

Workshop

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Softwares for PI Calculations

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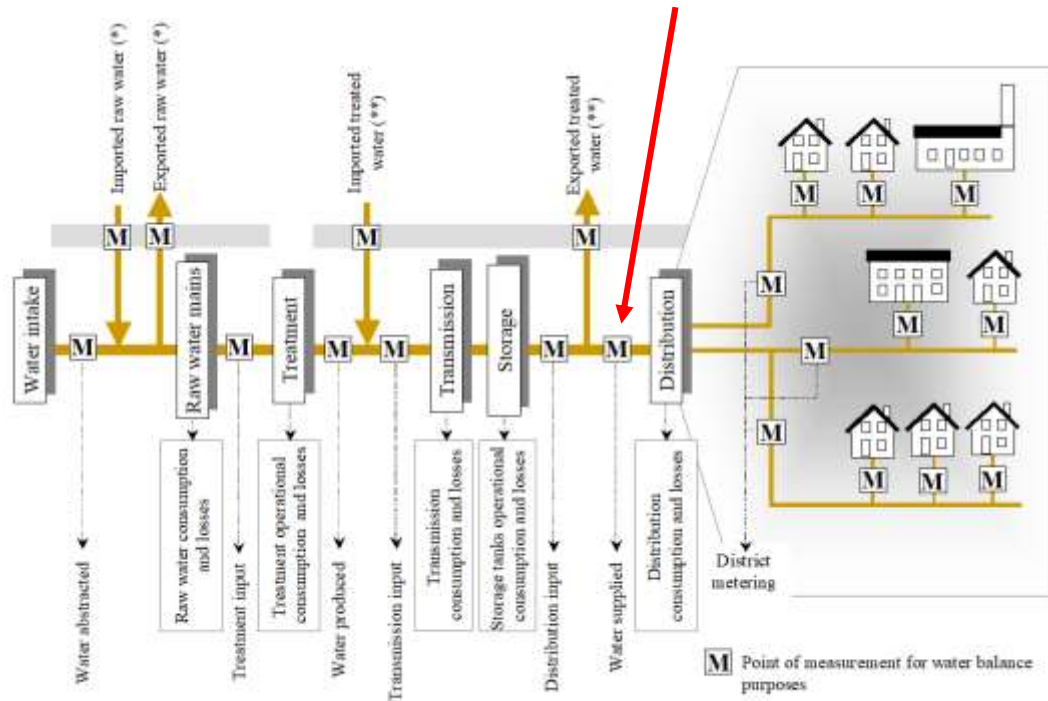
(with assistance from Mr. Allan Lambert)

Overview of Software for Water Balance and PI Calculations

- Since 1999 several free software packages have been used in West Balkans region for IWA Water Balance and PI Calculations
- Free software:
 - EasyCalcs: with option to change languages of text (Roland Liemberger)
 - CheckCalcs (English, Croatian, Greek, Serbian language versions): ILMSS Ltd
 - EURWB&PICalcs (English, Croatian versions): ILMSS Ltd
 - linked to EU Reference Document 'Good Practices on Leakage Management 2015'
- Commercial software:
 - PIFastCalcs (English, Croatian, Greek, Serbian language versions) ILMSS Ltd
 - WB&PIUCalcs (English) WLR&A Ltd
- Some of these softwares have confidence limits calculations included as standard, some as additions to special versions

The original 'standard' IWA Water Balance

Figure 2 of Performance Indicators Manual 2000 shows 'Water Supplied'



