Learning Module #3

A Listening and Learning Session on the Use of Percentage Performance Indicators for Non-revenue Water Management

George Kunkel, Will Jernigan, Cor Merks

KUNKEL
WATER EFFICIENCY CONSULTING

CAVANAUGH
Stewardship Through Innovation

Witteveen + Bos

North American Water Loss Conference 2017

San Diego, CA

December 4, 2017

Welcome - Attendee Survey - Participation

- Welcome to the Learning Module on Percentage Performance Indicators in Non-revenue Water Management
- Please complete the brief Survey handed to you upon entry to the Session
- Return your Survey to the Session assistant when complete
- Please be prepared to let us know your thoughts about performance indicators for NRW management, and particularly, how you view percentage performance indicators

Source: Socialbrite

Learning Module Agenda

Facilitators

George Kunkel, Kunkel Water Efficiency Consulting
Cor Merks, Witteveen+Bos
Will Jernigan, Cavanaugh
Larry Lewison, Cavanaugh

- Introduction – 10 minutes (G. Kunkel) & Circulation of Informational Survey to attendees
- Performance Indicators for Non-revenue Water Management: a North American Perspective – 20 minutes (G. Kunkel)
- Performance Indicators for Non-revenue Water Management: an international perspective – 20 minutes (C. Merks)
- Review of Survey Results – 15 minutes (W. Jernigan, L. Lewison)
- Facilitated Discussion with attendees – 20 minutes (W. Jernigan (lead), with G. Kunkel and C. Merks assisting)
- Summary – 5 min (G. Kunkel, W. Jernigan, C. Merks)

Performance Indicators are used throughout Society

- **Business**: Unemployment Rate, Inflation Rate, Dow Jones Industrials Average
- **Health**: Blood pressure, Cholesterol, Body Mass Index
- **Consumer**: 4-star or 5-star ratings for restaurants, hotels, movies, and other services. User reviews on websites, surveys are other mechanisms to rate performance.
- **Sports**: batting average, home runs, touchdowns or Goals scored, points per game
- **Weather**: High and low temperatures, rainfall, snowfall
- **Many other fields**……

Best Restaurants in San Diego!
Dao Fu

DAO FU

Vietnamese · Normal Heights · $$

FOOD 4.8 · DECOR 4.1 · SERVICE 4.4

Even though you're allowed to **"write on the walls"** with markers, don't be deceived by the **"quirky"** atmosphere at this Normal Heights Asian eatery – an affordable **"favorite"** for its **"generous"**, **"spicy"** dishes that appeal to carnivores and vegetarians alike; what's more, the staff **"always greets you warmly"** and is **"very willing to accommodate"** any special requests.

Source: zagat.com

Source: zagat.com

Performance Indicators for Non-revenue Water Management:

A North American Perspective

George Kunkel

History of Water Loss Assessments

- First documented account of water loss tracking:

  1957 AWWA Committee Report "Revenue-producing Versus Unaccounted-for Water"

- For several decades after this paper was published many state and regional water regulatory agencies adopted provisions that define:
  - Losses as varying definitions of "unaccounted-for" water (UFW)
  - Loss levels and targets expressed as an "unaccounted-for" percentage (UFW%), in some form of:

$$\frac{\text{Water Supplied minus Customer Consumption}}{\text{Water Supplied}}$$

- Sometimes the inverse "Metered Water Ratio" is used:

$$\frac{\text{Customer Consumption}}{\text{Water Supplied}}$$

Revenue-producing Versus Unaccounted-for Water

Committee Report

A report of Committee 4450 D—Revenue-producing Water, presented on May 13, 1957, at the Annual Conference, Atlantic City, N.J., by E. Shaw Cole (Chairman), Pres., Pitometer Assoc., New York, N.Y. Other members of the committee were: Ellwood H. Aldrich, E. Jerry Allen, David Auld, Egbert D. Case, Oswald A. Gierlich, Dewey W. Johnson, Arthur P. Kuranz, Howard W. Niemeyer, W. K. Van Zandt, and Howard R. Wright.

THE increase in the demand for water due to improved living standards, population growth, and industrial expansion is rapidly approaching the limit of the great natural resources. Most communities are finding it increasingly difficult and expensive to enlarge their sources of supply and plant facilities, so that the incentive to conserve their existing supply is greater than ever.

The cost of an additional supply is frequently more expensive than the original construction because of the need to go a greater distance from the community or to develop a new source which has less yield per invested dollar or simply because of inflation. Ground water is being depleted, and water tables are being lowered. The least expensive supplies were developed initially; but even without considering the steady rise in construction costs, future supplies will be almost certain to cost more than the existing ones.

Conservation is, therefore, a fundamental part of water works operation in an established community, due to the direct money savings in operation and the longer range savings from deferred capital costs for plant expansion.

Direct savings can be made in the cost of production by reducing the amount of chemicals or power consumed, or, if the water supply is purchased, the saving is in dollars paid to the wholesaler. Deferment of the need for plant expansion saves capital expenditures, and is thus another type of saving.

Transmission mains and distribution systems need to be expanded or reinforced when their designed capacity is exceeded, so as to maintain adequate pressures and a satisfactory reserve capacity. Reservoirs, standpipes, and elevated tanks likewise may need to be expanded as consumption increases.

This report is intended to aid the water works industry in its efforts to evaluate and improve conservation practices. It furnishes the operator of the water works plant complete information on the items which must be considered in accounting for the water supplied to the distribution system. If a proper analysis is made, he then will be in a position to determine whether his plant is being operated at maximum efficiency; or if not, what steps he should take to improve conditions.

