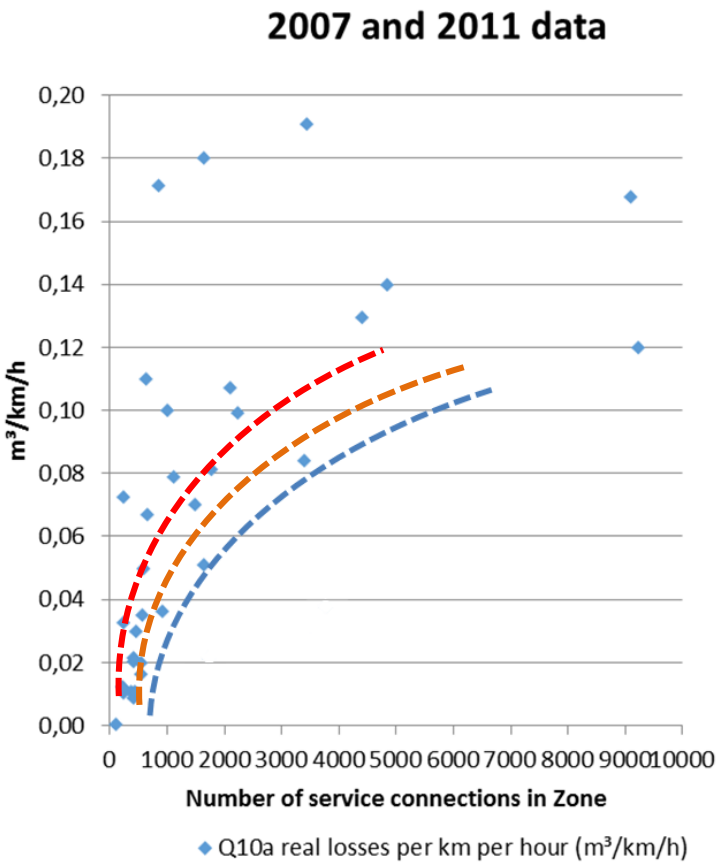
~ 90% of Austrian Utilities have < 3000 connections

> 80% of these systems have < 1000 connections

Review of Austrian/UK collaboration on understanding why this occurs since 2007, and recent developments

SIZE MATTERS:
DATA FROM OVGW BENCHMARKING STUDIES





source: Lambert, Koelbl & Fuchs-Hanusch (2014)

REASONS FOR LOW ILI IN SMALL SYSTEMS

Errors when calculating UARL – lack of systematic approach to infrastructure parameters and pressure

Influence of pressure:leak flow relationships for mostly flexible pipes if pressure less than around 40 metres

Small systems (< 3000 service connections):

» new unreported leaks quickly and easily identified from night flows, leads to shorter run times

» wider confidence limits for calculated CARL

» New research shows that for very small systems, low UARL leak frequency distributions need to be included

A POISSON DISTRIBUTION USED FOR FOOTBALL STATISTICS

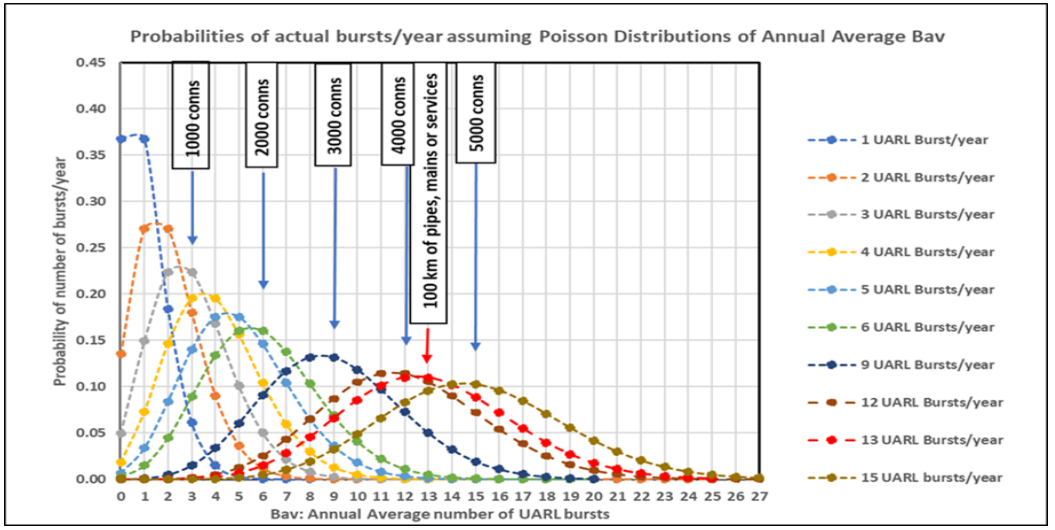
Used to predict probability of occurrence of small numbers of isolated events, when only average number over several periods of time is known.