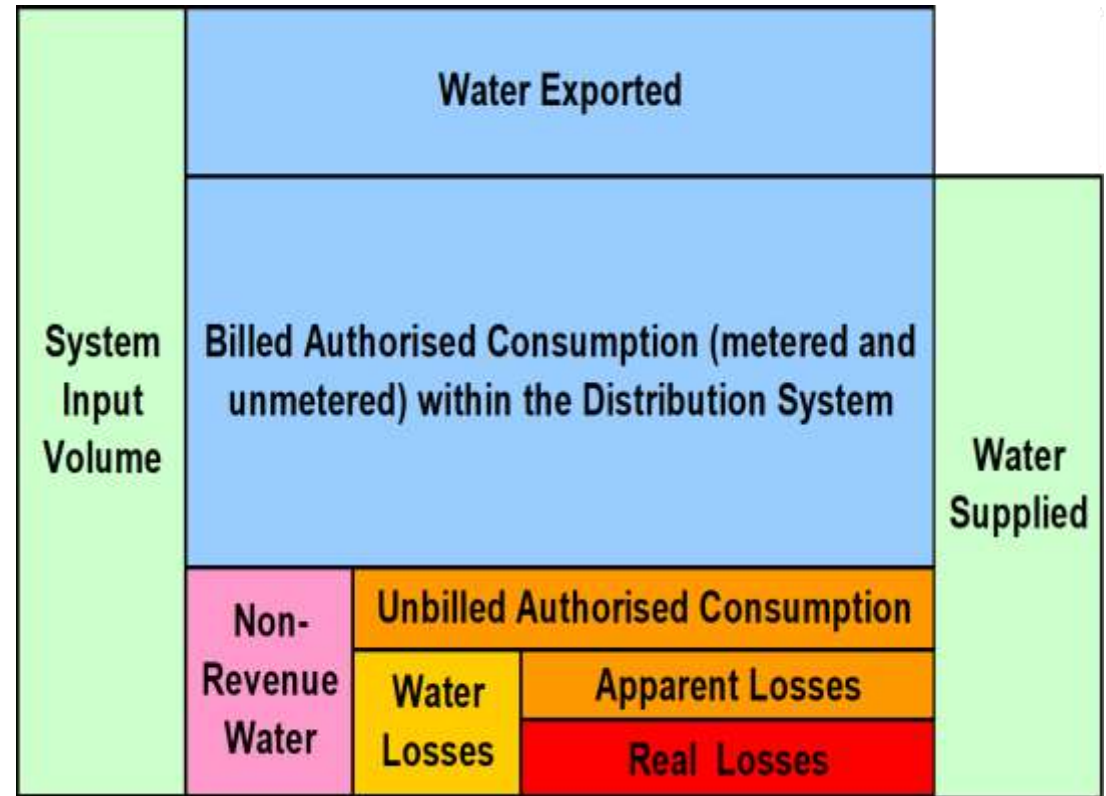
(*) - can be located anywhere between the water intake and the treatment
 (**) - can be located anywhere downstream treatment

PI Manual 2000 Water Balance mentions Water Exported, but omits Water Supplied

System Input Volume	Authorized consumption	Billed authorized consumption	Billed metered consumption (including water exported)	Revenue Water (or billed volumes)
			Billed unmetered consumption	
		Unbilled authorized consumption	Unbilled metered consumption	Non Revenue Water or (unbilled volumes)
			Unbilled unmetered consumption	
	Water losses	Apparent losses	Metering inaccuracies	
			Unauthorized consumption	
		Real losses	Transmission and distribution mains	
			Overflow or leakage of storage tanks	
			Service connections to meter	