1587

Source: AWWA

AWWA Water Loss Control Committee Report

2003

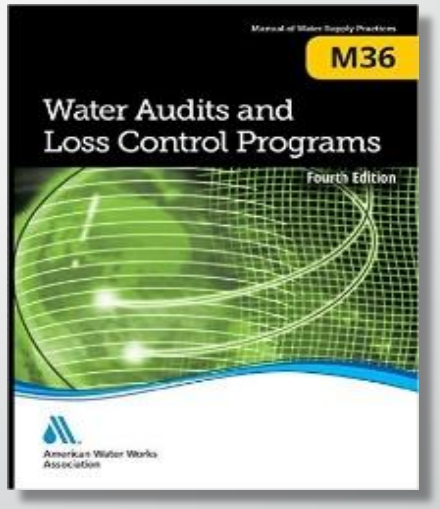
- Recommended conducting water loss assessments by quantifying volumes of loss and cost impacts of losses

COMMITTEE REPORT:

Applying worldwide BMPs in water loss control

Using Performance Indicators to Assess the Water Efficiency of Utilities

- The old way: "unaccounted-for" water (UFW) and the UFW percentage indicator (UFW%)
- The new and better way: AWWA Water Audit Methodology. Best practice Performance Indicators are embodied in:
  - AWWA M36 Publication, 4th ed. (2016)
  - AWWA Free Water Audit Software, v 5.0 (2014)



AWWA M36

AWWA Free Water Audit Software©

AWWA Free Water Audit Software: System Attributes and Performance Indicators

WAS v5.0

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Water Audit Report for: County Water Company

Reporting Year: 2013 1/2013 - 12/2013

*** YOUR WATER AUDIT DATA VALIDITY SCORE IS: 50 out of 100 ***

System Attributes:

Apparent Losses:	208.225	MG/Yr
+ Real Losses:	736.495	MG/Yr
= **Water Losses:**	**944.720**	MG/Yr
? Unavoidable Annual Real Losses (UARL):	83.69	MG/Yr
Annual cost of Apparent Losses:	$821,449	
Annual cost of Real Losses:	$139,934	Valued at **Variable Production Cost**

Return to Reporting Worksheet to change this assumpiton

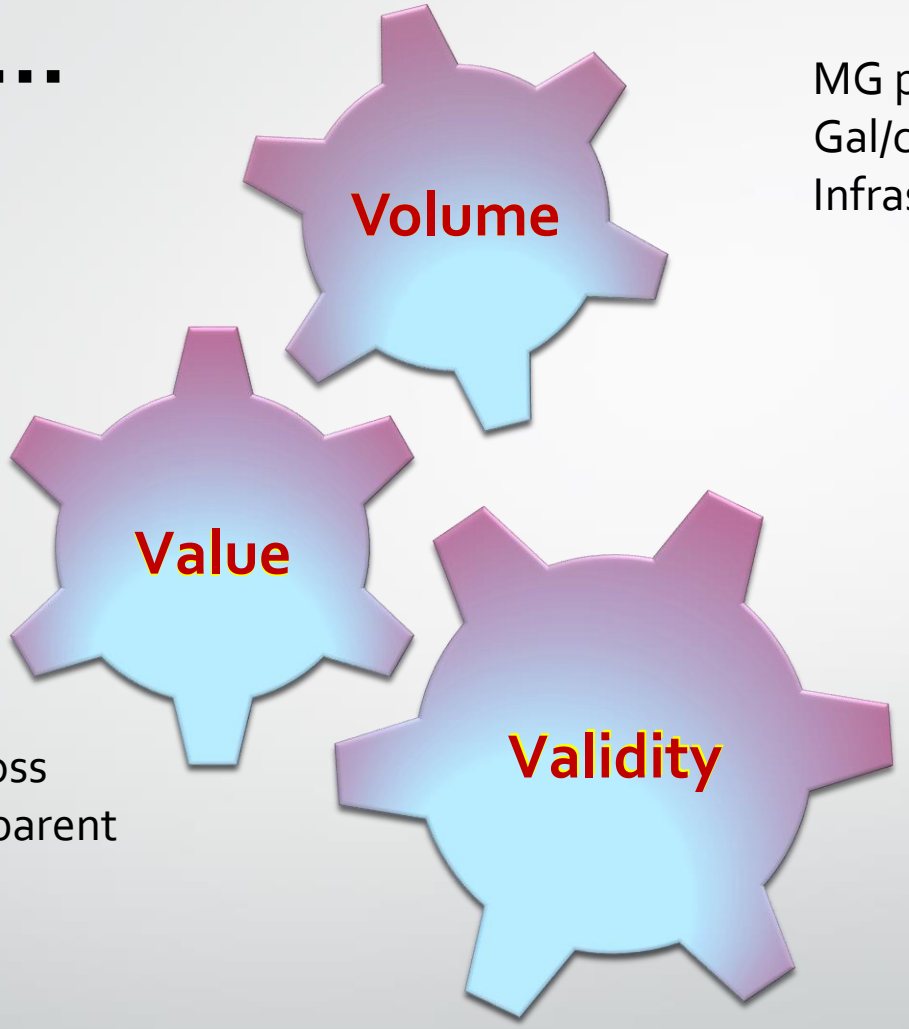
Performance Indicators:

Financial:	Non-revenue water as percent by volume of Water Supplied:	26.0%	
	Non-revenue water as percent by cost of operating system:	10.4%	Real Losses valued at Variable Production Cost
Operational Efficiency:	Apparent Losses per service connection per day:	46.78	gallons/connection/day
	Real Losses per service connection per day:	165.45	gallons/connection/day
	Real Losses per length of main per day*:	N/A	
	Real Losses per service connection per day per psi pressure:	2.55	gallons/connection/day/psi
	From Above, Real Losses = Current Annual Real Losses (CARL):	736.49	million gallons/year
	? Infrastructure Leakage Index (ILI) [CARL/UARL]:	8.80	

* This performance indicator applies for systems with a low service connection density of less than 32 service connections/mile of pipeline

How to Assess Water Loss and Its Impacts?