Example: goals per game in Premier League 2017-18

Team	Average Number of Goals conceded per game		Comparison of Predicted and Actual Number of Goals Conceded per game in a 38 game season					
			0	1	2	3	4	5
A	0.71	Actual	18	16	2	1	1	0
		Predicted	19	13	5	1	0	0
B	1.00	Actual	17	12	4	3	1	1
		Predicted	14	14	7	2	1	0
C	1.58	Actual	9	11	12	3	0	3
		Predicted	8	12	10	5	2	1

Poisson distribution has now been applied to study of low annual numbers of UARL bursts in small systems (WLR&A Ltd, 2019)

Graph shows how normal 'bell-shaped' distribution becomes more skewed as system size reduces



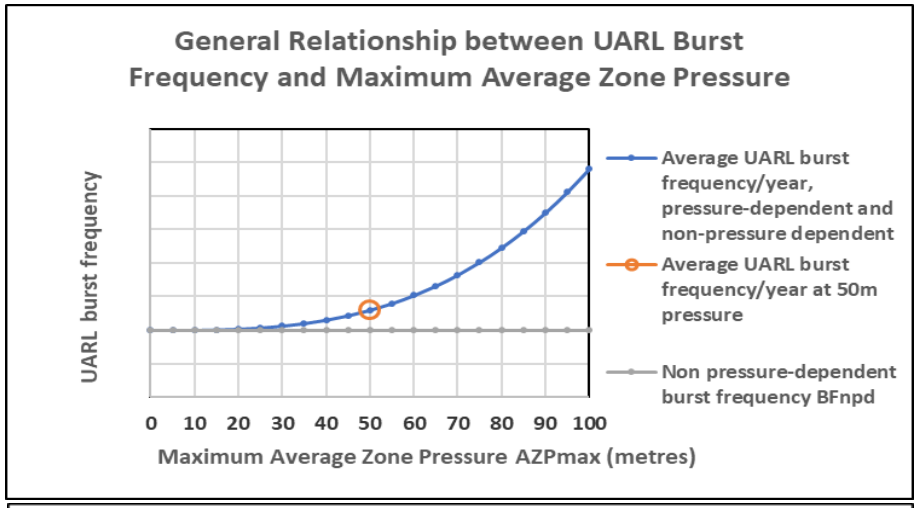
STEPS 1, 2: REVIEW AND IMPROVE BURST FREQUENCY ASSUMPTIONS

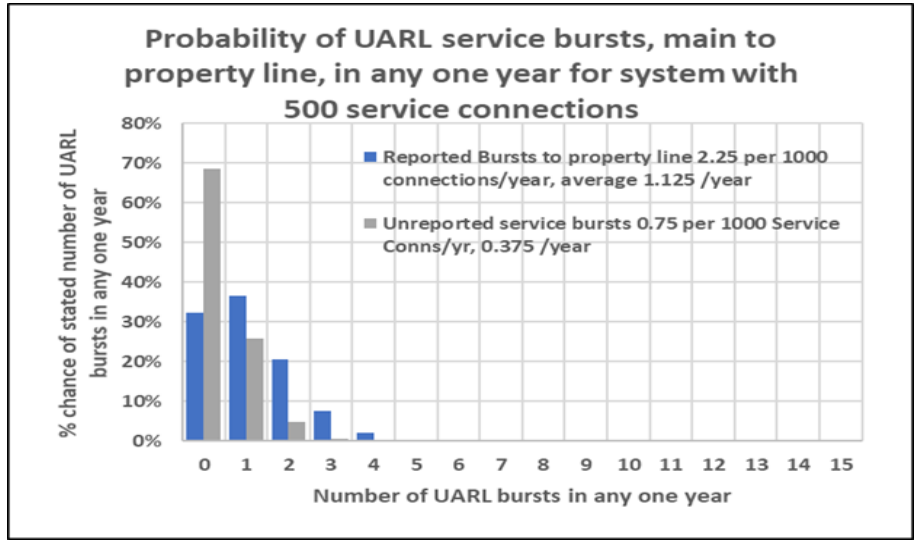
Step 1: Modify UARL average burst frequencies at 50m pressure for actual pressure

- using international (2012) preferred practical approach to pressure:burst frequency relationships

Step 2: Interpret low numbers of UARL bursts in small systems using the median values of the 3 Poisson probability distributions

- degree of skewness increases as system size falls
- example is for UARL bursts, mains to property line, for 500 service connections





STEPS 3 AND 4

Step 3: FAVAD: Fixed and Variable Area Discharges assumptions

- N1 = 0.5 for rigid pipes
- N1 = 1.5 for flexible pipes and unavoidable background leakage
- Assess %s of rigid and flexible pipes on mains, on services from main to property line, and on services from property line to meter

Step 4: Derive customised System Correction Factor SCF to customise standard linear UARL equation, using UARL with SCF software

$$\text{UARL (litres/day)} = \mathbf{SCF} \times (18 \times Lm + 0.8 \times Ns + 25 \times Lp) \times P$$

SCF varies with influence of pressure on 6 interacting zone-specific factors

