Introduction to Integrated Water Meter Management

Kobus van Zyl, University of Cape Town
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Introduction

- Water distribution system is an asset that has to be managed
- To measure is to know!
- Water meters used to measure the movement of water
- Water meters
  - cost money to install and maintain
  - generate money through sales
- There is a legal imperative on municipalities to measure consumption in accordance with applicable standards
Typical Issues

- Lack of capacity
- Divided responsibility between metering and billing
- Data not accessible for wdm programmes
- Lack of integration of bulk and consumer meter data
Why water meters?

- Equity
- Water efficiency and the environment
- Economic benefits
- System Management
Equity

- Consumers billed based on consumption
- Consumer can manage own consumption and thus cost of water
- Cross-subsidisation done openly and fairly
- Free basic water
Water Efficiency and the Environment

- All water taken from the environment
- Natural water resources limited
- When sources are inadequate, water is supplied intermittently with devastating consequences
- Meters reduce demand
- Meters required for loss management
Natural Water Resources
Water Resource Management
Water Purification
Bulk Supply and Distribution
Plumbing Systems
Waste Water Treatment
Urban Runoff
Where does it all go?
Economic benefits

- Measured consumption is basis of water billing system
- Water meters are the cash registers of a municipality
- Better metering system = greater income
System Management

- How much water is supplied and where does it go?
- How much water is consumed?
- How is consumption changing with time?
- A well-run integrated water meter management programme results in
  - better decisions
  - better planning
  - better service
Book Layout

- Introduction (Chapter 1)
- Water meter basics (Chapter 2)
- Types of meters (Chapter 3)
- Meter selection (Chapter 4)
- Meter lifecycle management (Chapter 5)
- Meter reading & data management (Chapter 6)
- Integrated water meter management (Chapter 7)
Book Layout (cont)

Text box highlighting important information

Text box giving an example or case study
**Glossary**

*Actual volume* \((V_a)\). The total volume of water passing through the water meter, irrespective of how long this takes.

*AMR. Automatic Meter Reading.*

*Apparent losses.* Water that seems like, but are not really water losses to a municipality. The main contributors to apparent losses are water meter under-registration, unauthorized consumption (water theft) and accounting errors.

*Automatic Meter Reading (AMR).* AMR uses technology to transmit meter readings automatically to a central location using phone network or radio frequency (RF) technologies.

*Automatic remote reading.* Meter readings are recorded automatically by connecting a handheld device to a connection point on the meter.

*Bulk transfer connection.* A connection through which water is transferred between two municipalities or from a bulk supplier to a municipality.

*Calculator.* See *counter*.

*Check valve.* See *non-return valve*.

*Classes.* See *meter classes*. 
Organisations and Products

Metrology Organisations
- International Organization of Legal Metrology (OIML), http://www.oiml.org
- Bureau International des Poids et Mesures (BIPM), http://www.bipm.org
- Southern African Development Community Cooperation in Measurement Traceability (SADC-MET), http://www.sadcmet.org
- National Metrology Institute of South Africa (NMISA), http://www.nmisa.org

Standards Organisations
- International Organization for Standardization (ISO), http://www.iso.ch/iso/home.htm
- European Committee for Standardization (CEN), http://www.cen.eu
- American National Standards Institute (ANSI), http://www.ansi.org
- African Organization for Standardization (AOS), http://www.arso-oran.org
- Southern African Development Community Cooperation in Standardization (SADCSTAN), http://www.sadcstan.co.za
- South African Bureau of Standards (SABS), https://www.sabs.co.za
Water Meter Management


Overview

- What is a water meter?
- Legislation and standards
- Introduction to water meter metrology
- Water meter classes
- Other meter requirements
What is a water meter?

- A device that measures the volume of water that passes through it.
- All meters have four basic components
  - Sensor
  - Transducer
  - Calculator
  - Indicator
Water meter components

Indicator
Counter
Transducer
Sensor
Sensor

- The element that detects the flow passing through the meter
- Used to classify meters
- Two main types
  - Volumetric
  - Inferential
Transducer

- Indicator
- Counter
- Transducer
- Sensor

Transducer transmits signal from sensor to calculator.
Direct and magnetic transducers
Calculator

- Accumulates volumetric reading through meter
Indicator

- Displays measurement
  - Rotating counter
  - Dials
  - Electronic
- Has to use m³ as units
- Clear differentiation between full values and fractions required
Rotating counter indicator
Rotating counter and dials indicator
Electronic indicator
Meter dials can be

- Open to the network and thus wet
- Sealed off from the network and dry
- Sealed off from the network and wet
Open wet dial meters

- **Advantages**
  - Damp not a problem

- **Disadvantages**
  - Can be susceptible to suspended solids
  - Need strong transparent cover
  - Algae can be a problem
Sealed dry dial meters

- Counter and indicator in sealed dry unit
- Good meters have an IP68 rating (note duration of test)
- Typically magnetic transducers

Advantages
- Protection against suspended particles
- Doesn’t need heavy glass cover

Disadvantages
- Damp obscuring display
- Algae can be a problem
- Needs protection against magnetic interference
Sealed wet dial meters

- Counter and indicator in sealed unit
- Typically filled with water with glycerine
- Typically magnetic transducers

**Advantages**
- Protection against suspended particles
- Doesn’t need heavy glass cover
- Damp and algae not problems

**Disadvantages**
- Need protection against magnetic interference
Additional components

- Calibration device
- Data storage
- Water price display
- Pulse output
  - Magnetic or optical
  - Each pulse indicates fixed volume through meter
  - Forward and reverse flow
  - Missed or false pulses
Legislation and standards

- Since meters used for measuring sales, they are subject to strict legislation
- In SA:
  - Municipal Services Act
  - Trade Metrology Act
- Each consumer meter must comply with SANS 1529
- Meters that don’t comply should immediately be withdrawn from service
- Meter verification has to be done by qualified and registered verification officer in a SANAS accredited testing laboratory
Legislation and standards (cont)

- SANS 1529: Water meters for cold potable water
  - Part 1: Metrological characteristic of meters ≤ 100 mm
  - Part 3: Physical dimensions
  - Part 4: Meters > 100 mm and ≤ 800 mm
  - Part 9: Electronic indicators
- Meters > 100 mm can’t be accuracy tested in SA, but other tests and accuracy certificate required.
- International standards
  - OIML R49
  - ISO 4064
  - EN14154
Metrology

- Every measuring instrument has limited accuracy
- Metrology is the science of measurement
- Legal metrology deals with legal requirements of measurements and instruments to protect consumers
- Specific terms used
Metrology definitions

- Actual volume $V_a$
- Indicated volume $V_i$
- Error = $V_i - V_a$
- Relative error = Error / $V_a$
Example of a meter accuracy calculation.