Three Vs…



MG per Year
Gal/connection/day
Infrastructure Leakage Index

$ per Year
Economic Loss
Real and Apparent

Data Input Grading
Water Audit Data Validity Score

Volumetric Percentage Performance Indicators (VPPI)

- The VPPI doesn't represent water loss standing well because:
  - It is mathematically skewed by varying levels of customer consumption
  - It does not reveal volumes of Real (physical) Losses and Apparent (customer) Losses
  - It does not take into account the costs of the activities to control losses
  - It is rarely successful in motivating actual loss reductions in water utilities → the VPPI is too frequently outrighted misleading

Volumetric Percentage Performance Indicators

"For every complex problem, there is an answer that is clear, simple, and wrong."

H.L. Mencken

20th Century American Journalist

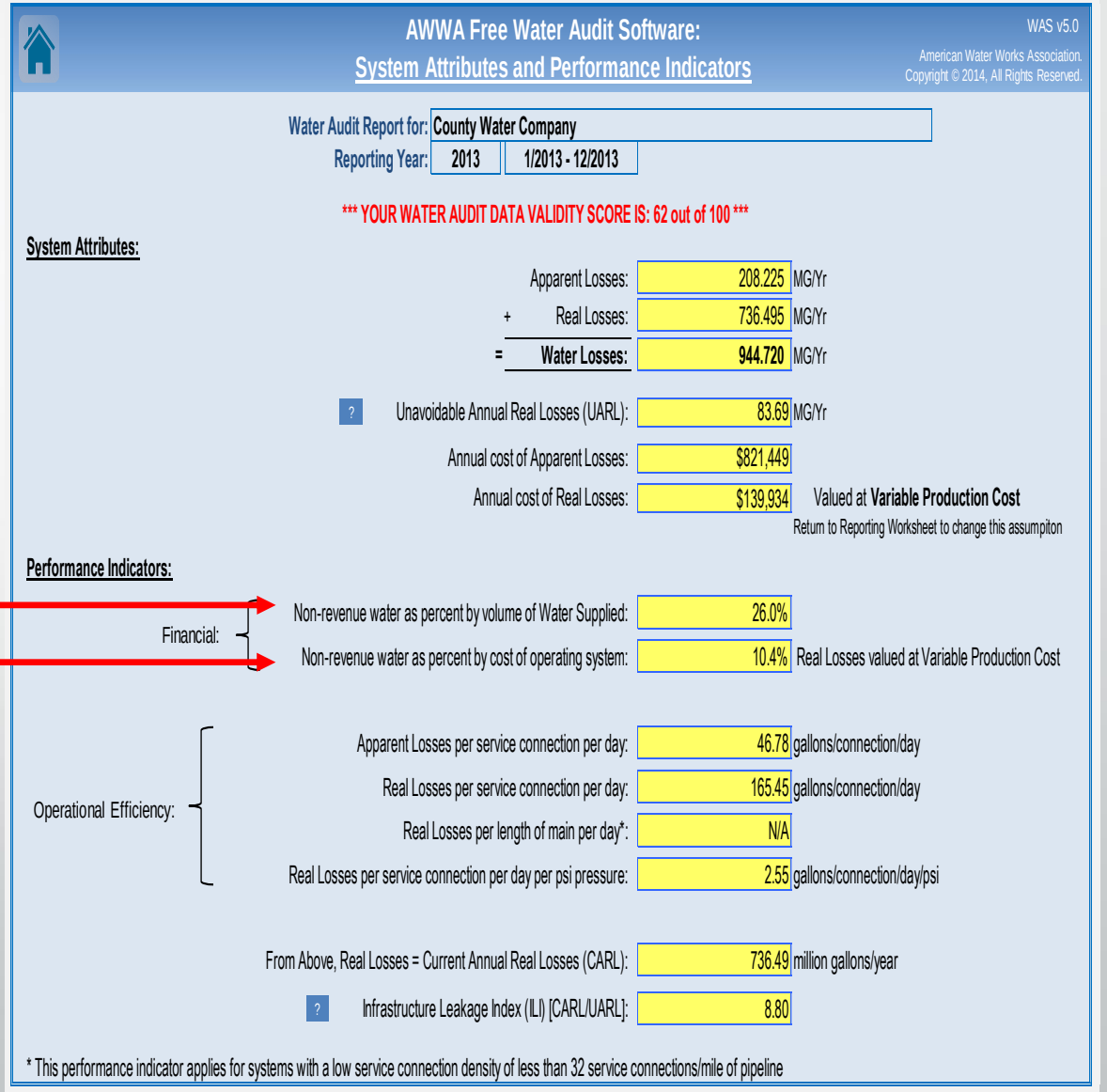
Source: Wikiquote

Unfortunately, many NA water utilities and regulatory agencies still employ the VPPI and regard it as:

- Simple to calculate, disseminate, employ and track
- Straightforward to use to set targets (despite a history of inability to motivate measurable loss reductions in water utilities)
- A difficult transition from current practices

AWWA Water Audit Method includes two % PIs ***but should it?.....***

- System Attributes include:
  - Apparent Losses volume
  - Real Losses volume
  - Water Losses
  - Unavoidable Annual Real Losses (UARL)
  - Apparent Losses cost
  - Real Losses cost
- Performance Indicators include:
  - Financial
    - NRW% by volume (VPPI)
    - NRW% by cost
  - Operational Efficiency
    - Apparent Losses normalized
    - Real Losses normalized (3 forms)
  - Infrastructure Leakage Index (ILI) = Current Annual Real Losses / UARL



AWWA Free Water Audit Software:
System Attributes and Performance Indicators

WAS v5.0

Water Audit Report for: County Water Company
Reporting Year: 2013 1/2013 - 12/2013

*** YOUR WATER AUDIT DATA VALIDITY SCORE IS: 62 out of 100 ***

System Attributes:

Apparent Losses:	208.225	MG/Yr
+ Real Losses:	736.495	MG/Yr
= **Water Losses:**	**944.720**	MG/Yr
? Unavoidable Annual Real Losses (UARL):	83.69	MG/Yr
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Ideal Uses of Performance Indicators for Non-revenue Water Management

- Assess Water Loss standing
  - *How significant are my system losses and their impacts?*
- Aid in setting goals and targets for Water Loss Control Programs to bring losses down to acceptable level
- Track progress in achieving loss reduction as programs are executed
  - *Is our water loss control program achieving the targeted goals?*
- Compare standing and progress with other water utilities
  - *How does my system compare with peer utilities or "best-in-class" utilities?*

AWWA Non-revenue Water Performance Indicators Task Force (PITF)

- Launched in 2015
- Goals
  - Communicate that AWWA does not have a "goal" for water utilities to achieve a certain level of losses as measured by a percentage, such as 15% UFW
  - Affirm an updated AWWA WLCC position regarding PI's, and any continued use of percentage indicators, by **June 2019**.
  - Conduct planning for an improved system of NRW performance measurement and effective targeting that can meet the twin goals of technical rigor and ease of comprehension

AWWA NRW PITF Members

- George Kunkel, Kunkel Water Efficiency Consulting, chair
- Andrew Chastain-Howley, Black & Veatch
- Steve Cavanaugh, Cavanaugh
- Steve Davis, Metering Technology Consultants
- Will Jernigan, Cavanaugh
- Chris Leauber, W/WW Authority of Wilson County, TN
- Sofia Marcus, Los Angeles Dept of Water & Power
- David Sayers, Black & Veatch
- Brian Skeens, CH2M
- Dan Strub, City of Austin, TX
- Reinhard Sturm, Water Systems Optimization
- Gary Trachtman, Arcadis
- Alan Wyatt, Independent Consultant

Performance Indicators for Non-revenue Water Management:

An International Perspective

Cor Merks

International Effort
Professionals Abandon Percentages

- Effort of international water loss practitioners to advocate for the discontinued use of percentage indicators
- Have rallied 135 supporters from 26 countries who advise against using volumetric percentage performance indicators. North American leads with 30 supporters from the USA and 4 from Canada.

http://www.leakssuite.com/kpis-fit-for-purpose/pros-abandon-percents-of-siv/

Allan Lambert (UK)
"the world's foremost authority on leakage management" is leading this effort

Water Loss Performance Indicators in recent International Perspective

- IWA Best Practice "Performance Indicators for Water Supply Services"
  - Third Edition, 2017
  - Current version of the PI set basically the same as 1st Edition, 2000
- EU Reference document "Good Practices on Leakage Management"
  - © European Union, 2015
- Upcoming Article in Water and Wastewater International (WWI) (A. Lambert, C. Merks, et al)
  - http://www.waterworld.com/articles/wwi/print/volume-32/issue-6/technology-case-studies/water-losses-ditch-the-percentages.html

Performance Indicators (PIs) for Water Supply Services

"An individual Performance Indicator should be unique and collectively appropriate for representing all the relevant aspects of an utility's performance in a true and unbiased way, thus reflecting the managing activity. Each performance indicator should contribute to the expression of the level of actual performance achieved in a certain area and during a given period of time, allowing for a clear comparison with targeted objectives and simplifying an otherwise complex evaluation."

IWA PI set related to environmental and economic water loss

Definition
Inefficiency of use of water resources (%) Percentage of water that enters the system and is lost by leakage and overflows up to the point of customer metering.
Non-revenue water by volume (%) Percentage of the system input volume that corresponds to non-revenue water.
Non-revenue water by cost (%) Percentage of the system input volume that corresponds to the valuation of non-revenue water components.

3rd Edition (2017) of "Performance Indicators for Water Supply Systems"

IWA PI set related to operational water losses

Definition
Water losses per connection (m^3/connection/year) Total (apparent and real) losses, expressed in terms of annual volume lost per service connection. This indicator is adequate for urban distribution systems.
Water losses per mains length (m^3/km/day) Total (apparent and real) losses, expressed in terms of annual volume lost per mains length. This indicator is adequate for bulk supply and low service connection distribution systems.
Infrastructure leakage index (-) Ratio between the actual real losses and an estimate of the minimum real losses that could be technically achieved for the system operating pressure, average service connection length and service connection density.