- Presented as graphs of SCF vs average pressure, and customised UARL in m^3/day vs average pressure, for any individual Zone or system, of any size

UARL WITH SCF SOFTWARE, DATA ENTRY

CALCULATION OF UARL in North American Units with System Correction Factor SCF										
Standard Linear Equations for UARL	US Units	UARL (USgal/day) = SCF x (5.4 x Lm + 0.15 x Nc + 7.5 x Lc) x AZP						Lm and Lc in miles, AZP in psi		
	Metric	UARL (m^3/day) = SCF x (18 x Lm + 0.8 x Ns + 25 x Lp) x AZP/1000						Lm and Lp in km, AZP in metres		
Service Connection Help		Data Input Section						Rigid/Flexible Pipes Help		
		Calculation by			A. Lambert	5th Aug 2019				
System Data for		Anytown Utility			Anyzone			Pipe Materials		
Components of Infrastructure and Standard Linear UARL calculations					UARL Assumptions @ 50m			% Rigid, N1 = 0.5	% Flexible, N1 = 1.5	
Number of services Ns, Main to property line or curb stop	US Units		Metric Units		Reported Bursts	75%		50	50	
	Number	3,000	3,000	Number	Unreported Bursts	25%				
Services, property Line or curb stop to meter, Length Lp	ft/conn	50.0	15.2	m/conn	Reported Bursts	75%		50	50	
	miles	28.41	45.7	km	Unreported Bursts	25%				
Mains length Lm	miles	36.00	57.9	km	Reported Bursts	95%		50	50	
					Unreported Bursts	5%				
Density of Connections DC per length of mains	per mile	83.3	51.8	per km	System Correction Factor using linear UARL Formula	System Correction Factor using Favad Only		System Correction Factor using Favad + Poisson	SCF using Pressure:bursts + Poisson + FAVAD	
Average Zone Pressure AZP	psi	40.0	28.1	metres	1.00	0.84		0.73	0.67	
Unavoidable Annual Real Losses UARL with SCF applied	USgalpd	34299			34299	28973		25096	23114	
			129	m^3/day	129	109		94	87	
Note: small differences in UARL ^ and ^ are due to rounding errors when the Metric UARL equation is converted to US Units										