A water meter has an initial reading of 123.456 m³. After exactly 200 l of water has passed through the meter over a period of 5 minutes, the meter reading is changed to 123.654 m³. To determine the flow rate through the meter, and the relative error of the meter at this flow rate:
Example of a meter accuracy calculation.

A water meter has an initial reading of 123.456 m³. After exactly 200 l of water has passed through the meter over a period of 5 minutes, the meter reading is changed to 123.654 m³. To determine the flow rate through the meter, and the relative error of the meter at this flow rate:

Actual volume $V_a = 200$ l.

Actual flow rate = actual volume / time $= 200 / 5 = 40$ l/min, or $2\ 400$ l/h.

Indicated volume $V_I = 123.654 - 123.456 = 0.198$ m³, or 198 l.

Error $= V_I - V_a = -2$ l, i.e. the meter under-registered the volume by 2 l.

Relative error = error / actual volume $= -2 / 200 = -1\%$. This means the meter under-registers the flow by 1% at a flow rate of $2\ 400$ l/h.
Meter accuracy curve
Terminology

- Permanent flow rate $q_p$
- Starting flow rate $q_{start}$
- Overload flow rate $q_s$
Requirements for meter accuracy

The graph illustrates the relative error of a meter across different flow rates. The flow rates are divided into three zones:

1. **Lower zone**
   - $q_{\text{min}}$ to $q_t$
   - Relative error ranges from -5% to 0%

2. **Upper zone**
   - $q_t$ to $q_p$
   - Relative error ranges from 0% to 5%

3. **Flow rate**
   - $q_p$ to $q_s$
   - Relative error is constant at 0%
Terminology

- Maximum permissible error
- Minimum flow rate $Q_{\text{min}}$
- Transitional flow rate $Q_t$
- Lower zone
- Upper zone
Examples of accuracy curves
Conventional meter classes

- Maximum permissible errors 5 % in lower zone and 2 % in higher zone.
- Meter classes defined by extent of zones, not accuracy
- Allowed accuracy for used meters is 8 % and 3.5 %

Table 2-1 Meter classes defined by SABS 1529 for permanent flow rates up to 10 m³/h

<table>
<thead>
<tr>
<th>Meter class</th>
<th>Minimum flow rate ($q_{min}$)</th>
<th>Transitional flow rate ($q_t$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$0.04 , q_p$</td>
<td>$0.10 , q_p$</td>
</tr>
<tr>
<td>B</td>
<td>$0.02 , q_p$</td>
<td>$0.08 , q_p$</td>
</tr>
<tr>
<td>C</td>
<td>$0.01 , q_p$</td>
<td>$0.015 , q_p$</td>
</tr>
<tr>
<td>D</td>
<td>$0.0075 , q_p$</td>
<td>$0.0115 , q_p$</td>
</tr>
</tbody>
</table>
Example: Consider a meter with a permanent flow rate of 1 m³/h or 1 000 l/h. The minimum accuracy requirements for this meter is shown in Figure 2.10 for classes A to D.
Example: Consider a meter with a permanent flow rate of 1 m³/h or 1000 l/h. The minimum accuracy requirements for this meter is shown in Figure 2.10 for classes A to D.
Example: Consider a meter with a permanent flow rate of 1 m$^3$/h or 1 000 l/h. The minimum accuracy requirements for this meter is shown in Figure 2.10 for classes A to D.
Example: Consider a meter with a permanent flow rate of 1 m³/h or 1 000 l/h. The minimum accuracy requirements for this meter is shown in Figure 2.10 for classes A to D.
New meter classes

- Use $Q_1$, $Q_2$, $Q_3$ and $Q_4$ instead of $q_{\text{min}}$, $q_t$, $q_p$ and $q_s$
- $Q_2/Q_1$ must be 1.6
- $Q_4/Q_3$ must be 1.25
- Manufacturer determines $Q_3/Q_1$
  - Defining property of meter
  - Known $R$

<table>
<thead>
<tr>
<th>Meter Class</th>
<th>Applicable to</th>
<th>Maximum permissible error</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lower zone</td>
</tr>
<tr>
<td>1</td>
<td>Only meters with $Q_p \geq 100$ m$^3$/h.</td>
<td>3%</td>
</tr>
<tr>
<td>2</td>
<td>All meters with $Q_p &lt; 100$ m$^3$/h. May be applied to meters with $Q_p \geq 100$ m$^3$/h</td>
<td>5%</td>
</tr>
</tbody>
</table>
Other requirements

- **Materials**
  - Parts in contact with water should not leach chemicals
  - Brass should be DZR (Dezincification resistant)
  - Plastic meters may not be exposed to the sun

- **Flow and water quality**
  - Most types of meters must have built-in strainer
  - Must be able to withstand reverse flow

- **Operating conditions**
  - Temperature
  - Humidity
  - Electromagnetic interference
Other requirements (cont)

- **Pressure**
  - SANS 1529 assumes working pressure to be 1 600 kPa unless otherwise specified
  - Maximum pressure loss

<table>
<thead>
<tr>
<th>Group</th>
<th>Maximum pressure loss</th>
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<tbody>
<tr>
<td>P100</td>
<td>100 kPa</td>
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<tr>
<td>P60</td>
<td>60 kPa</td>
</tr>
<tr>
<td>P30</td>
<td>30 kPa</td>
</tr>
<tr>
<td>P10</td>
<td>10 kPa</td>
</tr>
</tbody>
</table>
Required Seals and markings