3rd Edition (2017) of "Performance Indicators for Water Supply Systems"

AWWA M36 PI set with financial function

Definition and comments
Non-revenue water (NRW) by volume Volume of NRW as a percentage of system input volume. Easily calculated from water audit data; has limited value in high-level financial terms only; it is misleading to use this as a measure of operational efficiency. This indicator should not be used for year-to-year tracking or for benchmarking with other utilities.
NRW by cost Value of NRW as a percentage of the annual cost of running the system. Incorporates different unit costs for non-revenue water components; good financial indicator; should not be used for long-term performance tracking by the water utility or for benchmarking with other utilities.

4th Edition (2016) of "Water Audits and Loss Control Programs"

AWWA M36 PI set with operational function (1 of 2)

Definition and comments
Apparent Losses [gal/service connection/d] Basic but meaningful performance indicator for apparent losses. Easy to calculate once apparent losses are quantified.
Real Losses [gal/service connection/d] or **[gal/mi of mains/d]** only if service connection density is < 32/mi Best of the simple "traditional" performance indicators; useful for target setting; limited use for comparisons between systems.
Real Losses [gal/service connection/d/psi] or **[gal/mi of mains/d/psi]** only if service connection density is < 32/mi Easy to calculate this indicator if the ILI is not yet known; useful for comparisons between systems.

4th Edition (2016) of "Water Audits and Loss Control Programs"

AWWA M36 PI set with operational function (2 of 2)

Definition and comments
Unavoidable Annual Real Losses UARL (gal) = (5.41 × Lm + 0.15 × Nc + 7.5 × Lc) × P × 365 d/year A theoretical reference value representing the technical low limit of leakage that could be achieved if all today's best technology could be successfully applied. A key variable in the calculation of the ILI. The UARL calculation has not yet been proven fully valid for very small systems.
Infrastructure Leakage Index = CARL / UARL Ratio of the Current Annual Real Losses (CARL) to the UARL; best indicator for comparisons among systems. This indicator is best applied only after sufficient water audit data validity is achieved and all justifiable pressure management is completed.

4th Edition (2016) of "Water Audits and Loss Control Programs"

EU Reference document 'Fit for Purpose' PIs (1 of 2)

Objective	Good practice 'Fit for Purpose' Performance Indicator for leakage				
	VPPI	MGPY (Volume/year)	gal/service connection/d	gal/mi of mains/d *	ILI (with pressure mentioned)
Target-setting and tracking progress, for an individual system	NO	YES (for large systems)	YES	YES	Only if all justifiable pressure management completed
Technical performance comparisons of different systems	NO	NO	NO	NO	YES
Draw general conclusions from single or multiple systems	NO	NO	NO	NO	YES, together with other context factors
* only if service connection density is less than 32/mi; if not, choose service connections					

EU Reference document "Good Practices on Leakage Management", 2015

EU Reference document 'Fit for Purpose' PIs: context matters (2 of 2)

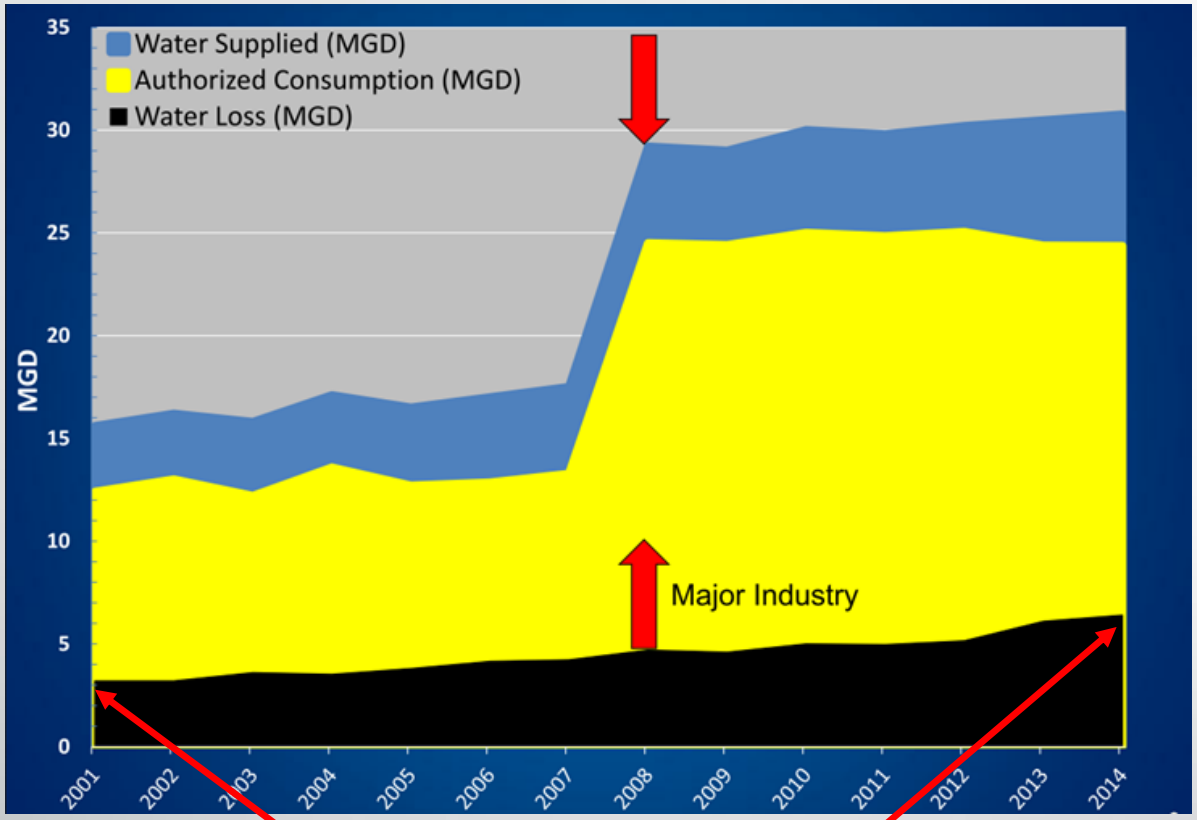
Does the PI make allowance for system specific key factors:	Good practice 'Fit for Purpose' Performance Indicator for leakage				
	VPPI	gal/service connection/d	gal/mi of mains/d *	gal/mi of mains/d/psi *	ILI (with pressure mentioned)
% of time pressurized?	NO	YES	YES	YES	YES
water exported?	NO	YES	YES	YES	YES
length of mains?	NO	NO	YES	YES	YES
number of connections?	NO	YES	NO	NO	YES
average pressure?	NO	NO	NO	YES	YES
connection density?	NO	NO	NO	NO	YES
length of services?	NO	NO	NO	NO	YES
how low could you go?	NO	NO	NO	NO	YES, the UARL
* only if service connection density is less than 32/mi; if not, choose service connections					