Necessary Improvements since 2000

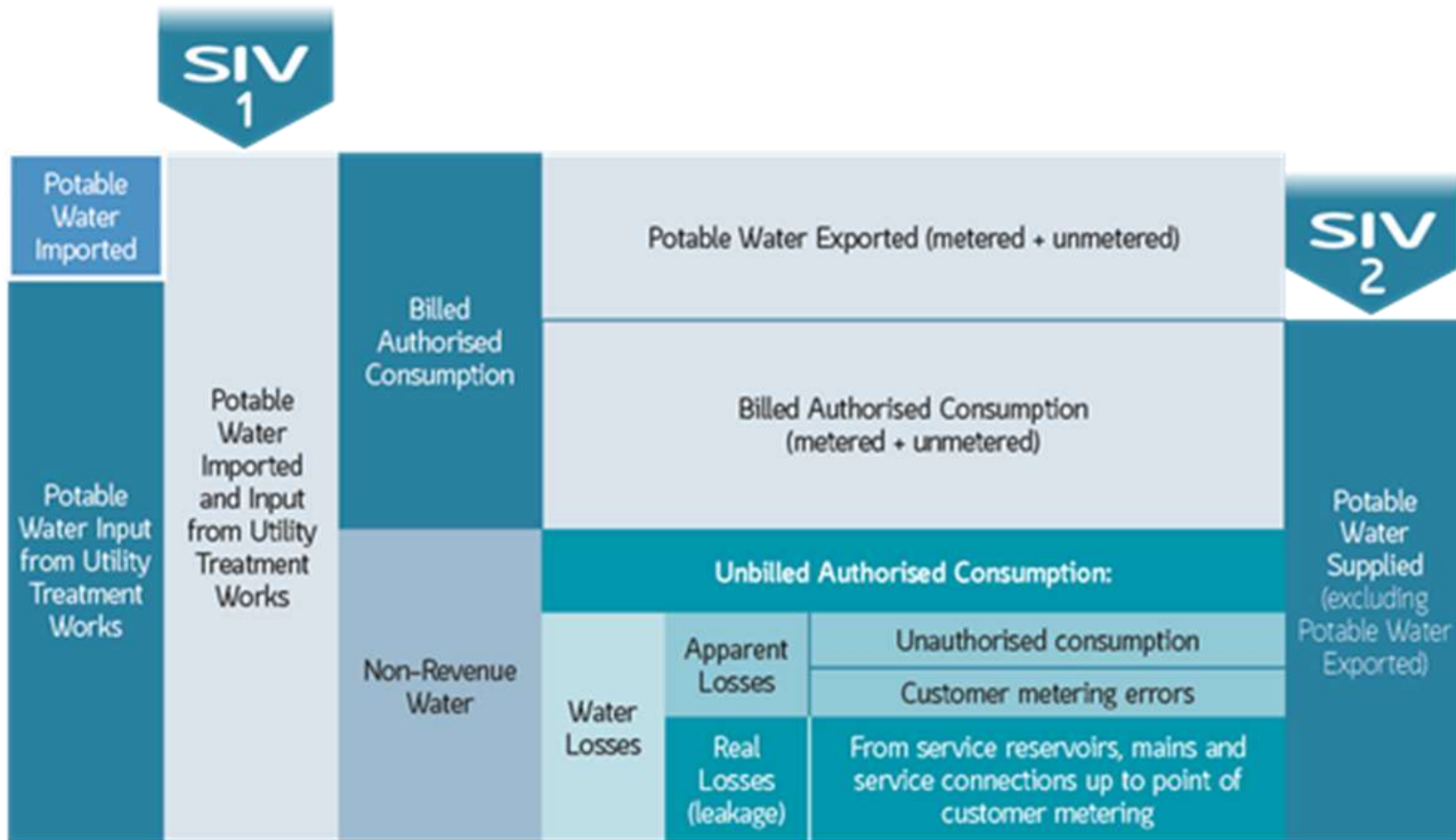
- System Input Volume SIV needs to be more clearly defined
 - should mention bulk metered volumes have been 'corrected for known errors'
 - does SIV include any Water Exported
 - 'Water Supplied' WS should be shown separately
 - Which % did you calculate, % of SIV or %s of WS?
 - %s by volume used as PIs are easily manipulated
- These concerns were corrected in some, but not all, 'country' versions
 - but not in subsequent issues of IWA Performance Indicators Reports



IWA Water Balance used in most ILMSS software

'LEAKS' Suite of LEAKAGE EVALUATION and ASSESSMENT KNOW-HOW SOFTWARE						
International Standard Components of Water Audit (Water Balance) for Transmission or Distribution Systems						
Based on IWA Report 'Performance Indicators for Water Supply Systems', July 2000, with minor modifications						
Volume from Own Sources	System Input Volume (corrected for known errors)	Water Exported				Billed Water Exported
		Water Supplied	Authorised Consumption		Revenue Water	Billed Metered Consumption
Water Losses				Billed Authorised Consumption	Non-Revenue Water	Billed Unmetered Consumption
				Unbilled Authorised Consumption		Unbilled Metered Consumption
			Apparent Losses	Unbilled Unmetered Consumption		
			Real Losses	Unauthorised Consumption		
				Customer Metering Inaccuracies		
				Leakage on Mains		
Leakage and Overflows at Storages						
Leakage on Service Connections up to point of customer metering						
Water Imported						
Note 1:	The IWA Task Force on Performance Indicators recommends that the term 'Unaccounted for Water' (UFW) is not used.					
See below for definitions of terminology used. The calculation on the 'Water Balance' Worksheet uses a simplified version of this Water Balance. .						

IWA Water Balance used in 2015 EU Reference Document 'Good Practices on Leakage Management'



Water balance calculations without confidence limits

- When the IWA standard water was published in 2000, the next question was:
 - but what about the errors in the data?
- So from 2002 confidence limits were included in EasyCalcs, PIFastCalcs, and Professional versions of CheckCalcs
- The 2nd (2007) Edition of the Performance Indicators Report included a mathematical Appendix on how to calculate Uncertainty
- But even now very few Water Balances show calculated confidence limits or uncertainty (both terms are used in practice)

How does Water Balance software calculate Confidence Limits?