- Manufacturer
- Permanent flow rate in m³/h
- Serial number
- Flow direction
- Body approval for cartridge meters
- SA approval number
- Metrological class (A, B, C or D)
- H or V if only horizontal or vertical installation
- Working pressure if different than 1 600 kPa
- Pressure loss class
Types of Water Meters

Integrated Water Meter Management
Classification of water meters

- Water meters
  - Mechanical
  - Electromagnetic (Section 3.8)
  - Ultrasonic (Section 3.9)
  - Volumetric
  - Inferential
  - Combination (Section 3.7)
  - Rotary piston (Section 3.3)
  - Radial vane
  - Helical vane
    - Single jet (Section 3.4)
    - Multijet (Section 3.5)
    - Woltmann (Section 3.6)
Rotary Piston meters
Examples of Rotary Piston meters
Characteristics of Rotary Piston meters

- Positive displacement
- High sensitivity at low flows (available in class D)
- Any orientation
- Commonly used for domestic applications.
- Sensitive to suspended solids in water
# Metrological characteristics of common rotating piston meters

<table>
<thead>
<tr>
<th>Class</th>
<th>Size (mm)</th>
<th>( q_{\text{start}} ) (l/h)</th>
<th>( q_{\text{min}} ) (l/h)</th>
<th>( q_{t} ) (l/h)</th>
<th>( q_{p} ) (l/h)</th>
<th>( q_{s} ) (l/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>15</td>
<td>1</td>
<td>10</td>
<td>15</td>
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<td>C</td>
<td>15</td>
<td>3</td>
<td>15</td>
<td>22.5</td>
<td>1500</td>
<td>3000</td>
</tr>
<tr>
<td>C</td>
<td>20</td>
<td>4</td>
<td>25</td>
<td>37.5</td>
<td>2500</td>
<td>5000</td>
</tr>
<tr>
<td>C</td>
<td>25</td>
<td>6</td>
<td>35</td>
<td>52.5</td>
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<td>7000</td>
</tr>
<tr>
<td>C</td>
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<td>11</td>
<td>50</td>
<td>75</td>
<td>5000</td>
<td>10000</td>
</tr>
<tr>
<td>C</td>
<td>40</td>
<td>18</td>
<td>100</td>
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<td>20000</td>
</tr>
<tr>
<td>D</td>
<td>15</td>
<td>3</td>
<td>7.5</td>
<td>11.5</td>
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<td>6</td>
<td>18.75</td>
<td>28.75</td>
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<td>5000</td>
</tr>
</tbody>
</table>
Single Jet meters
Examples of Single Jet meters
Characteristics of Single Jet meters

- Inferential
- Commonly used for domestic applications
- Not sensitive to water quality
- Must be installed upright and horizontal
- Sensitive to disturbances in flow profile, e.g. bend or partially blocked strainer
Metrological characteristics of common single jet meters

<table>
<thead>
<tr>
<th>Class</th>
<th>Size (mm)</th>
<th>$q_{\text{start}}$ (l/h)</th>
<th>$q_{\text{min}}$ (l/h)</th>
<th>$q_t$ (l/h)</th>
<th>$q_p$ (l/h)</th>
<th>$q_s$ (l/h)</th>
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<td>30</td>
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<td>3000</td>
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<td>5000</td>
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<td>C</td>
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<td>22</td>
<td>100</td>
<td>150</td>
<td>10000</td>
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</tbody>
</table>
Multijet meters
Examples of Multijet meters
Characteristics of Multijet meters

- Inferential
- Similar to single jet except for number of jets on impeller
- Uses internal bypass with regulating screw
- Often available as cartridge meters
- Longer life due to balanced forces on impeller
- Not sensitive to velocity profile
- Must be installed upright and horizontal
- Clogged strainer can cause over-registration
- Commonly used for domestic applications
Metrological characteristics of common multijet meters

<table>
<thead>
<tr>
<th>Class</th>
<th>Size (mm)</th>
<th>$q_{\text{start}}$ (l/h)</th>
<th>$q_{\text{min}}$ (l/h)</th>
<th>$q_{\text{t}}$ (l/h)</th>
<th>$q_{p}$ (l/h)</th>
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</table>
Woltmann meters: Horizontal (WP) and Vertical (WS)
Examples of Woltmann meters
Characteristics of Woltmann meters

- Inferential meters with helical vane impellers
- Horizontal (WP)
  - By far the most common type of Woltmann
  - Low pressure loss through meter
  - Not good sensitivity at low flow rates
  - Typically only class B, but better than minimum performance
  - Often as cartridge meters
  - Can handle dirty water
  - Can be installed in virtually any orientation
  - Sensitive to velocity profile, especially spiralling flow
Metrological characteristics of common WP Woltmann meters

<table>
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<th>Class</th>
<th>Size (mm)</th>
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<th>$q_{\text{min}}$ (l/h)</th>
<th>$q_{\text{t}}$ (l/h)</th>
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<td>2000000</td>
</tr>
<tr>
<td>B</td>
<td>400</td>
<td>15000</td>
<td>30000</td>
<td>200000</td>
<td>1000000</td>
<td>2000000</td>
</tr>
<tr>
<td>B</td>
<td>400</td>
<td>15000</td>
<td>45000</td>
<td>300000</td>
<td>1500000</td>
<td>3000000</td>
</tr>
<tr>
<td>B</td>
<td>500</td>
<td>20000</td>
<td>45000</td>
<td>300000</td>
<td>1500000</td>
<td>3000000</td>
</tr>
<tr>
<td>B</td>
<td>500</td>
<td>20000</td>
<td>75000</td>
<td>500000</td>
<td>2500000</td>
<td>5000000</td>
</tr>
</tbody>
</table>
Combination meters
Examples of combination meters
Characteristics of Combination meters

- Not really unique meter type - combination of two meters.
- Consist of
  - Main meter – typically Woltmann or Multijet
  - Bypass meter – typically Positive Displacement, Multijet or Single Jet
  - Automatic change-over valve in line with main meter
- Very wide measuring range
- Both meters must be read and volumes combined
- Problem if change-over valve fails
Combination meter accuracy curve
Metrological characteristics of common combination meters