EU Reference document "Good Practices on Leakage Management", 2015

Perception of Water Loss Performance Indicators

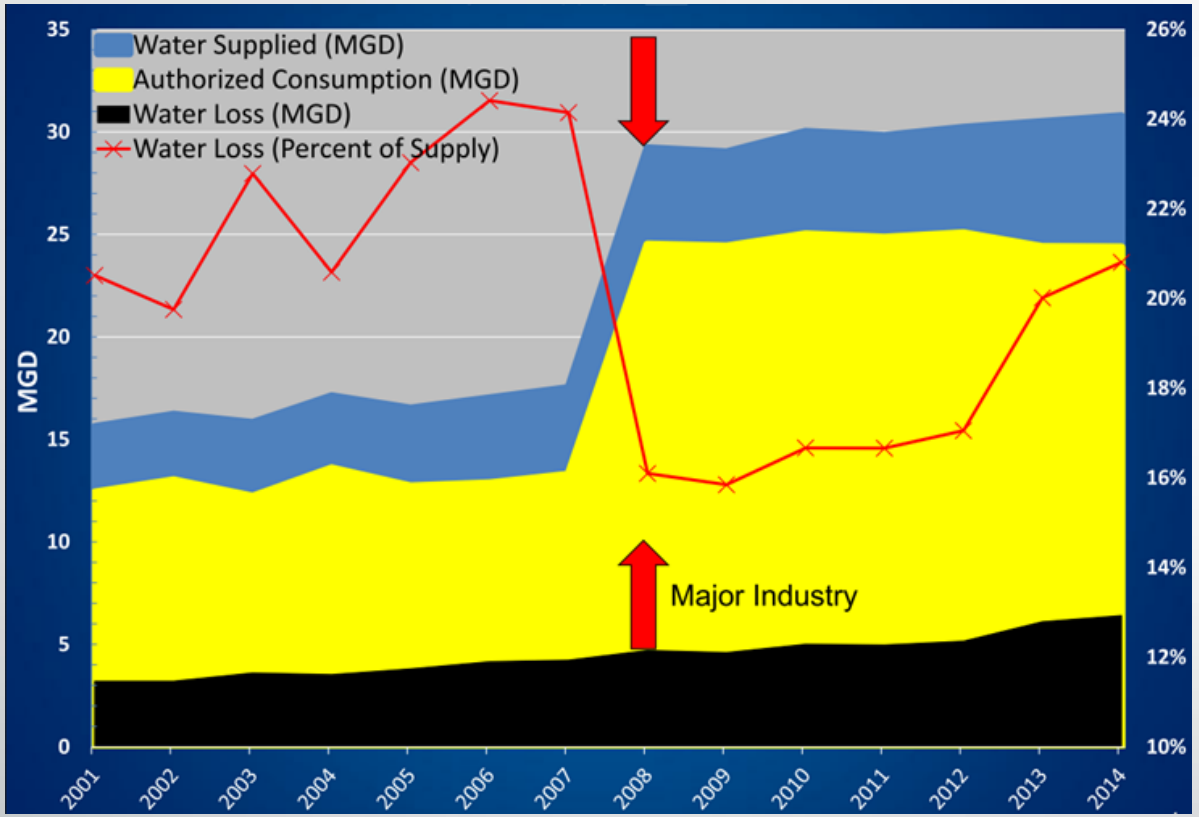
- VPPI are not/never agreed as operational water losses PI:
  - Not in the 1st (2000), 2nd (2006) nor 3rd (2017) Edition of "Performance Indicators for Water Supply Systems"
  - Not in the 4th Edition (2016) of AWWA Manual M36
  - Not in the EU Reference document (2015)
- Statement PI 2017 Conference in Vienna, Austria, May 2017: '*Everyone knows VPPI must not be used for target-setting and/or making technical comparisons*.'

