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Probabilistic water losses estimation in water distribution networks and comparison with the top down - water balance approach: A large-scale application to the city center of Patras in western Greece

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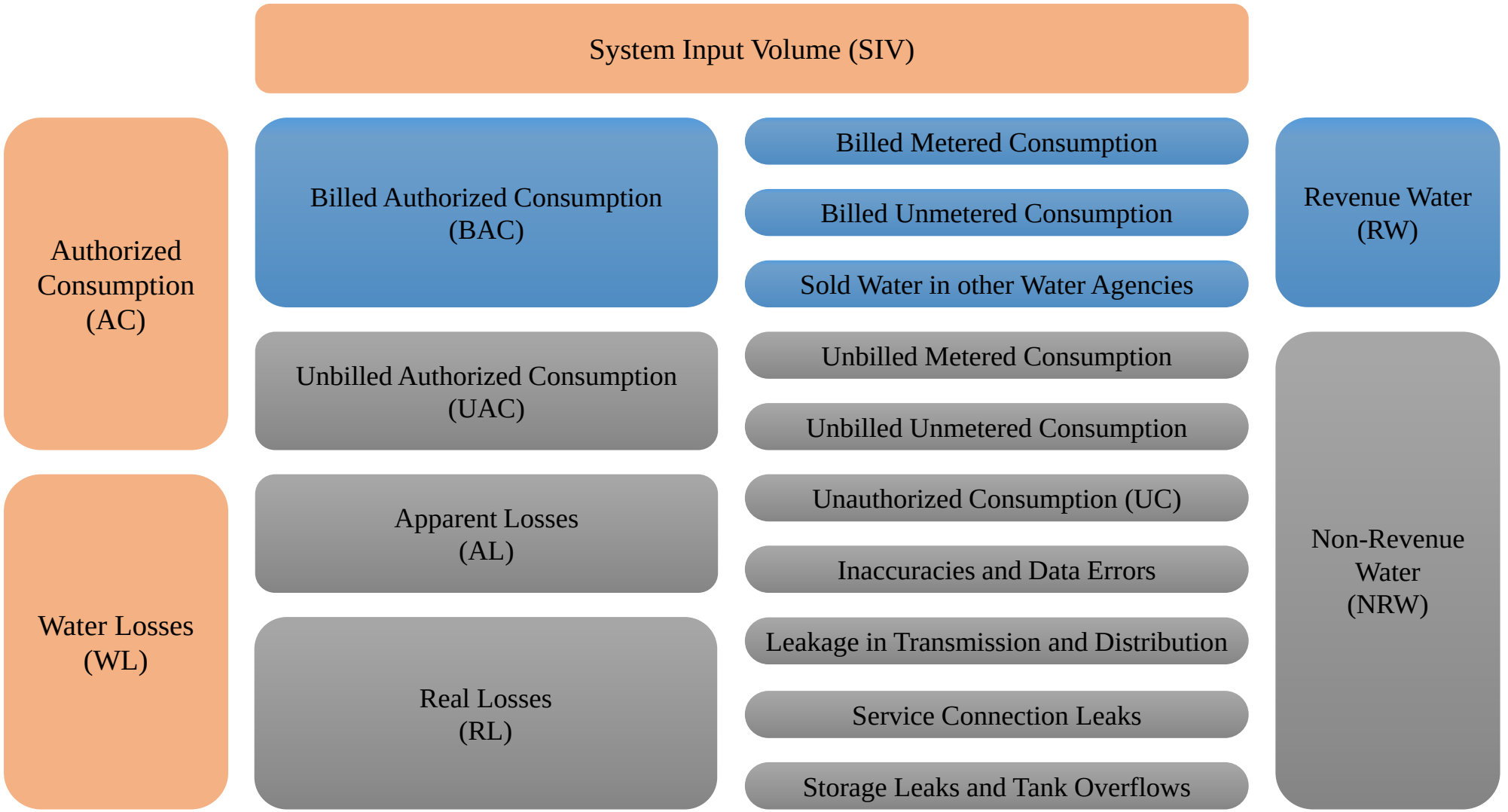
Water Balance Approach