<table>
<thead>
<tr>
<th>Class</th>
<th>Size (mm)</th>
<th>$Q_{\text{start}}$ (l/h)</th>
<th>$Q_{\text{min}}$ (l/h)</th>
<th>$Q_{\text{t}}$ (l/h)</th>
<th>$Q_p$ (l/h)</th>
<th>$Q_s$ (l/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>50 x 20</td>
<td>10</td>
<td>25</td>
<td>37.5</td>
<td>25 000</td>
<td>50 000</td>
</tr>
<tr>
<td>B</td>
<td>60 x 20</td>
<td>10</td>
<td>25</td>
<td>37.5</td>
<td>25 000</td>
<td>50 000</td>
</tr>
<tr>
<td>B</td>
<td>80 x 20</td>
<td>10</td>
<td>25</td>
<td>37.5</td>
<td>60 000</td>
<td>120 000</td>
</tr>
<tr>
<td>B</td>
<td>100 x 25</td>
<td>13</td>
<td>35</td>
<td>52.5</td>
<td>60 000</td>
<td>120 000</td>
</tr>
<tr>
<td>B</td>
<td>140 x 40</td>
<td>38</td>
<td>60</td>
<td>2 000</td>
<td>150 000</td>
<td>300 000</td>
</tr>
</tbody>
</table>
Electromagnetic meters

- Uses Faraday’s induction law: conductor moving through a magnetic field will induce a voltage
Electromagnetic meters (cont)

- Very accurate within range (0.5 – 0.1 %)
- Electromagnets can use DC or AC power
- No obstruction to flow
- Accuracy can be affected by
  - Deposits on electrodes
  - Air in fluid
  - Turbulence and water hammer
  - Sediments
- Electrical connection required
Examples of Electromagnetic meters
Ultrasonic meters

- Use properties of sound waves travelling through liquid:
  - Transit time
  - Doppler effect

- Transit time meters
  - More accurate on larger pipes
  - Work better in clean liquids
  - Sensitive to velocity profile
  - Permanently installed meters have high accuracy (0.25 – 1 %)
  - Clamp-on meters not very accurate – can’t be used for checking the accuracy of other meters
Operation of transit time ultrasonic meter
Ultrasonic meters (cont)

- **Doppler meters**
  - Require particles or bubbles in fluid
  - Determine velocity by bouncing off sound waves from particles
  - Errors can occur if particles in slow moving part of flow
  - Low accuracy - not suitable for billing meters
Operation of Doppler ultrasonic meter
<table>
<thead>
<tr>
<th>Property</th>
<th>Rotary Piston (Section 3.3)</th>
<th>Single Jet (Section 3.4)</th>
<th>Multi Jet (Section 3.5)</th>
<th>Horizontal (WP) Woltmann (Section 3.6)</th>
<th>Combination (Section 3.7)</th>
<th>Electromagnetic (Section 3.8)</th>
<th>Ultrasonic (Section 3.9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classification</td>
<td>Mechanical Volumetric</td>
<td>Mechanical Inferential</td>
<td>Mechanical Inferential</td>
<td>Mechanical Inferential</td>
<td>Mechanical Varies*</td>
<td>Electromagnetic Inferential</td>
<td>Ultrasonic Inferential</td>
</tr>
<tr>
<td>Sizes commonly used (mm)</td>
<td>15 – 40</td>
<td>15 - 40</td>
<td>15 - 40</td>
<td>40 - 500</td>
<td>50x20 -150x40</td>
<td>300 - 2000</td>
<td>400 - 4000</td>
</tr>
<tr>
<td>Sensitivity to velocity profile</td>
<td>Insensitive</td>
<td>Medium</td>
<td>Low</td>
<td>High</td>
<td>Medium*</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Sensitivity to water quality</td>
<td>High</td>
<td>Medium</td>
<td>Medium</td>
<td>Low</td>
<td>Medium*</td>
<td>Very Low</td>
<td>Low</td>
</tr>
<tr>
<td>Typical classes</td>
<td>B, C and D</td>
<td>B and C</td>
<td>B and C</td>
<td>B</td>
<td>B</td>
<td>Not categorised</td>
<td>Not categorised</td>
</tr>
<tr>
<td>Pressure loss</td>
<td>High</td>
<td>Low</td>
<td>Medium</td>
<td>Medium</td>
<td>High*</td>
<td>Very low</td>
<td>Very low</td>
</tr>
<tr>
<td>Orientation</td>
<td>Any</td>
<td>Mainly horizontal</td>
<td>Horizontal</td>
<td>Almost any</td>
<td>Horizontal</td>
<td>Almost any</td>
<td>Almost any</td>
</tr>
<tr>
<td>Minimum straight length upstream</td>
<td>None</td>
<td>0 - 5 d</td>
<td>None</td>
<td>5 d</td>
<td>5 d</td>
<td>5-10 d</td>
<td>10 d</td>
</tr>
<tr>
<td>Minimum straight length downstream</td>
<td>None</td>
<td>0 - 3 d</td>
<td>None</td>
<td>3 d</td>
<td>3 d</td>
<td>3 d</td>
<td>3 d</td>
</tr>
<tr>
<td>Electricity required?</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
## Typical meter replacement cost

<table>
<thead>
<tr>
<th>Nominal Diameter (mm)</th>
<th>Typical replacement cost (R)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>R1 700,00</td>
</tr>
<tr>
<td>20</td>
<td>R1 800,00</td>
</tr>
<tr>
<td>25</td>
<td>R2 000,00</td>
</tr>
<tr>
<td>40</td>
<td>R2 200,00</td>
</tr>
<tr>
<td>50</td>
<td>R3 800,00</td>
</tr>
<tr>
<td>80</td>
<td>R5 000,00</td>
</tr>
<tr>
<td>100</td>
<td>R10 000,00</td>
</tr>
<tr>
<td>150</td>
<td>R16 000,00</td>
</tr>
<tr>
<td>200</td>
<td>R32 000,00</td>
</tr>
<tr>
<td>250</td>
<td>R50 000,00</td>
</tr>
<tr>
<td>300</td>
<td>R100 000,00</td>
</tr>
<tr>
<td>400</td>
<td>R200 000,00</td>
</tr>
<tr>
<td>450</td>
<td>R380 000,00</td>
</tr>
</tbody>
</table>
Water Meter Selection