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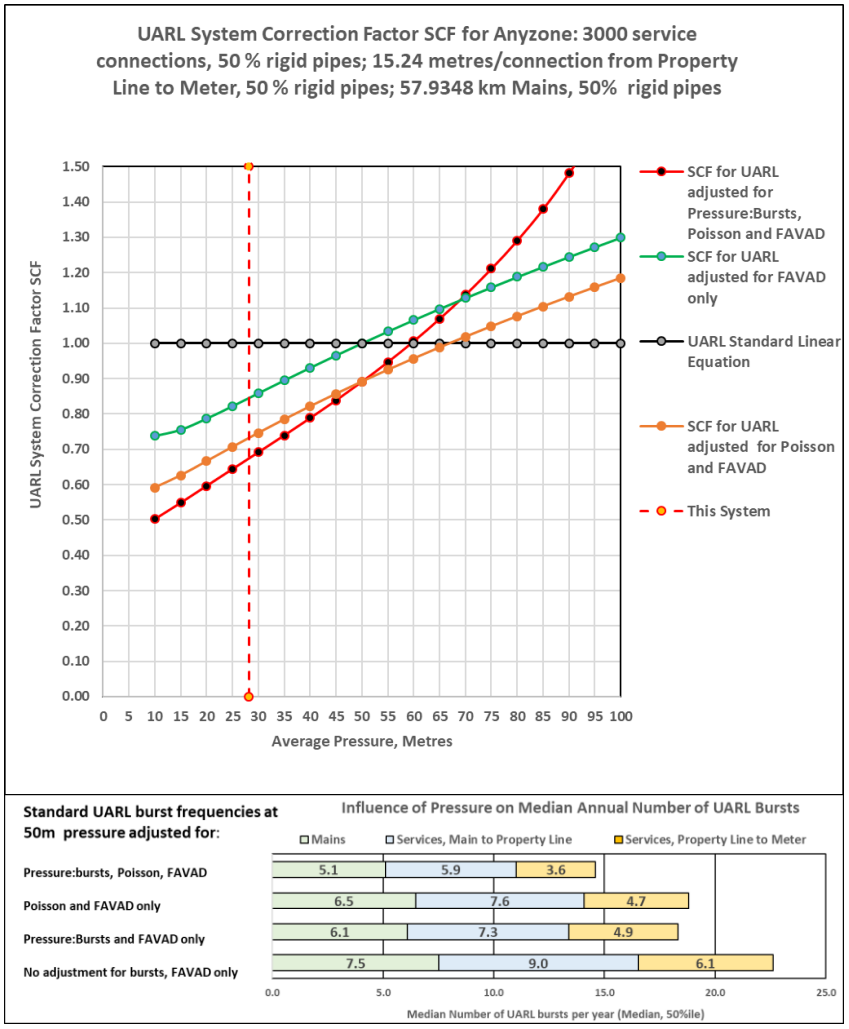
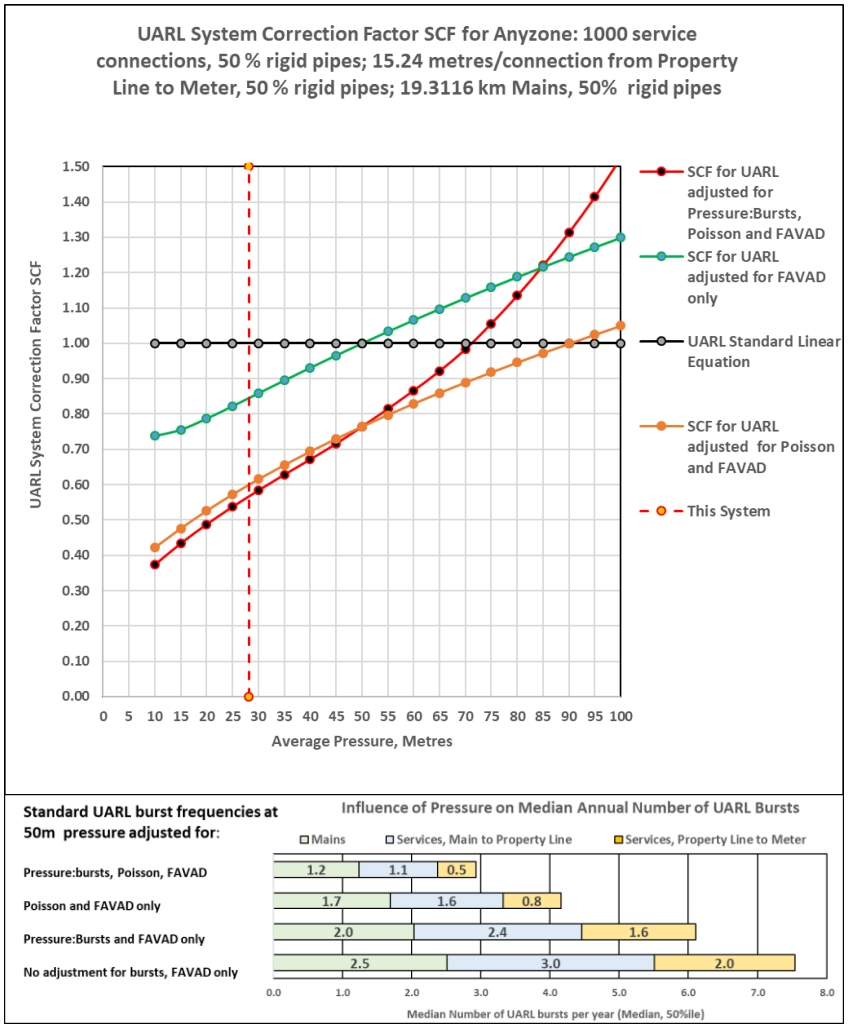
EXAMPLE OF HOW SCF AND BURSTS REDUCE WITH SYSTEM SIZE

