The Water Balance

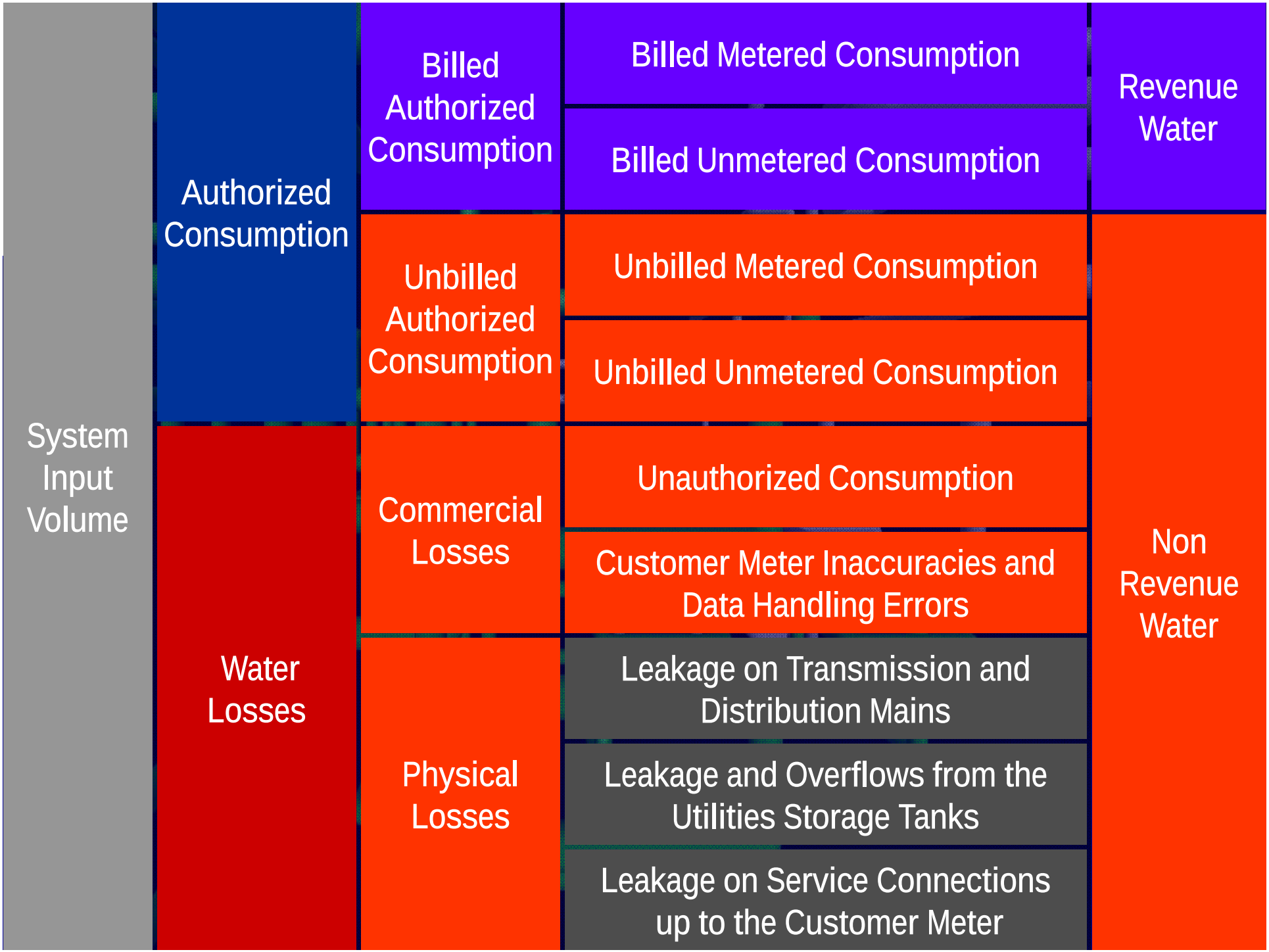
Water Balance and Performance Indicator Training
Bangkal, 11/18/10

Content

- Defining the water balance
- Calculating the water balance
- Probability analysis

Why is Calculating the Water Balance so Important ??