Integrated Water Meter Management
Meter sizing is very important

- **Meter too small**
  - Overload flow regularly exceeded
  - Meter deteriorates
  - Large under-registration losses

- **Meter too large**
  - Cost more to purchase and install
  - Demand often in low accuracy region of meter
  - Large under-registration losses
Questions to ask

- What is the purpose of the meter?
- Does the meter comply with standards and policies?
- Is the meter rated for the expected flow rates and conditions?
- What is the most economical meter to use?
Where should meters be installed?
Case study: Tshwane generally installs water meters in the following locations: (Westman 1997)

- Household or small domestic installations: 15 – 25mm meters.
- General consumers such as flats, businesses, hotels, schools, etc: 40–150mm meters.
- Very large consumers: meters greater than 100mm.
- Reservoir inlet and outlet pipes: 50 – 800mm meters.
- Zone metering: 50 – 400mm meters.
- Bulk transfers from bulk suppliers: 300 – 800mm meters.
- Own sources such as fountains and springs, boreholes and treatment plants: 100 – 500mm meters.
Consumer meters

- Cash register – important!
- Even use where payment for water does not exist or isn't linked to consumption.
- Two categories: Small and Large
- Small connections ($\leq 25$ mm)
  - Domestic and low consumption ICI
  - Standard procedures for domestic consumers
  - On-site leakage often occurs on these properties
- Large connections ($> 25$ mm)
  - Bulk users
  - Accuracy and maintenance of meters very important
Bulk transfer meters

- Water transfers from bulk supplier or between municipalities
- Large quantities of water – high meter accuracies required
- Metering typically part of agreement between parties
- Electronic and 3 - 5 beam ultrasonic meters often used
Management meters

- Measure movement of water in system
- Essential for
  - Operations
  - Water loss estimation and management
  - Pumping patterns and energy consumption
  - Water demand patterns and peak factors
  - Network model calibration
- DMA meters important for management and loss management
Legal and policy requirements

- National legislation requires consumer meters to comply with SANS 1529 – non negotiable.
- SANS 1529 tests include
  - Type approval
  - Initial verification
  - Individual meter verification
- SABS approval number must be shown on meter body
- Each consumer meter sold in SA must be verified by accredited laboratory and officer within the country.
- Verified meter sealed
Meter seals
Policy requirements

- Each municipality is unique and should develop its own policies on water metering based on local conditions
- Policy may include
  - Meter classes for different applications
  - Types of meters for different applications
  - Preferred and prohibited meters
  - Minimum installation requirements
  - Logging requirements
Example: Tshwane’s list of allowable and preferred meter types for different applications.

<table>
<thead>
<tr>
<th>Application</th>
<th>Typical meter size range (mm)</th>
<th>Allowable meter types (preferred meter type in bold)</th>
</tr>
</thead>
</table>
| Household, small consumer    | 15 - 25                      | Multijet  
Rotary piston                                     |
| General consumer             | 40 - 150                     | Woltmann WP  
Woltmann WS  
Multijet  
Rotary piston                                     |
| Large consumer               | >150                         | Woltmann WP  
Electromagnetic                                     |
| Reservoir outflows           | 50 - 800                     | Woltmann WP  
Electromagnetic  
Woltmann WS  
Insertion meters                                     |
| Zone metering                | 50 - 400                     | Woltmann WP  
Insertion meters                                     |
| Bulk supplier connections    | 300 - 800                    | Electromagnetic  
Woltmann WP  
Woltmann WS                                         |
| Own sources                  | 100 - 500                    | Electromagnetic  
Woltmann WP  
Insertion meters                                     |
### Table 4.1: Typical meter sizing table (adapted from Infraguide3)

<table>
<thead>
<tr>
<th>Size (mm)</th>
<th>Type</th>
<th>Flow range (L/min)</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>Positive displacement</td>
<td>1 – 55</td>
<td>Single family, duplex, small business (up to 10 staff)</td>
</tr>
<tr>
<td>20</td>
<td>Positive displacement</td>
<td>2 – 110</td>
<td>Large residences, homes with irrigation systems or swimming pools, flats with up to 6 units, petrol station without car wash, churches, small institutional users.</td>
</tr>
<tr>
<td>25</td>
<td>Positive displacement</td>
<td>3 – 185</td>
<td>Residences with pools and irrigation system, small to medium apartment buildings (6–17 units), small schools (up to 200 students), institutional (up to 50 staff), churches with other activities (e.g. day schools), large individual commercial buildings, group of commercial buildings (up to 10 units).</td>
</tr>
<tr>
<td>38</td>
<td>Positive displacement</td>
<td>5 – 375</td>
<td>Apartment buildings (18–40 units), old age homes (up to 50 units), schools (up to 400 students), medium-sized hotels (up to 30 units), large petrol stations without automatic car wash, small processing plants, small shopping centres, medium laundromats, restaurants, small hospitals (up to 100 beds), medical buildings.</td>
</tr>
<tr>
<td>50</td>
<td>Woltmann WP</td>
<td>7 – 600</td>
<td>Medium apartment buildings (41–120 units), duplex complex (41–80 units), schools with small irrigation systems (up to 2000 students), medium hospitals, medium shopping centres, medium hotels, large petrol stations with workshops.</td>
</tr>
</tbody>
</table>
Flow range and operating conditions

- Flow range determined by user characteristics
- Can be measured, but don’t log old meter that may have large errors
- Consider type of user, application of water, number of units served, number of employees, etc.
- Look at similar users
- Consider annual average demand and seasonal and diurnal patterns.
- Holiday homes have peak consumption for short periods of time
Typical domestic demand distribution

