Self-Assessment Matrix for Water Systems' Technical and Operational Performance

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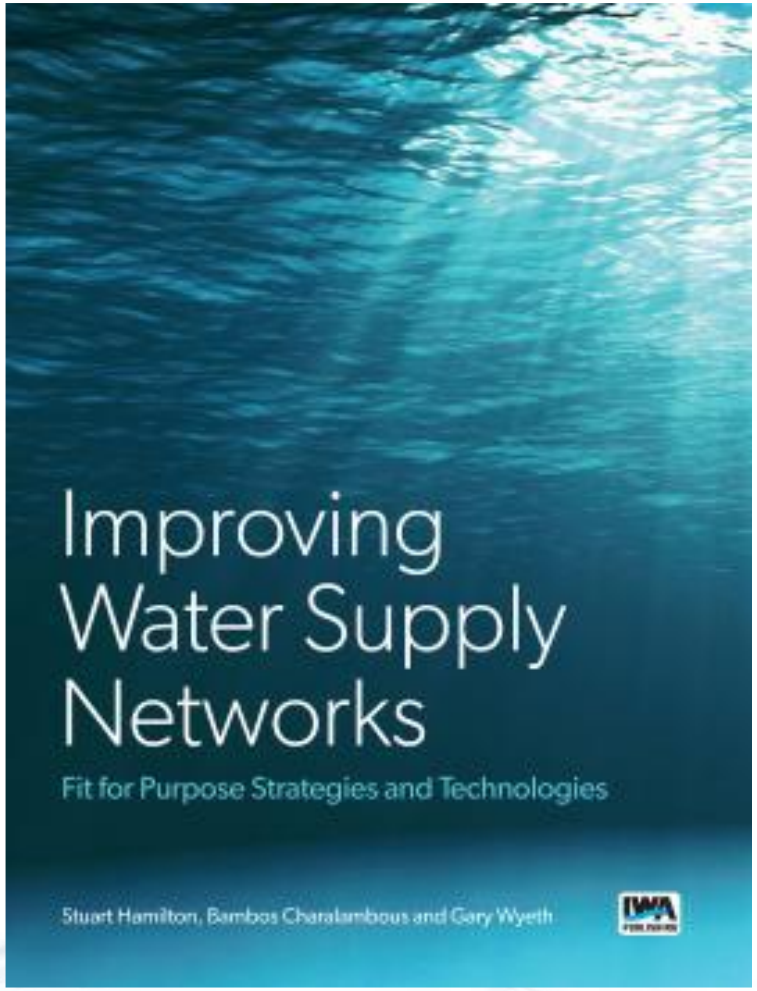
Presentation Summary



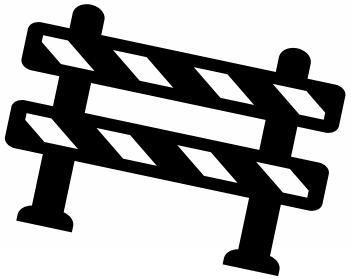
- Based on a recently published (15/03/2021) book by IWA Publishing "**Improving Water Supply Networks: Fit for Purpose Strategies and Technologies**".
- Present a summary of the concepts developed in the above book in **self-assessing the performance of water supply networks** and how best to improve these.
- Demonstrate the **Water System Improvement (WSI) Calculator** subsequently developed to facilitate the self-assessment process.

Aim of the Self-Assessment

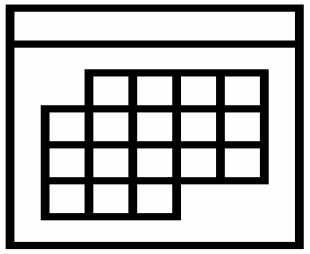
- Provide utility operators with a **better understanding** of the water supply system.
- Enable **qualitative assessment** of the current system performance.
- Enhance the capability of water utilities to advance from their current level of performance, or **step on the improvement ladder**, to the next one.
- Form the basis for **further progress** and **system enhancement** towards improved performance.
- Make **small sustainable steps** (advances) today through better control and management, and use of appropriate technologies and equipment.

Barriers to Improvement of Water Systems

- To move from one operational level to the next **may seem an extremely difficult** or even an impossible task.
- Organizational **cultures, operational regimes and practices** developed over many years in a water utility **may act as barriers** to moving forward.
- Culture is difficult to change, it becomes **organizational tradition** and passed on to new employees as the norm.
- As an example, **intermittency in water supply** is considered in many parts of the world as the **norm.**

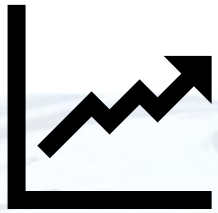


Water System Self-Assessment Matrix



- A matrix developed based on **collective experiences, knowledge and expertise**.
- Begins at the **current level of water system** and proceeds to the next level through a series of much-needed **sustainable changes** and system improvements.
- Imperative to fully **understand, measure and document a water utility's current level of operations** and then develop plans on how to move forward to the next operational level.