- Framework for assessing a utility's water loss situation
- Calculating the water balance:
  - reveals availability/reliability of data and level of understanding
  - creates awareness of problems/issues
  - directs direction of improvements
- Tool for communication and benchmarking
- Understanding Water Balance is a **MUST** for prioritizing attention and investments


System Input Volume
Authorized Consumption
Billed Authorized Consumption
Billed Metered Consumption
Billed Unmetered Consumption
Revenue Water
Unbilled Authorized Consumption
Unbilled Metered Consumption
Unbilled Unmetered Consumption
Water Losses
Commercial Losses
Unauthorized Consumption
Customer Meter Inaccuracies and Data Handling Errors
Physical Losses
Leakage on Transmission and Distribution Mains
Leakage and Overflows from the Utilities Storage Tanks
Leakage on Service Connections up to the Customer Meter
Non Revenue Water

Calculating the Water Balance

Calculating a Water Balance

- Step 1 – determine system input volume
- Step 2 – determine authorized consumption
  - billed authorized consumption
  - unbilled authorized consumption
- Step 3 – estimate commercial losses
  - water theft, fraud
  - meter under-registration
  - data handling errors
- Step 4 – calculate physical losses

Step 1 - System Input Volume

- Easy if all input is accurately metered
- But in the absence of production metering:
  - flow measurements using portable devices
  - reservoir drop tests
  - analysis of pump curves, pressures and pumping hours
- Accuracy of system input volume is of great importance for accuracy of water balance
- Accuracy of +/- 1-2% possible with good metering, but very questionable otherwise

Indicative Examples of Meter Accuracy

Equipment/Method	Approximate Accuracy Range
Electromagnetic Flow Meters	< 0.15 – 0.5 %
Ultrasonic Flow Meters	0.5 – 1 %
Insertion Probes	≥ 2 %
Mechanical Meters	1.0 – 2 %
Venturi Meters	0.5 – 3 %
Meas. Weirs in open channels	> 5%
Volume calculated with pump curves	10 – 50 %

Note: actual meter accuracy will depend on many factors (like flow profile, calibration, meter installation, maintenance) and has to be verified case by case.

Step 2: Authorized Consumption

- **Definition:** the annual volume of metered and/or un-metered water taken by registered customers, the water supplier and others who are authorized to do so
- **Components:**
  - billed metered consumption
  - billed unmetered consumption
  - unbilled metered consumption
  - unbilled unmetered consumption

Step 2a: Authorized Billed Metered and Unmetered Consumption

- data from billing department
- important:
  - check correlation of meter reading and billing cycle with period for which the water balance is established
  - apply corrections if required

Step 2b: Authorized Unbilled Metered Consumption

- **Definition:** supply to customers, free of charge, but metered
- **Issues/remarks:**
  - generally not very significant
  - can sometimes be substantial (e.g. if large military facilities have the right to receiving water free of charge)

Step 2c: Authorized Unbilled Unmetered Consumption

- Two extremes:
  - normal situation: a very small component example: the Water Services Association of Australia accept only 0.5% of system input unless utilities can demonstrate it is more.
  - unusual situation: can be a very large component; in some places the single largest one in the water balance

Step 2c: Authorized Unbilled Unmetered Consumption; "Usual" Situation

- often seriously overestimated on purpose - to "mask" other losses
- components to be individually estimated:
  - fire fighting (how often? how much?)
  - mains and sewer flushing (same question!)
  - public fountains (why not metered?)
  - street washing (how often? how much?)
  - irrigation of public gardens (why not metered?)