Data entry values

Calculated Values

Standard deviation = Megalitres x 95% CLs/2

Component of IWA Standard Water Balance	Megalitres	95% Confidence Limits	Standard Deviation	Variance = SD ²
System Input Volume	6117	+/- 2% —————→	61 —————→	3721
Billed Authorised Consumption	5200	+/- 1% —————→	26 —————→	676
Non-revenue Water	917	+/-15% ←————	69 ←————	4397
Unbilled Authorised Consumption	80	+/- 50% —————→	20 —————→	400
Water Losses	837	+/-16% ←————	69 ←————	4797
Apparent Losses	111	+/- 50% —————→	23 —————→	529
Real Losses	726	+/-20% ←————	73 ←————	5326

Always ADD the variances, irrespective of whether you are adding or subtracting the volumes in Megalitres

Example

- The previous example is a real system in Australia, with an ILI of 1.0
 - Bulk metering is assumed as $\pm 1\%$, Metered Consumption $\pm 1\%$
 - Yet the uncertainty of the Real Losses volume calculation is $\pm 20\%$!
- This result is not at all unusual for Utilities with good leakage management and low ILIs
 - and this is well known to any person who has done uncertainty calculations
- However, uncertainty calculations provide useful additional knowledge even for high leakage systems
 - Using them, we can prioritise activities which will have the greatest influence in reducing uncertainty of NRW and Real Losses calculations

Some practical tips

- If you use confidence limits, the item of input data with the biggest 'standard deviation' (which also gives the biggest variance) quickly identifies where you should try to improve your data reliability
 - to reduce the uncertainty of the calculated Real Losses volume
- Use of confidence limits software consistently shows that the most significant problem areas in a Water Balance are usually:
 - bulk metering measurement errors
 - customer metering errors matching recorded consumption to bulk metering volumes between start and finish dates
 - uncertainty about customer meter under-registration in systems where customers have storage tanks

Uncertainty calculations for Performance Indicators

- We can also calculate uncertainty for Performance Indicators for NRW, Apparent Losses and Real Losses
- For KPI uncertainty calculations, the results are dominated by the parameter with the largest % uncertainty
 - and for many systems, this is the Real Losses volume!
- This means that moderate errors in mains length, number and length of service connections, and average pressure, don't have as much influence as you might perhaps expect

Leaks Suite

- Through the free-to-all LEAKSSuite website, Allan Lambert is encouraging practitioners to start to understand how to do their own uncertainty calculations,
- In <http://www.leakssuite.com/random-uncertainty-in-leakage-kpis/> , Allan explains step by step, in reasonably user-friendly language, how to create your own spreadsheet
 - see also short article in next 'Water Detectives'
- the **WB&PIUCalcs software** is also available for purchase at <http://www.wlrand.co.uk/wbpiucalcs/>
 - but Allan would prefer that you 'do it yourself', because
Hear and forget; see and remember; do and understand (Confucious)

Water Balance in WB&PIUCalcs software

2. Water Balance Calculation with Uncertainty calculations			Colour coding of Cells		Data entry	Calculated
COLUMN >	1	2	3		4	
ROW	COMPONENTS OF WATER BALANCE		BASIS OF CALCULATION		ANNUAL VOLUME AV m³	
A	WATER FROM OWN SOURCES	WOS			8000000	
B	WATER IMPORTED	WI			4000000	
C	SYSTEM INPUT VOLUME	SIV	SIV = WOS plus WI		12000000	
D	WATER EXPORTED	WE			2000000	
E	WATER SUPPLIED	WS	WS = SIV minus WE		10000000	
F	BILLED METERED CONSUMPTION	BMC			7800000	
G	BILLED UNMETERED CONSUMPTION	BUC			300000	
H	NON-REVENUE WATER	NRW	NRW = WS - BMC - BUC		1900000	
I	UNBILLED AUTHORISED CONSUMPTION	UAC	0.5%	x BMC	39000	
J	WATER LOSSES	WL	WL = NRW - UAC		1861000	
K	UNAUTHORISED CONSUMPTION	UC	0.1%	x BMC	7800	
L	CUSTOMER METERING ERRORS	CME	2.0%	x BMC	156000	
M	APPARENT (COMMERCIAL) LOSSES	AL	AL = UC + CME		163800	
N	REAL (PHYSICAL) LOSSES	RL	RL = WL - AL		1697200	
O	IF NUMBER OF WATER BALANCE IN DAYS =	365	then REAL LOSSES in m³/day =		4650	
Sensitivity testing: review the calculated priorities in Column 9 for action to reduce uncertainty of Real Losses						