- Common for utilities to **underestimate the effort and work needed** to improve system efficiency.
- To **move forward** will take many processes, some simple and some that are not so easy, along with some that will **require investment and time**.



Network Operations

Water System are broadly divided into **four operational Categories**:

A. Basic Network
B. Ordinary Network
C. Smart Network
D. Intelligent Network

Water System Operations are represented using **seven Key Areas** which are considered crucial:

1. Bulk Flow Measurement
2. Customer Metering
3. Pressure Management
4. Leakage Management
5. Asset Management
6. Water Balance and KPIs
7. Human Resources

BULK FLOW MEASUREMENT

SYSTEM LEVEL	BASIC NETWORK SYSTEM	ORDINARY NETWORK SYSTEM	SMART NETWORK SYSTEM	INTELLIGENT NETWORK SYSTEM
Level 1	No reliable flow measurement Limited metering of bulk flows in the system	All bulk flows are metered but not sure about the meter accuracy	Bulk flows are metered, remotely read, monitored, and analysed with a permanent meter accuracy test program in place	Bulk flows metered, remotely read, monitored and analysed with software recognition for meter accuracy drifts with automatic meter recalibration capability and flow pattern analysis
Level 2	A continued program for the installation of bulk meters.	Meters are manually read and/or remotely monitored with meter accuracy occasionally checked	Bulk flows are metered, remotely read, monitored and analysed with software to recognise when meter accuracy drifts	Bulk flows are metered, remotely read, monitored and analysed with software recognition for meter accuracy drifts with automatic meter recalibration capability and flow forecasting based on historical supply and demand trends
Level 3	The majority or all of the system bulk flows are metered	Bulk flows are metered, remotely read, monitored, and analysed with frequent meter accuracy tests	Bulk flows metered, remotely read, monitored and analysed with software recognition for meter accuracy drifts and flow pattern analysis	Complete machine learning algorithms that control the system, to manage system input volumes and pressures

BULK FLOW MEASUREMENT – WATER SYSTEM IMPROVEMENT STEP LADDER

INTELLIGENT NETWORK

SMART NETWORK

ORDINARY NETWORK

BASIC NETWORK

Machine learning algorithms bulk system control

Software controlled with flow forecasting and automatic meter recalibration

Software controlled with automatic meter recalibration

Continuous flow pattern analysis with self-accuracy meter checks

Remote reading and analysis with self-accuracy meter checks

Remote reading and analysis, permanent meter accuracy tests

Remote reading, frequent meter accuracy tests

Manual reading, occasional meter accuracy checks

All bulk flows are metered

Majority bulk flows metered

Substantial bulk flow metering

Unreliable, limited bulk flow metering

CUSTOMER METERING

SYSTEM LEVEL	BASIC NETWORK SYSTEM	ORDINARY NETWORK SYSTEM	SMART NETWORK SYSTEM	INTELLIGENT NETWORK SYSTEM
Level 1	No or limited customer metering Unreliable information on the age and type of meters Customer database has not been updated for a long time	Substantial or universal customer metering Customer database is periodically updated Illegal connections are sporadically detected Meter readers are occasionally rotated	Customer database is updated and linked to a GIS. Handheld devices are used for meter reading and bills issued on the spot. AMR meters introduced	All customer meters have sound sensors, to detect leak noises, with connected communication systems allowing for automatic correlation and pinpointing of leaks. Fraudulent activities are detected via the AMI and AMR systems
Level 2	Inadequate meter and customer information No assessment is made and there is no program to deal with water theft	There is a meter replacement program in place Customer database is regularly updated There is a thorough illegal connections detection program in place	Demand management program in place based on consumption patterns identified via a GIS-billing infrastructure Continuous replacement programme of customer meters to AMR capability	All customer meters have sound sensors, to detect leak noises, with connected communication systems allowing for automatic correlation and pinpointing of leaks. Automatic alerts sent out to customers, when excessive customer side usage experienced
Level 3	Not all customers have meters installed No regular replacement policy, only when meters stop No system of controlling meter readers	All customers are metered with good accuracy meters Meter readers are rotated, and often spot checks are made Handheld devices are used for meter reading	All customers are metered with high accuracy AMR system AMI system in place following a strict meter replacement policy	Complete machine learning algorithms that control the system, so the system is run with internal flow measurement, measuring and adjusting the meters for accuracy with a total self-billing and billed collection procedure without any human interventions