![Bar chart showing flowrate distribution](image)
Typical Domestic Water Consumption

m³/h

Time period: 29/01/2012 - 31/01/2012
Mean interval: 5 minutes
Consumption on Monday, 31 Jan 2012

Time period: 30/01/2012 - 31/01/2012

Mean interval: 2 minutes
Consumption between 0:00 and 6:00
Consumption between 6:00 and 12:00

Time period: 30/01/2012 06:00:00 PM - 30/01/2012 12:00:00 PM
Mean interval: 30 seconds
Consumption between 12:00 and 18:00
Consumption between 18:00 and 24:00
Domestic consumption (low frequency)
Domestic consumption with leakage
Leak development

m³/h

LOCKERBY/SEARLE/ABCD1234

Fri, 27/1/ - Fri, 03/2/
Time period: 27/01/2012 - 04/02/2012
Occurrence of on-site leaks

![Bar chart showing the occurrence of on-site leaks in different locations.](chart.png)

- Jhb Residential: 70%
- Jhb Other: 80%
- Cape Town: 50%
- Bloemfontein: 60%
- Windhoek: 70%
- Swakopmund: 20%
- Boulder, Colorado: 30%
- USA various: 40%
Occurrence of on-site leaks in CT

![Bar chart showing the percentage occurrence of on-site leakage by suburb. The bar chart indicates that Langa and Salt River have the highest percentage of leakage, followed by Woodstock, Rosebank, Newlands, Pinelands, Mandela Park, Observatory, Claremont, Thornton, Lakeside, Camps Bay, Tokai, Green Point, and Mowbray, which have the lowest percentage of leakage.]
Mean on-site leakage rates

- Jhb Residential
- Jhb Other
- Cape Town
- Bloemfontein
- Windhoek
- Swakopmund
- Spain
- UK domestic
- UK non-domestic
Distribution of on-site leakage rates

![Graph showing distribution of on-site leakage rates for different cities]
Consumption in Johannesburg

- Measured on-site losses, 25%
- Apparent losses from on-site losses, 3%
- Apparent losses from consumption (assumed), 2%

Measured real consumption, 70%
Estimate peak flow using loading units

<table>
<thead>
<tr>
<th>Fixture Type</th>
<th>Loading Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bath mixer</td>
<td>4.0</td>
</tr>
<tr>
<td>Toilet with cistern</td>
<td>0.3</td>
</tr>
<tr>
<td>Toilet with flush valve</td>
<td>16</td>
</tr>
<tr>
<td>Shower head</td>
<td>0.6</td>
</tr>
<tr>
<td>Sink mixer</td>
<td>0.6</td>
</tr>
<tr>
<td>Basin mixer</td>
<td>0.4</td>
</tr>
<tr>
<td>Bidet mixer</td>
<td>0.2</td>
</tr>
<tr>
<td>Washing machine</td>
<td>0.6</td>
</tr>
<tr>
<td>Urinal</td>
<td>0.2</td>
</tr>
<tr>
<td>15 mm tap</td>
<td>0.3</td>
</tr>
<tr>
<td>20 mm tap</td>
<td>1.0</td>
</tr>
</tbody>
</table>
Peak flow from loading units
Example: Determining the peak flow through a meter based on fixture loading units

Consider a house with 1 bath, 2 showers, 3 toilets, 2 wash basins, 2 sinks, one washing machine and 3 garden taps. First, calculate the total loading units for the house by adding up the loading units for the individual fixtures obtained from Table 4-2:

<table>
<thead>
<tr>
<th>Fixture</th>
<th>Fixture loading units (from Table 4-2)</th>
<th>No of fixtures</th>
<th>Total fixture loading units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bath mixer</td>
<td>4.0</td>
<td>1</td>
<td>4.0</td>
</tr>
<tr>
<td>Shower heads</td>
<td>0.6</td>
<td>2</td>
<td>1.2</td>
</tr>
<tr>
<td>Toilet with cistern</td>
<td>0.3</td>
<td>3</td>
<td>0.9</td>
</tr>
<tr>
<td>Wash basin mixer</td>
<td>0.4</td>
<td>2</td>
<td>0.8</td>
</tr>
<tr>
<td>Sink mixer</td>
<td>0.6</td>
<td>2</td>
<td>1.2</td>
</tr>
<tr>
<td>Washing machine</td>
<td>0.6</td>
<td>1</td>
<td>0.6</td>
</tr>
<tr>
<td>20 mm Garden tap</td>
<td>1.0</td>
<td>3</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Total loading units for the house: 11.7

Now look up the peak flow through the meter from Fig 4-5 (a) as 3100 l/h.
Operating conditions

- Water quality
- Pressure
- Pressure loss
- Theft and vandalism
- Installation requirements
- Need for on-site verification
- Electrical supply
- Meter reading
Economic considerations

- Consider various of meter over its lifetime
  - Price of meter
  - Installation cost
  - Expected service life
  - Cost of meter under-registration
  - Water price
  - Lost sewage charge
  - Maintenance costs
  - Operational costs
  - Meter reading costs
Getting the Most out of Meters: Operation and Maintenance

Integrated Water Meter Management
Meter management process

- Manage:
  - Identify meters to analyse
  - Cost benefits analyses

- Install:
  - Identify meters to install
  - Select
    - Chapter 4
  - Install
  - Identify meters to maintain

- Test:
  - Test
  - Identify meters to test

- Maintain:
  - Maintain
  - Section 4.3
  - Section 4.4
  - Section 4.5
Installation requirements

- Comply fully to supplier’s recommendations, including:
  - Flow direction
  - Orientation of pipe work
  - Orientation of meter
  - Minimum straight lengths up and downstream
  - Separate strainer
  - Isolating valves on both sides
  - Lightning and surge protection for electrical components
Installation requirements (cont)

- On large meters, also consider
  - Allowance for in-situ testing
  - Flexible couplings for easy removal
  - Protection against vibrations, shocks and water hammer
  - Thrust blocks and pipe supports
  - Ensure gasket flanges don’t protrude into pipe.