Assessment of Random Uncertainty and Priorities				
5	6	7	8	9
Random Uncertainty			U ²	Priorities to reduce Uncertainty of Real Losses
+/- u %	+/- U Mm ³		U ² values are ALWAYS added	
2.0%		160000	25600000000	1
2.0%		80000	6400000000	3
1.5%	178885	< SQRT (U ²) <	32000000000	
2.0%		40000	16000000000	5
1.8%	183303	< SQRT (U ²) <	33600000000	
2.0%		156000	24336000000	2
20.0%		60000	36000000000	4
13.1%	248065	< SQRT (U ²) <	61536000000	
20.0%		7800	60840000	7
13.3%	248187	< SQRT (U ²) <	61596840000	
20.0%		1560	2433600	8
20.0%		31200	973440000	6
19.1%	31239	< SQRT (U ²) <	975873600	
14.74%	250145	< SQRT (U ²) <	62572713600	
with Uncertainty = +/-		14.74%	685	m ³ /day
Test the implications of changing %s in Column 3 and Column 5				

Uncertainty of Infrastructure, Pressure and KPIs

3. Leakage KPI Calculations with Uncertainty Calculations			Colour coding of Cells		Data from Parts 1 or 2	Calculated
COLUMN >	1	2	3	4	5	6
ROW	Infrastructure parameters and Leakage Performance Indicator Calculations with Uncertainty Calculations	INFRASTRUCTURE AND PRESSURE PARAMETERS				
		MAINS LENGTH Lm	NUMBER of SERVICE CONNECTIONS Ns, MAIN TO PROPERTY LINE	LENGTH OF SERVICE CONNECTIONS, PROPERTY LINE TO METER		AVERAGE SYSTEM PRESSURE Pav
				lp/Ns	lp	
A	UNITS OF PARAMETER OR PERFORMANCE INDICATOR	km	-	metres per connection	km	metres
B	BEST ASSESSMENT OF VALUE OF PARAMETER OR KPI =	1000.00	40000	10.0	400.00	40.0
C	RELATIVE UNCERTAINTY +/- u% =	1.5%	2.0%	20.0%	20.1%	7.5%
D	UNCERTAINTY +/- U =	15.00	800	2.0	80.40	3.0
E	LOWER LIMIT OF UNCERTAINTY =	985.00	39200	8.00	319.60	37.00
F	UPPER LIMIT OF UNCERTAINTY =	1015.00	40800	12.00	480.40	43.00
G	PARAMETERS USED IN CALCULATIONS				Ns, lp/Ns	
H	UNCERTAINTY AND RELATIVE UNCERTAINTY ARE CONSIDERED TO CORRESPOND TO A CONFIDENCE LEVEL OF +/-	95.0%				

Assessment of Random Uncertainty and Priorities				
7	8	9	10	11
LEAKAGE PERFORMANCE INDICATORS				
REAL LOSSES RL	REAL LOSSES		UNAVOIDABLE ANNUAL REAL LOSSES UARL *	INFRASTRUCTURE LEAKAGE INDEX ILI
	m ³ /km of mains per day	litres/ service conn./ day		
m ³ /day			m ³ /day	-
4650	4.65	116	2400	1.94
14.74%	14.81%	14.87%	8.30%	16.91%
685	0.69	17.3	199	0.33
3965	3.96	99	2201	1.61
5335	5.34	134	2599	2.27
From Water Balance	Using RL, Lm	Using RL, Ns	Using Lm, Ns, Lp, Pav	Using RL, Lm, Ns, Lp, Pav
*Figures for UARL are calculated in Table 3 then copied back into Table 2				