CUSTOMER METERING – WATER SYSTEM IMPROVEMENT STEP LADDER

BASIC NETWORK

ORDINARY NETWORK

SMART NETWORK

INTELLIGENT NETWORK

- System control via machine learning algorithms with a self-billing and collection procedure
- Combined customer meters and leak sensors with automatic alerts for fraudulent, excessive use and system leaks
- Combined customer meters and leak sensors with automatic alerts for fraudulent use
- All customers are metered with high accuracy AMR system with AMI system in place
- AMR-GIS billing infrastructure and demand management program
- Customer database updated and linked to a GIS, an AMR and PDA devices in place
- All customers metered, good accuracy meters, PDA devices used
- Meter replacement program in place, customer database regularly updated, fraud detection program operational
- Customers metered, database periodically updated, checks for fraudulent water use
- Not all customers metered and no meter replacement policy in place
- Inadequate meter and customer database
- Limited, poor accuracy meters, unreliable and outdated database

Scoring System for Key Areas of Improvement

- Each Key Area has **three levels of improvement** thus building a matrix with **twelve improvement steps** in each of the seven Key Areas.
- A **scoring system** is used to assess the utility's overall system performance, from **1 at the bottom level** right through to **12 at the top level.**

SCORING	BASIC NETWORK SYSTEM – A	ORDINARY NETWORK SYSTEM – B	SMART NETWORK SYSTEM – C	INTELLIGENT NETWORK SYSTEM – D
Level 1	1	4	7	10
Level 2	2	5	8	11
Level 3	3	6	9	12

Software Development

Developed with the kind assistance of Roland Liemberger

Water System Improvement Calculator

Based on the Water System Improvement Matrix Methodology

Version 1.04

01-Mar-21

... the best things in life are not free but priceless!

Water Utility/System	EXAMPLE WATER UTILITY
City	
Country	
Date	

WSI-Calc

System Self-Assessment

- Bulk Flow Measurement
- Customer Metering
- Pressure Management
- Leakage Management
- Asset Management
- Water Balance and Water Loss KPIs
- Human Resources

Results

Key System Information

Acknowledgements

Bulk Flow Measurement

Instructions	System Level
Click on the red box and use the drop down menu to choose the system level which best describes your system	A1

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Results

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System Level	BASIC NETWORK SYSTEM A	ORDINARY NETWORK SYSTEM B	SMART NETWORK SYSTEM C	INTELLIGENT NETWORK SYSTEM D
1	No reliable flow measurement Limited metering of bulk flows in the system	All bulk flows are metered but not sure about the meter accuracy	Bulk flows are metered, remotely read, monitored, and analysed with a permanent meter accuracy test program in place	Bulk flows metered, remotely read, monitored and analysed with software recognition for meter accuracy drifts with automatic meter recalibration capability and flow pattern analysis
2	A continued program for the installation of bulk meters.	Meters are manually read and/or remotely monitored with meter accuracy occasionally checked	Bulk flows are metered, remotely read, monitored and analysed with software to recognise when meter accuracy drifts	Bulk flows are metered, remotely read, monitored and analysed with software recognition for meter accuracy drifts with automatic meter recalibration capability and flow forecasting based on historical supply and demand trends
3	The majority or all of the system bulk flows are metered	Bulk flows are metered, remotely read, monitored, and analysed with frequent meter accuracy tests	Bulk flows metered, remotely read, monitored and analysed with software recognition for meter accuracy drifts and flow pattern analysis	Complete machine learning algorithms that control the system, to manage system input volumes and pressures

Customer Metering

Instructions	System Level
Click on the red box and use the drop down menu to choose the system level which best describes your system	A3

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System Level	BASIC NETWORK SYSTEM A	ORDINARY NETWORK SYSTEM B	SMART NETWORK SYSTEM C	INTELLIGENT NETWORK SYSTEM D
1	No or limited customer metering Unreliable information on the age and type of meters Customer database has not been updated for a long time	Substantial or Universal customer metering Customer database is periodically updated Illegal connections are sporadically detected	Customer database is updated and linked to a GIS. Handheld devices are used for meter reading and bills issued on the spot. AMR meters introduced	All customer meters have sound sensors, to detect leak noises, with connected communication systems allowing for automatic correlation and pinpointing of leaks. Fraudulent activities are detected via the AMI and AMR systems
2	Inadequate meter and customer information No assessment is made and there is no program to deal with water theft	There is a meter replacement program in place Customer database is regularly updated There is a thorough illegal connections detection program in place	Demand management program in place based on consumption patterns identified via a GIS-billing infrastructure Continuous replacement programme of customer meters to AMR capability	All customer meters have sound sensors, to detect leak noises, with connected communication systems allowing for automatic correlation and pinpointing of leaks. Automatic alerts sent out to customers, when excessive customer side usage experienced
3	Not all customers have meters installed No regular replacement policy, only when meters stop No system of controlling meter readers	More than 98% of customers are metered with good accuracy meters Meter readers are rotated, and often spot checks are made Handheld devices are used for meter reading	More than 98% of customers are metered with high accuracy AMR system AMI system in place following a strict meter replacement policy	Complete machine learning algorithms that control the system, so the system is run with internal flow measurement, measuring and adjusting the meters for accuracy with a total self-billing and billed collection procedure without any human interventions