Step 2c: Authorized Unbilled Unmetered Consumption; “Unusual" Situation

- Free supply, examples:
  - Brazil: SABESP considers all water supplied to informal settlements “authorized”, not as commercial losses
  - Former Soviet Union: often large volumes of water are give for free to population groups and institutions
  - Supply to privileged consumers (“palaces” and farms) in the Middle East

Step 3:
Estimating Commercial Losses

- Unauthorized consumption
  - illegal connections
  - misuse of fire hydrants and fire fighting systems
  - Vandalized, tampered or bypassed consumption meters
  - corrupt meter reading
- Unknown export of water to external distribution systems (open boundary valves)
- Customer meter inaccuracies
- Low estimates for billed, unmetered customers
- Data handling errors

Step 4: Calculating Physical Losses

- **Definition:** Losses from pressurized system up to the point of customer use
- Simple mathematically:

System Input Volume
– Authorized Consumption
– Commercial Losses
= Physical losses

- But, results sometimes inaccurate and unreliable
- Especially in systems with poor/no metering or high commercial losses

Probability Analysis

Concept of Probability Analysis in Water Balance Calculations

- Some elements in Water Balance are estimates
- Probability analysis allows judging the overall reliability of the Water Balance
- Confidence levels express relative accuracy:

  a 95 % level means that I am 95% confident that an input value is within X% of the true value

Calculating Probabilities: Example

Water Balance Components	Example	
	Volume M3/day	95% Confid. Limit (%)
System Input	300,000	+/- 2%
Billed Author. Cons.	200,000	+/- 0%
Non Revenue Water	100,000	???
Unbilled Author. Cons.	5,000	+/- 50%
Water Losses	95,000	???
Commercial Losses	30,000	+/-30%
Physical Losses	65,000	???

Applying 95% Confidence Limits to the Water Balance

	Volume (V) [m3/d]	95% Confidence Limits (CL)		Standard Deviation (SD) [=V x CL / 1.96]		Variance (Va) [= SD^2]	
System Input Volume	300,000	+/- 2 %	→				
Billed Author. Consumption	200,000	+/- 0 %	→				
Non-Revenue Water	100,000						
Unbilled Author. Consumption	5,000	+/- 50 %					
Water Losses	95,000						
Commercial Losses	30,000	+/- 30 %					
Real Losses	65,000						

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System Input Volume	300,000	+/- 2 %	→	3,061	→		
Billed Author. Consumption	200,000	+/- 0 %	→	0	→		
Non-Revenue Water	100,000						
Unbilled Author. Consumption	5,000	+/- 50 %					
Water Losses	95,000						
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System Input Volume	300,000	+/- 2 %	→	3,061	→	9,369,721	
Billed Author. Consumption	200,000	+/- 0 %	→	0	→	0	+
Non-Revenue Water	100,000						
Unbilled Author. Consumption	5,000	+/- 50 %					
Water Losses	95,000						
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Billed Author. Consumption	200,000	+/- 0 %	→	0	→	0	+
Non-Revenue Water	100,000	+/- 6 % [=SD/V*1.96]	←	3,061	←	9,369,721	
Unbilled Author. Consumption	5,000	+/- 50 %					
Water Losses	95,000						
Commercial Losses	30,000	+/- 30 %					
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Non-Revenue Water	100,000	+/- 6 %	←	3,061	←	9,369,721	+
Unbilled Author. Consumption	5,000	+/- 50 %	→	1,275	→	1,626,926	
Water Losses	95,000						
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Unbilled Author. Consumption	5,000	+/- 50 %	→	1,275	→	1,626,926	
Water Losses	95,000	+/- 7 %	←	3,316	←	10,996,647	
Commercial	30,000	+/- 30 %					
Losses							
Real Losses	65,000						

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Water Losses	95,000	+/- 7 %	←	3,316	←	10,996,647	+
Commercial Losses	30,000	+/- 30 %	→	4,592	→	21,084,965	
Real Losses	65,000						

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Water Losses	95,000	+/- 7 %	←	3,316	←	10,996,647	+
Commercial Losses	30,000	+/- 30 %	→	4,592	→	21,084,965	
Real Losses	65,000	+/- 17 %	←	5,664	←	32,081,612	

Key Messages

- Water Balance is an important tool for understanding the water usage and loss situation
- However, there are problems:
  - utilities initially lack needed information
  - no information on nature and location of leakage
- Water Balance to be improved with two other methods:
  - Physical loss component analysis
  - Leakage measurements in the system