- After installation
  - Remove air slowly through meter
  - Verify logger/electronic readings against meter
  - As-built drawings
  - Update meter database
Maintenance

- Meters require maintenance like any other mechanical equipment
  - Clean strainers
  - Clean and repair meter boxes
  - Fix leaks
  - Replace damaged registers and covers
  - Open large meters for visual inspection
- Consider the cost of not doing maintenance
- Maintain at a rate to avoid backlogs developing
Meter testing

- Meters should be tested to check their condition and rate of deterioration.
- Starting flows and accuracy at low flow rates deteriorate fastest.
- Meter performance not the same between municipalities
- Check that meters are correctly sized

Testing methods

- Calibrated master meter
- Insertion flow meter
- Portable test rig
- Clamp-on ultrasonic meter (not suitable for verification)
Median domestic meter error in CT (age)

\[
y = -0.3602x + 1.0479 \\
R^2 = 0.9668
\]
Median domestic meter error in CT (volume)

\[ y = -0.0009x - 1.2957 \]

\[ R^2 = 0.9177 \]
Testing frequency

- Large meters: once every five years (AWWA)
- Small meters: once every ten years (AWWA)
- Domestic meters can be grouped and a representative sample tested
  - Important to randomly select meters to test
  - Use a minimum of 30 – 50 meters per group
Analysis

- Use meter database and test results as basis for analysis of meters.
  - Check for wrongly sized meters
  - Predict performance of different meter models
  - Prioritise meters to be replaced

- Replacement analysis methods
  - Payback period method
  - Net present value method
Meter Reading and Data Management

Integrated Water Meter Management
Meter reading
(Section 6.3)

Data verification
(Section 6.4)

Data application
(Chapter 7)
Meter reading database

- Should be at the core of the meter reading process
- Spreadsheets don’t work
- Meter data should be accessible for other uses
  - Shared database
  - Direct link
  - Indirect link via file export - import
Who should be responsible for meter reading?

- **Treasury**
  - Revenue Collection
  - Link to Consumer Data / Account Data
  - Revenue Loss
  - City Wide Water Loss
    - No bulk meter info
    - No network layout

- **Engineering**
  - Manage meters in the field
  - Meter readers can fulfil wider range of functions
  - Need consumption statistics
  - Physical location of the meter important to know
  - Graphical representation of data
  - GIS link for data
  - Responsible for repairs and water loss management
# Required consumer fields

<table>
<thead>
<tr>
<th>Field</th>
<th>Item</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Account number</td>
<td>A unique account number.</td>
</tr>
<tr>
<td>2</td>
<td>Stand ID</td>
<td>A unique identification number for the stand, often made up of the Town, Suburb, Stand, Portion and Sub portion.</td>
</tr>
<tr>
<td>3</td>
<td>Stand number</td>
<td>The registered number of the stand.</td>
</tr>
<tr>
<td>4</td>
<td>Stand portion</td>
<td>Portion a stand is divided into more than one portion.</td>
</tr>
<tr>
<td>5</td>
<td>Ward</td>
<td>Number of the ward the stand is situated in.</td>
</tr>
<tr>
<td>6</td>
<td>Area Code</td>
<td>A code indicating which area of the town the stand is situated.</td>
</tr>
<tr>
<td>7</td>
<td>Suburb</td>
<td>The name or a code for the suburb the stand is part of.</td>
</tr>
<tr>
<td>8</td>
<td>GIS Code</td>
<td>Location of the stand</td>
</tr>
<tr>
<td>9</td>
<td>Owner’s name</td>
<td>The stand owner’s full name and title.</td>
</tr>
<tr>
<td>10</td>
<td>Physical address</td>
<td>The full street address of the stand.</td>
</tr>
<tr>
<td>11</td>
<td>Postal address</td>
<td>The owner’s postal address.</td>
</tr>
<tr>
<td>12</td>
<td>Phone numbers</td>
<td>Fields for office, work, fax and cell phone numbers.</td>
</tr>
<tr>
<td></td>
<td>Required consumer fields (cont)</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Land use</td>
<td>A code indicating the registered land use of the property, for instance residential or industrial.</td>
</tr>
<tr>
<td>14</td>
<td>Zone</td>
<td>A code indicating the zoning of the stand.</td>
</tr>
<tr>
<td>15</td>
<td>Value of land</td>
<td>Value of the stand from the valuation roll.</td>
</tr>
<tr>
<td>16</td>
<td>Value of improvements</td>
<td>Value of the stand plus buildings.</td>
</tr>
<tr>
<td>17</td>
<td>Stand size</td>
<td>The area of the stand in standardised units.</td>
</tr>
<tr>
<td>18</td>
<td>Floor space</td>
<td>The total floor space of buildings on the stand.</td>
</tr>
<tr>
<td>19</td>
<td>Allowable floor space ratio</td>
<td>The ratio of floor space to stand size that is allowed for this area.</td>
</tr>
<tr>
<td>20</td>
<td>Occupied</td>
<td>A code indicating whether the stand is occupied or vacant.</td>
</tr>
<tr>
<td>21</td>
<td>Debtor</td>
<td>The details of the person or body responsible the accounts (if different from the owner). Full name, address and other contact details should be included.</td>
</tr>
<tr>
<td>22</td>
<td>Basic tariff</td>
<td>The tariff structure for the basic (fixed) part of the water bill.</td>
</tr>
<tr>
<td>23</td>
<td>Consumption tariff</td>
<td>The consumption tariff structure (including block rates).</td>
</tr>
</tbody>
</table>
### Required meter reading fields