Results

Water Utility	EXAMPLE WATER UTILITY
Date	

Topic	System Level	Score
Bulk Flow Measurement	A1	1
Customer Metering	A3	3
Pressure Management	B1	4
Leakage Management	C1	7
Asset Management	B1	4
Water Balance and Water Loss KPIs	B1	4
Human Resources	B1	4
Total Score		**27**

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Bulk Flow Measurement

Customer Metering

Pressure Management

Leakage Management

Asset Management

Water Balance and Water Loss KPIs

Human Resources

Total Score	Class	Remarks
7 – 12	**E3**	Wasteful and inefficient system operating procedures failing to make proper use of resources and assets impacting in the continued deterioration of assets and level of service
13 – 19	**E2**	Inferior standard and quality of system management lacking organised administration and planning of the water supply network failing to deliver the required level of service and commitment to system improvement
20 – 26	**E1**	Critical operational stage which needs to be bolstered with improved processes, standards and procedures in order to reverse the downward spiral and take back system control
27 – 36	**D**	Satisfactory supply regime nevertheless wasteful use of resources and inefficient system operation which requires further enhancement, strengthening, improvement and control leading to increased performance
37 – 48	**C**	Efficient use of resources with systems in place that deliver the desired level of service, however there is room for system efficiencies and optimisation of processes
49 – 61	**B**	High degree of efficiency in all system operations employing advanced technologies and knowhow to sustain the gains of efficiency and to build a platform to enable further advancement
62 – 73	**A**	Optimum use of technology, equipment, and human resources in operating and maintaining the water supply system in an intelligent, productive, cost efficient and effective manner
74 – 84	**A***	It could be described now as a “dream”. This would be the utility of the future operated by machine learning algorithms, self-controlled and managed with minimal supervisory control by humans

Classification based on Overall Score

Possible Areas of Intervention

1. **Bulk Metering** (Score 1 – limited and unreliable bulk metering):
   - Comprehensive and accurate bulk water metering from the source(s) to the distribution network is of the utmost importance and a **pre-requisite** in the efficient and effective **NRW reduction and management strategy**.
2. **Customer Metering** (Score 3 – not all customers are metered / no regular meter replacement):
   - The degree of meter coverage in the distribution network and the accuracy of measurements are **critical in water balance calculations** and resulting NRW.
3. **Human Resources** (Score 4 –staff training and capacity building but no NRW unit):
   - Having a **NRW department / unit** with a cross-departmental function is crucial in the management of NRW activities. Appropriate and **continuous trainings** and capacity building is a key factor in a successful and sustainable NRW reduction.

- **Moving forward** in system improvement and sustaining the gains of efficiency is **hard work.**
- Completing a system improvement program is like **climbing a ladder,** each step gained means getting closer to the goal.
- A successful system improvement program **is not about standing on a moving escalator** taking you easily to your ultimate goal.
- It is about **sustainable improvement** as you go forward enabling you to **climb the next rung on the ladder in a steady and secure way.**

Key System Information

Name of Water Utility	EXAMPLE WATER UTILITY	
Country	-	
Number of Metered Customers	67,200	
Number of Unmetered Customers	47,800	
Length of Mains	2,300	km
Number of Service Connections	115,150	(including illegal connections and inactive accounts)
Number of DMAs	72	
Average Supply Time	12.0	hours per day
Average Operating Pressure	70.0	meters head
System Input Volume	250,000	m3/day
Billed Consumption	113,000	m3/day
Non-Revenue Water	137,000	m3/day
NRW	55%	of system input volume
NRW	2,380	l/conn./ (w.s.p.)

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Many thanks for your Attention!

- **eBook available – IWA Publishing Open Access:**

  Improving Water Supply Networks: Fit for Purpose Strategies and Technologies

  https://iwaponline.com/ebooks/book/819/Improving-Water-Supply-Networks-Fit-for-Purpose

- **WSI Calculator:**

  …. The best things in life are not free but priceless! Ask anyone of the authors for your "priceless" copy.

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