Uncertainty for Infrastructure, Pressure and KPIs

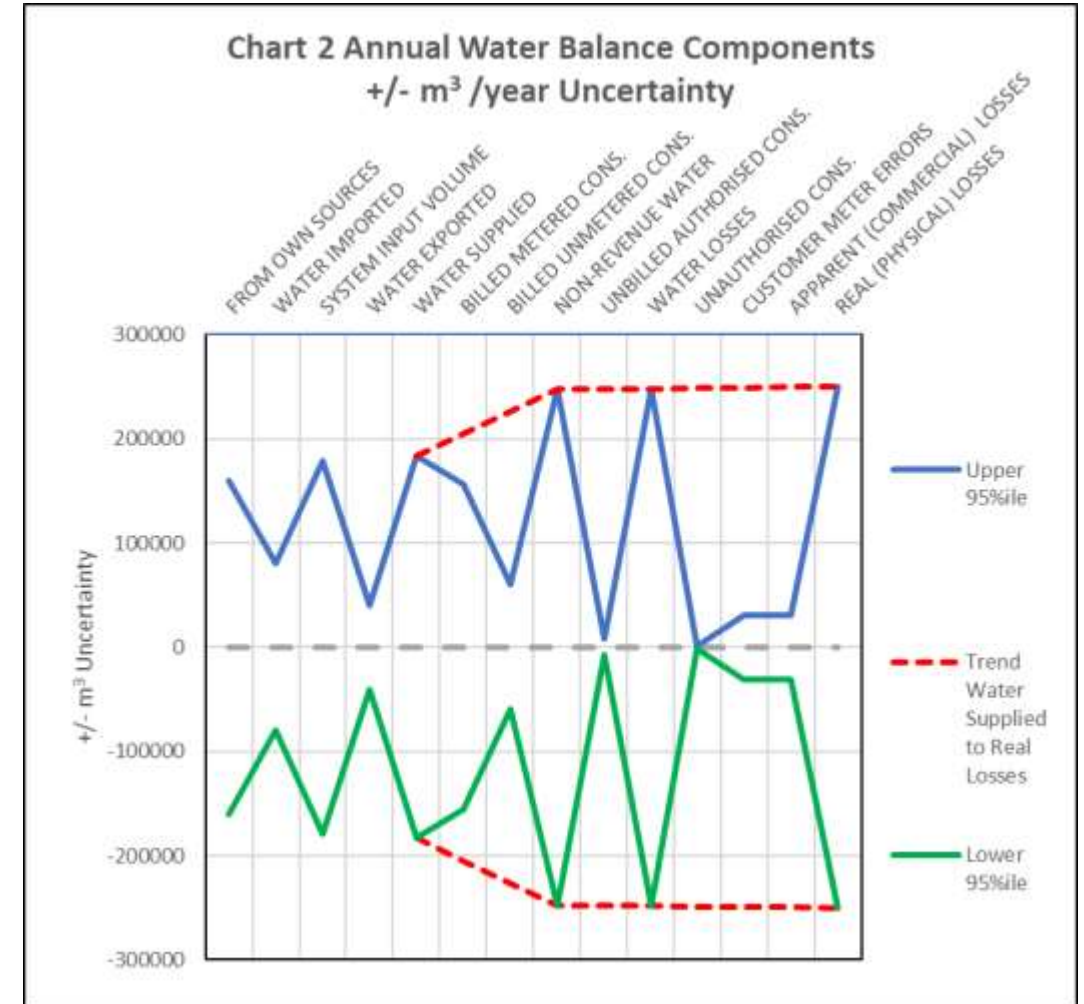
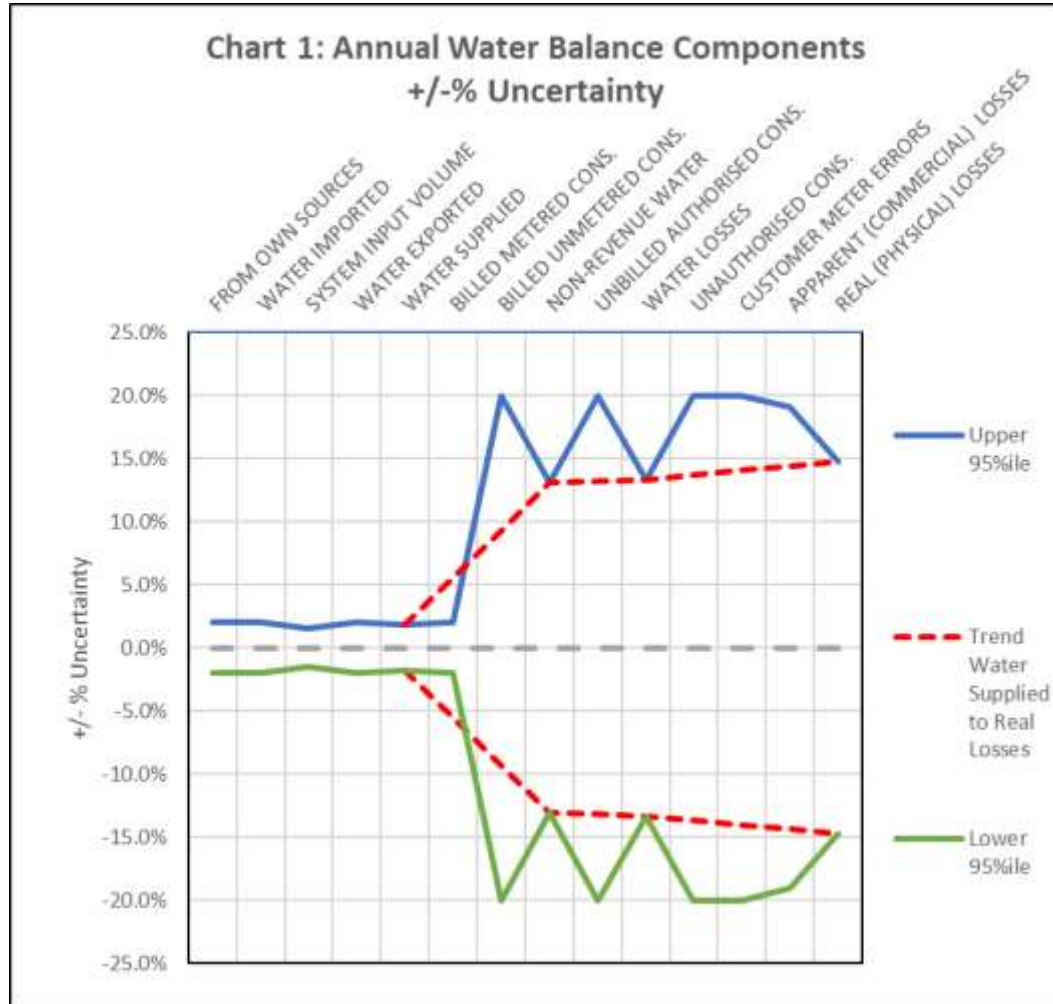
3. Leakage KPI Calculations with Uncertainty Calculations			Colour coding of Cells		Data from Parts 1 or 2	Calculated
COLUMN >	1	2	3	4	5	6
ROW	Infrastructure parameters and Leakage Performance Indicator Calculations with Uncertainty Calculations	INFRASTRUCTURE AND PRESSURE PARAMETERS				
		MAINS LENGTH Lm	NUMBER OF SERVICE CONNECTIONS Ns, MAIN TO PROPERTY LINE	LENGTH OF SERVICE CONNECTIONS, PROPERTY LINE TO METER lp/Ns	lp	AVERAGE SYSTEM PRESSURE Pav
A	UNITS OF PARAMETER OR PERFORMANCE INDICATOR	km	-	metres per connection	km	metres
B	BEST ASSESSMENT OF VALUE OF PARAMETER OR KPI =	1000.00	40000	10.0	400.00	40.0
C	RELATIVE UNCERTAINTY +/- u% =	1.5%	2.0%	20.0%	20.1%	7.5%
D	UNCERTAINTY +/- U =	15.00	800	2.0	80.40	3.0
E	LOWER LIMIT OF UNCERTAINTY =	985.00	39200	8.00	319.60	37.00
F	UPPER LIMIT OF UNCERTAINTY =	1015.00	40800	12.00	480.40	43.00
G	PARAMETERS USED IN CALCULATIONS				Ns, lp/Ns	
H	UNCERTAINTY AND RELATIVE UNCERTAINTY ARE CONSIDERED TO CORRESPOND TO A CONFIDENCE LEVEL OF +/-					95.0%