3000 SERVICES, 50% RIGID PIPES



1000 SERVICES, 50% RIGID PIPES



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LEARNINGS – WATER BALANCE, PI

More and more countries are implementing the **IWA water balance** and **ILI** as decisive PI in national guidelines

Unfortunately "**%**" are still widely used as technical indicator

Using ILI bears risk that higher losses "hidden" in high pressure systems

- Calculate and always quote average system pressure
- Identify potentials for pressure reduction
- Cross-checks with other performance indicators

Use ILI for the purpose it was developed for

- Assessment and comparisons of Technical Performance in managing Real Losses between different systems with different characteristics
- Monitoring and target setting: only when pressure management completed

Use m³/km/h and l/conn/d for the traditional purpose of

- Utility internal monitoring of individual systems/sub-systems
- Utility internal target setting of individual systems/sub-systems
- but not for comparisons between systems/sub-systems

LEARNINGS – SMALL SYSTEMS

Logical reasons for ILIs less than 1 in some very small systems

UARL with SCF software with Poisson and pressure:bursts can:

- calculate a customised median UARL for any individual small system (and DMA)
- be used for research into generalised SCF vs system size relationships

Thank you for your interest!

Copies of this presentation can be downloaded from:

www.bluenetworks.at

https://www.leakssuitelibrary.com/pros-abandon-percents-of-siv/

For further information on UARL with SCF software,

visit https://www.wlranda.com/software or contact info@wlranda.com

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