Why don't VPPI work?- Simulated example I (1 of 2)



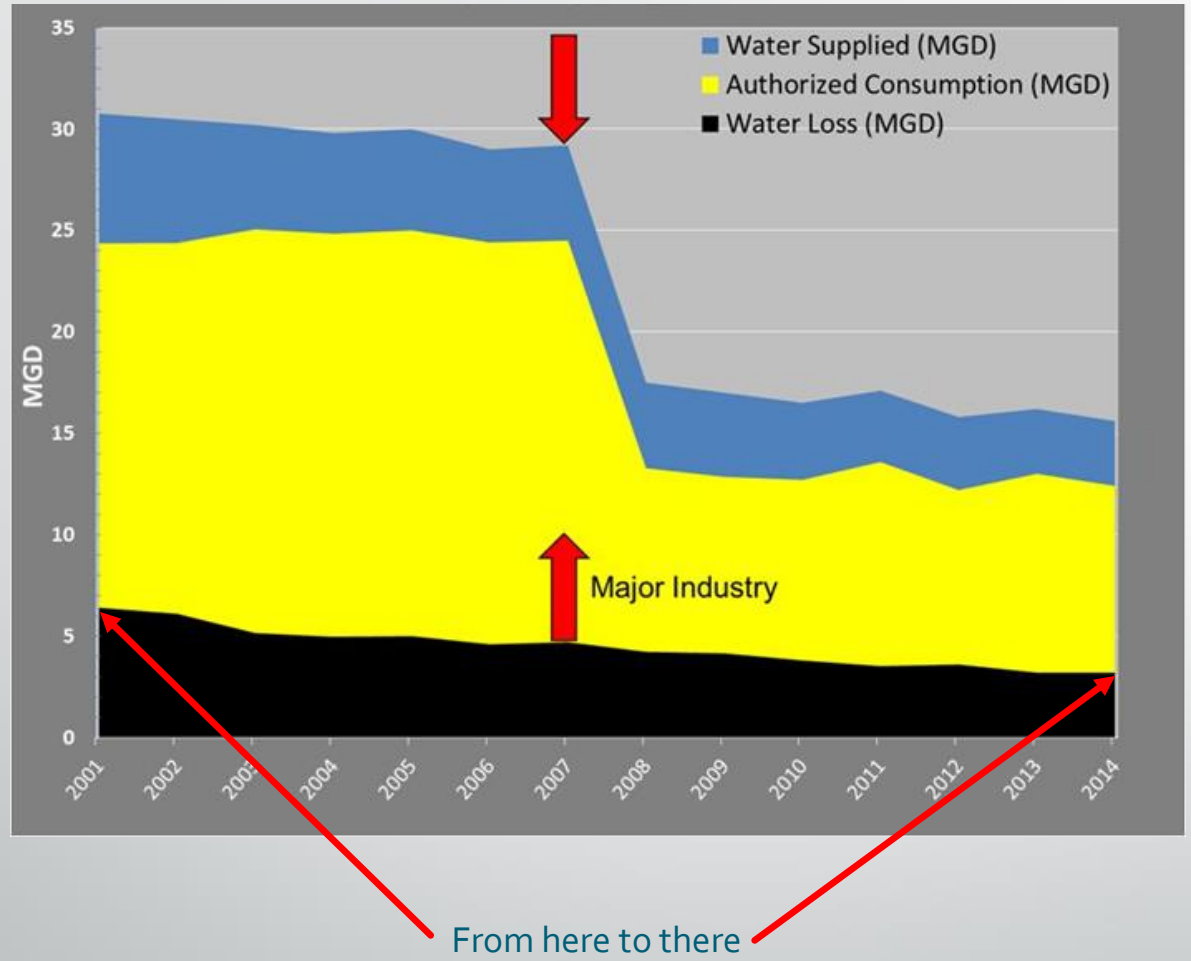
- Utility has no Water Loss Control Program in place
- Steadily rising Water Losses over 13 years; doubled from 3 to 6 MGD
- A Major Industry moves to the City so Authorized Consumption has increased

Why don't VPPI work?- Simulated example I (2 of 2)