- WL = NRW – UAC
- NRW = SIV – BAC
- WL = RL + AL

UC is estimated using semi-empirical approaches

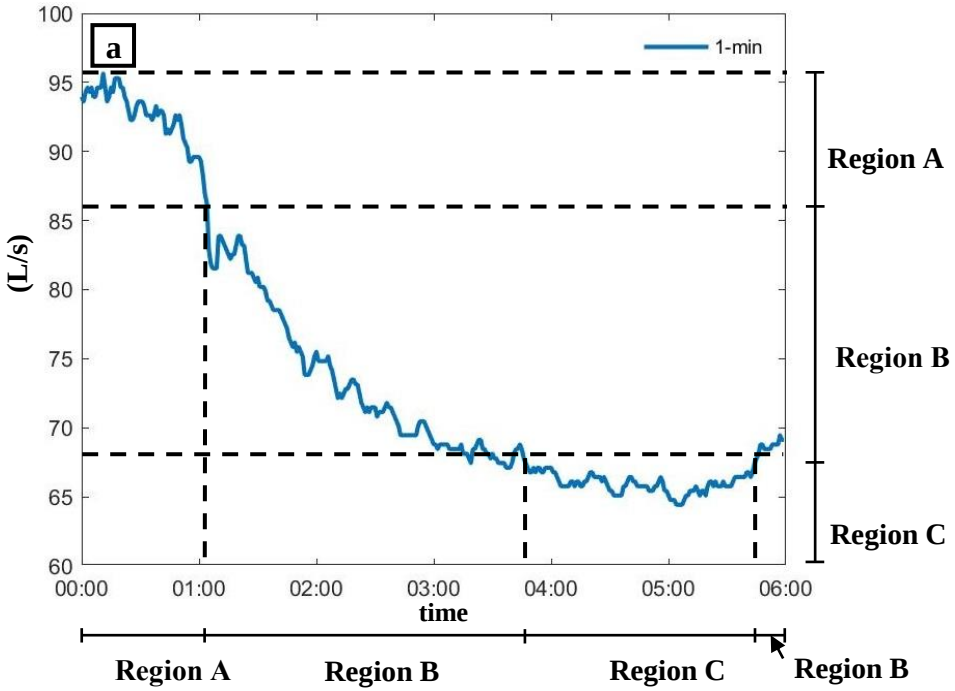
Minimum Night Flow approach

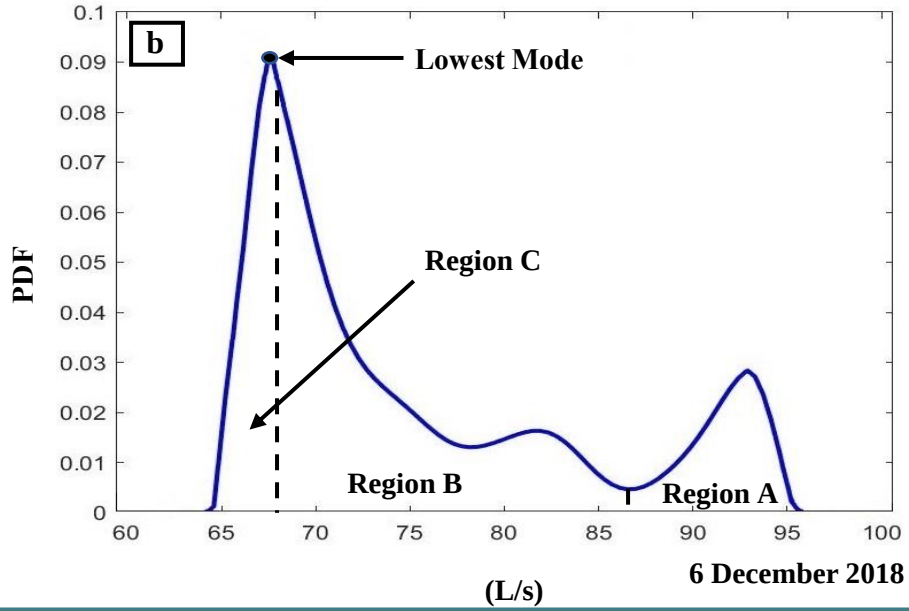
- Based on the concept that human activity is minimal during late night and early morning hours.
- We estimate MNF as the ensemble mean of the lowest modal values (i.e. the most probable states of night flows) observed during the night hours of each day in the low consumption period of the year (4-month long period from 01 November – 28 February).
- Decompose MNF to net night flow (NNF = the leakage rate during night hours), and users' night consumption (UNC, which can be both authorized and unauthorized).

$$NNF = MNF - UNC$$

- To obtain the RL, the NNF should be multiplied by the night-day factor (NDF).

$$RL = NNF \times NDF$$





Data and Area of Application

- **Area of Application**
  The 4 largest pressure management areas (PMAs) of the city of Patras, which consist of more than 200 km of (mainly) HDPE and PVC pipes, cover the entire city center of Patras, and serve approximately 58 000 consumers.

- **User's consumption and Flow-Pressure Data**
  Users' consumption and flow-pressure data at 1 min temporal resolution for the 4-month low consumption period of the year (from 01 November 2018 to 28 February 2019) were acquired for each of the 4 installed stations.

- **Quality assessment**
  Data were, first, quality assessed in order to remove any errors related to data transmission system malfunctions (i.e. communication glitches of the 3G transmission system).

Comparison between WB and MNF approaches

Estimates of real losses (RL) obtained using the water balance (WB) and MNF approaches as a fraction of the system input volume (SIV)

PMA name	WB RL (%)	MNF RL low limit (%)	MNF RL upper limit (%)	Absolute relative difference (%)
Boud	38.05	41.04	41.36	**7.28 – 7.99**
Kentro	48.41	46.37	47.32	**2.30 – 4.39**
Panachaiki	30.66	28.99	30.28	**1.25 – 5.77**
Prosfygika	53.72	58.40	59.39	**8.01 – 9.54**

The two approaches lead to very similar results, with absolute relative differences lower than 10% for all 4 PMAs. This indicates that the top-down (water balance) and bottom-up (MNF) approaches effectively converge when**:**

a) The network's specific characteristic are known and there is sufficient understanding of the consumption types and patterns during day and night hours, and

b) MNF estimation is done in a rigorous statistical setting from high resolution flow-pressure timeseries.

For more info

01 Serafeim, A.V.; Kokosalakis, G.; Deidda, R.; Karathanasi, I. and Langousis, A. (2021) Probabilistic estimation of minimum night flow in water distribution networks: large-scale application to the city of Patras in western Greece, Stoch. Environ. Res. Risk. Assess., https://doi.org/10.1007/s00477-021-02042-9.

02 Serafeim, A.V.; Kokosalakis, G.; Deidda, R.; Karathanasi, I.; Langousis, A. (2022) Probabilistic Minimum Night Flow Estimation in Water Distribution Networks and Comparison with the Water Balance Approach: Large-Scale Application to the City Center of Patras in Western Greece, Water, 14, 98, https://doi.org/10.3390/w14010098.

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