4. Unavoidable Annual Real Losses Uncertainty Calculations			Colour coding of Cells	UARL Fixed Defaults	Data from Parts 1, 2 or 3	Calculated
COLUMN >	1	2	3	4	5	6
ROW	CALCULATION OF UNCERTAINTY OF UNAVOIDABLE ANNUAL REAL LOSSES UARL			UARL equation coefficients	UARL components per metre of pressure	
A	UARL litres/day = (18 x Lm + 0.8 x Ns + 25 x Lp) x Pav	Units	Value		litres/day per metre	m ³ /day per metre
B	LENGTH OF MAINS Lm	km	1000.00	18.0	18000	18.00
C	UTILITY SERVICE CONNECTIONS, MAIN TO PROPERTY LINE Ns	Number	40000	0.80	32000	32.00
D	PRIVATE UNDERGROUND SERVICE CONNECTION, FROM PROPERTY LINE TO CUSTOMER METER Lp	km	400.0	25.00	10000	10.00
E	TOTAL OF UARL COMPONENTS per metre of pressure	Volume per metre			60000	60.00
F	AVERAGE SYSTEM PRESSURE Pav	Metres	40.00			
G	UNAVOIDABLE ANNUAL REAL LOSSES UARL	m ³ /day		2400		

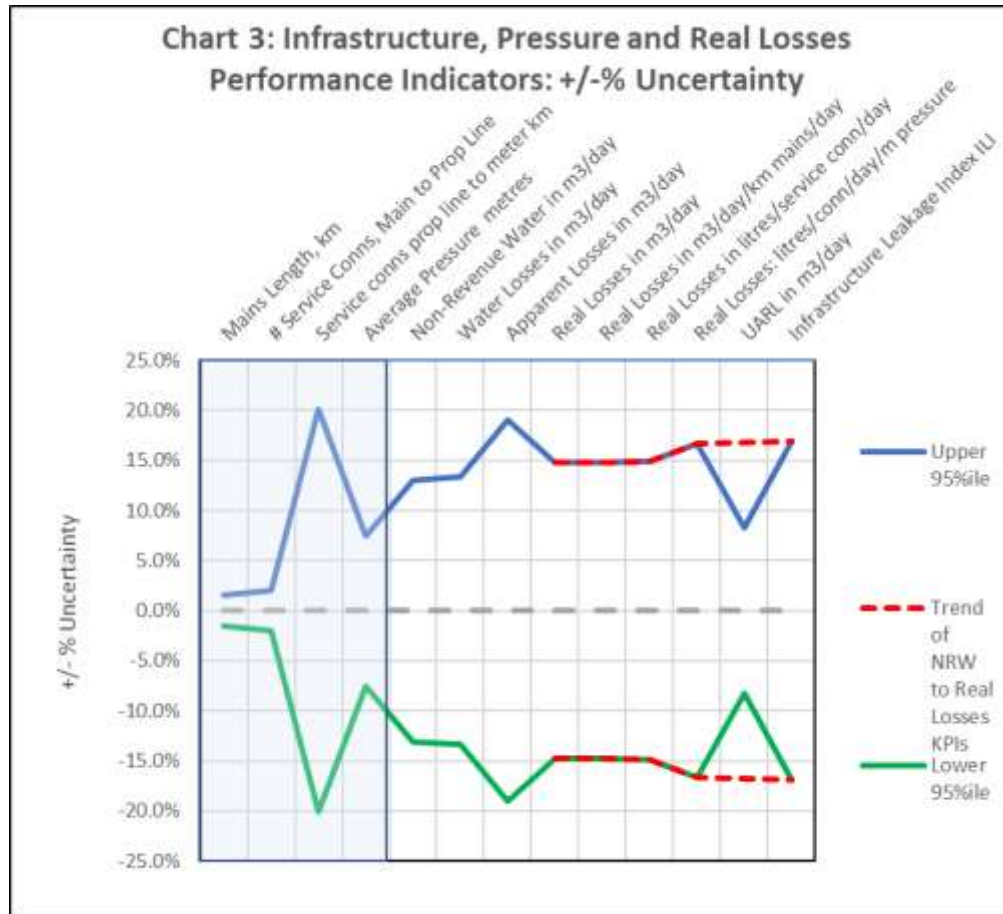
Assessment of Random Uncertainty and Priorities				
7	8	9	10	11
LEAKAGE PERFORMANCE INDICATORS				
REAL LOSSES RL	REAL LOSSES		UNAVOIDABLE ANNUAL REAL LOSSES	INFRASTRUCTURE LEAKAGE INDEX ILI
	m ³ /km of mains per day	litres/ service conn./ day	REAL UARL *	
m ³ /day			m ³ /day	-
4650	4.65	116	2400	1.94
14.74%	14.81%	14.87%	8.30%	16.91%
685	0.69	17.3	199	0.33
3965	3.96	99	2201	1.61
5335	5.34	134	2599	2.27
From Water Balance	Using RL, Lm	Using RL, Ns	Using Lm, Ns, Lp, Pav	Using RL, Lm, Ns, Lp, Pav
*Figures for UARL are calculated in Table 3 then copied back into Table 2				

Assessment of Random Uncertainty and Priorities				
7	8	9	10	11
Random Uncertainty				Pooled uncertainty calculation
+/- u %	+/-U		U ²	
1.5%		0.27	0.0729	Square root of sum of U ² values
2.0%		0.64	0.4096	
20.1%		2.01	4.0400	
3.54%	2.13	< SQRT (U ²) <	4.5225	Square root of sum of u ² values
7.50%	3.0			
8.30%	199			

Uncertainty of Water Balance in %, and in m³/year



Uncertainty of Leakage Performance Indicators



- Uncertainty of infrastructure and pressure parameters are in grey area to left side of chart
- NRW uncertainty is +/-13%
- Real loss uncertainty is +/-14.7%
- l/conn/day uncertainty +/-14.8%
- m³/km/day uncertainty +/- 14.9%
- UARL uncertainty +/- 8.3%
 - less than Real Loss volume uncertainty!
- ILI uncertainty +/- 16.9%
 - only 2.2% more than uncertainty of real loss volume!