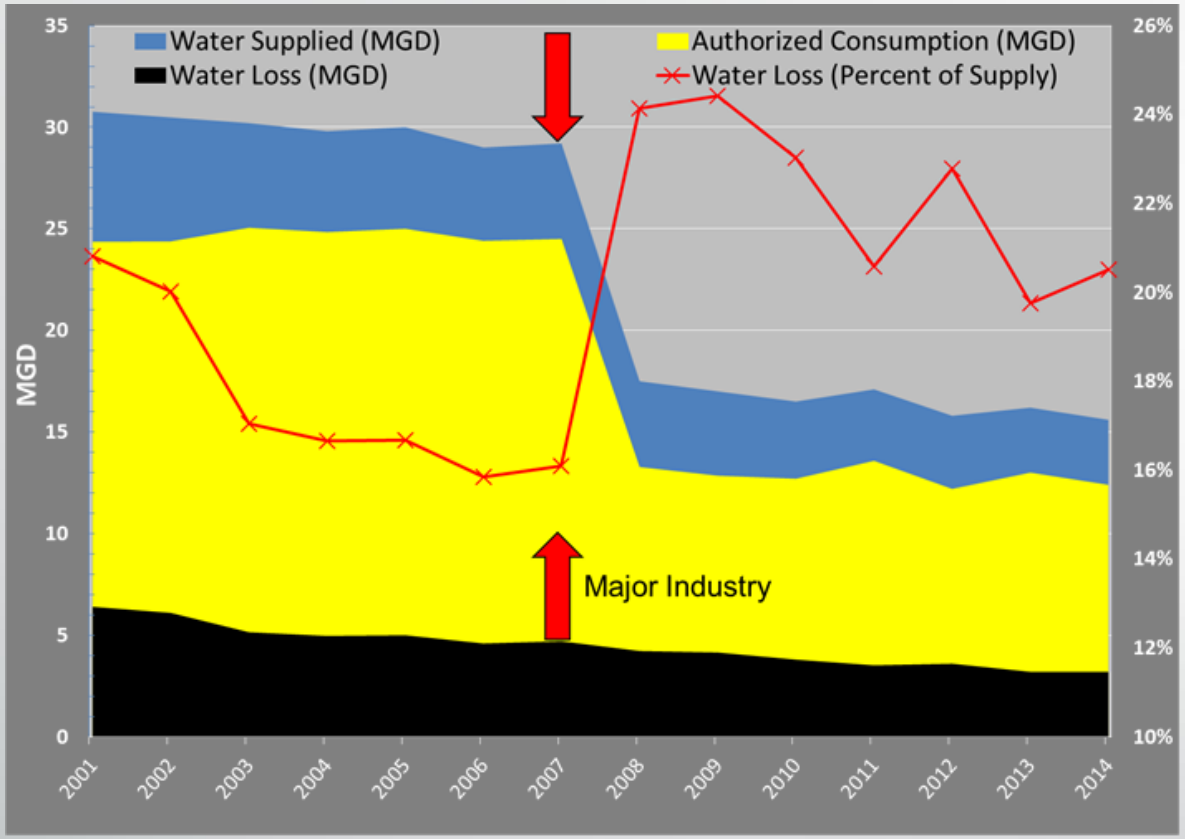
- Water Loss in MGD and by % of Water Supplied
- It seems our VPPI drastically improved when the major Industry moved to the City
- Performance 2014 seems similar as 2001
- But Water Losses over 13 years doubled from 3 to 6 MGD
- VPPI is misleading

Why don't VPPI work?- Simulated example II (1 of 2)



- Utility has comprehensive Water Loss Control Program in place
- Steady reductions in Water Losses over 13 years; halved from 6 to 3 MGD
- Our Major Industry stays in the City but changes to Treated Effluent
- Authorized Consumption has decreased

Why don't VPPI work?- Simulated example II (2 of 2)



- Water Loss in MGD and by % of Water Supplied
- It seems our VPPI drastically deteriorated when the Major Industry changed to TE
- Performance 2014 seems similar as 2001
- But Water Losses over 13 years halved from 6 to 3 MGD
- VPPI is misleading

Why don't VPPI work?- Zagreb, Croatia

Water Balance Annual Volumes expressed in Million cubic metres (Mm3)					
Year	System Input Volume	Revenue Water	Non-Revenue Water	Apparent Losses	Real Losses
	Mm3	Mm3	Mm3	Mm3	Mm3
2012	120.7	49.4	71.3	2.0	69.3
2013	114.1	47.3	66.8	1.9	64.9
Change (2013-2012)	-6.6	-2.1	-4.5	-0.1	-4.4

Water Balance Annual Volumes expressed as % of System Input Volume (% of SIV)					
Year	System Input Volume	Revenue Water	Non-Revenue Water	Apparent Losses	Real Losses
	% of SIV	% of SIV	% of SIV	% of SIV	% of SIV
2012	100.0%	40.9%	59.1%	1.7%	57.4%
2013	100.0%	41.5%	58.5%	1.7%	56.9%
% Change	0.0%	0.5%	-0.5%	0.0%	-0.5%

Always a Zero-Sum calculation: one +X%, the other –X%, or both o%

Why don't VPPI work?- Denmark, Benchmarking 2014

Danish water industry context:

- Groundwater levels are falling
- Water is expensive
- Utilities have to pay additional tax (≈ 0,0035 USD/gal) if VPPI > 10%
- Per capita consumption reduced
- Water loss volumes much reduced
  - NRW in gal/mi of mains/d: 32-1,080
  - ILI of 27 out of 37 Utilities ≤ 1.0, highest 2.5
  - VPPI of 28 out of 37 Utilities < 10%

Lessons learned:

- Consumption strongly influences NRW volume as VPPI
- 'Fit for Purpose' PIs crucial
- The ILI helps to identify likely priorities for action
- VPPI are "unfair" to peri-urban, rural Utilities
- gal/mi of mains/d is "unfair" to urban Utilities
- Monetary penalties on VPPI are "unfair" to all Utilities

Let the past go!

- VPPI just don't work!
- Move away from VPPI and move towards using [gal/service connection/d] or [gal/mi of mains/d] and the ILI
- [gal/service connection/d/psi] or [gal/mi of mains/d/psi] also allows for differences in pressure
- Professionally use:
  - The ILI for technical performance comparisons of water supply systems
  - [gal/service connection/d] or [gal/mi of mains/d] for target-setting and tracking progress

Attendee Survey Results Discussion

Facilitated Discussion

- How best to proceed in North America, and specifically USA, in halting the use of VPPI?
- What are the greatest barriers to moving forward?
- What are the greatest needs in moving forward?
  - Education/Training
  - Outreach/Policy/Regulation
  - Funding
  - Other

Summary

- Thank you for sharing your thoughts and insights on Performance Indicators for Non-revenue Water Management
- Feel free to send your follow-up thoughts to:

George Kunkel Kunkel Water Efficiency Consulting Kunkelwaterefficiency@gmail.com

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Stewardship Through Innovation

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