<table>
<thead>
<tr>
<th>Field</th>
<th>Item</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Meter serial number</td>
<td>The serial number on the meter.</td>
</tr>
<tr>
<td>2</td>
<td>Meter count</td>
<td>The meter number if more than one meter serves the same stand. Typically, the first meter is indicated by 0, the second meter by 1, etc.</td>
</tr>
<tr>
<td>3</td>
<td>Number of units</td>
<td>The number housing units served by the meter.</td>
</tr>
<tr>
<td>4</td>
<td>Installation date</td>
<td>Date the meter was installed.</td>
</tr>
<tr>
<td>5</td>
<td>Number of digits</td>
<td>Number of digits on the meter dial. Only full m³ digits are included. Typically 4 for small meters and 5 or 6 for larger meters.</td>
</tr>
<tr>
<td>6</td>
<td>Meter measurement unit</td>
<td>Should be m³.</td>
</tr>
<tr>
<td>7</td>
<td>Meter size</td>
<td>Meter size in mm.</td>
</tr>
<tr>
<td>8</td>
<td>Meter route number</td>
<td>The meter reader route the meter forms part of. Sometimes referred to as the meter book number.</td>
</tr>
<tr>
<td>9</td>
<td>Meter location</td>
<td>Location of the meter on the stand.</td>
</tr>
<tr>
<td>10</td>
<td>Average Consumption</td>
<td>The average daily demand for the current month.</td>
</tr>
<tr>
<td>11</td>
<td>Meter reading data</td>
<td>Repeat for a given number of meter readings, for instance the last 25 readings.</td>
</tr>
<tr>
<td>11.1</td>
<td>Reading date</td>
<td>Date the reading was taken.</td>
</tr>
<tr>
<td>11.2</td>
<td>Meter reading</td>
<td>The reading on the meter.</td>
</tr>
<tr>
<td>11.3</td>
<td>Reading type</td>
<td>A code describing the type of reading that was done, for instance a ‘reading’ or ‘estimate’.</td>
</tr>
</tbody>
</table>
Meter Data Management

- Consumer vs. Bulk
- Combination with smart devices
- Outsourcing and control
- Meter management system (Asset Management)
  - Basic data
    - GPS Co-ordinate
    - Physical characteristics
    - Installation date
  - Fault reporting and actions
    - History for each meter
  - Replacement program
    - Replacement Prioritisation
Meter reading

- Rules
  - Read from left to right
  - Meter must give reading in m³
  - Meter must differentiate between full m³ and fractions
  - Only read full m³
- Beware of meters using x10 m³
Meter readers

- Meter readers should be
  - precise
  - not suffer from reading impairments
  - properly trained
  - provided with the correct tools
  - trained on safety issues, e.g. opening manhole covers, dangerous animals

- When reading meters
  - read both serial number and indicator reading
  - identify and report problems with meter or system
Meter reading

- Ideally once per month
- Have to read at least every three months
- If less, intermediate months are estimated – can cause problems

Metering systems
- Direct reading
- Automatic remote reading
- Automatic meter reading (AMR)
Reading management

- **Minimise errors**
  - Record only once
  - Electronic data transfers

- **Additional data**
  - Meter state
  - Failure reason

- **Robust System**
  - Additional readings at any stage
  - Force actions on certain events, e.g. Final/Initial reading for replacements/install
Direct meter reading

- Reading taken directly from meter
- Readings taken using pen & paper or handheld terminals
- Handheld devices better
  - Force reader to follow rout and visit all meters
  - Perform initial verification
  - Enter problems from standard menu
  - Automatic transfer to meter reading database
  - Can be GPS linked

- Advantages of direct meter reading
  - No additional equipment installed on meter
  - Meter readers are ‘eyes and ears’ on the ground
Direct meter reading

- Disadvantages
  - High labour cost
  - Readers often have problems accessing meters
  - Reading errors are common
Automatic remote reading

- Reading taken automatically from connection point on meter by handheld device

- Advantages
  - Higher reading success rate
  - Meter readers more efficient

- Disadvantages
  - Special and more expensive meters
  - Batteries?
Automatic Meter Reading (AMR)

- Transmit meter reading to reader or central base station
- Use phone network or RF technology

**Advantages**
- High reading success rate
- Save on labour cost
- Advance systems can use two-way communication
- Built-in intelligence e.g. logging or on-site leakage

**Advantages of central base station systems**
- Can read all meters in the system simultaneously
- Can monitor use more closely if required
Automatic Meter Reading (AMR)

- Disadvantages
  - Installation cost
  - Batteries or power supply
  - Maintenance requirements and cost
  - Operational costs
Bulk meters

- Include
  - Bulk transfer meters
  - Network management meters
  - Bulk consumer meters
- Large volumes, thus require special attention
- Should be read very regularly, preferably continuously
Bulk meter reading options

- **Manually**
  - Not the preferred method
  - Regularly at the same day and time

- **On-site logging**
  - Data not automatically available
  - Need to visit logger to download data

- **Telemetry logging**
  - Logger data transferred to central station
  - Transfer automatic or on demand

- **SCADA**
Bulk meter reading options (cont)

- **SCADA**
  - Allows data collection and control of pumps, valves, etc.
  - Meters can be linked into SCADA system

- **AMR**
  - Bulk meters more suitable for AMR than small meters
Data Verification

- Reading can be wrong due to
  - Faulty meter
  - Illegitimate consumption
  - Data error
    - Manual reading or data entering errors
    - Signal pickup errors (e.g. loggers)
    - Data communication and transfer errors
    - Database errors
Verification steps

- Meter reading verification
  - Reading order size
  - Date
  - Route
  - All meters read

- Evaluate against an historical record
  - Last month consumption vs AADD
  - Last 3 months consumption vs AADD
  - Zero consumption
  - Constant consumption
  - Consumption vs. land use, zoning, stand size, improvement value
Meter reading database procedures

- Estimate consumption on same day of each month
- Identify and handle errors
  - Too few data records to estimate consumption
  - Inconsistent dates
  - Meter clock-overs (need data on number of digits)
  - New meters
  - Replaced meters
  - Spikes and dips in consumption
  - Missing readings
  - Long gaps in readings
- Standard and user-defined reports and queries
Integrated water meter management – putting it all together

Integrated Water Meter Management
Users of water meter data

- Treasury
  - Billing
- Engineering
  - Water demand management
  - Non revenue management
  - Network modelling
  - Meter management
- Management
  - Systems and policies
  - Adequate resources
  - Strategic planning
- Coordination important
Application of water meter data

- Main integrated applications
  - Strategic planning
  - Information management
  - Asset management
  - Water management
Strategic planning

- IWMM system requires strong overall leadership
- Managed by a high level inter-disciplinary committee?
- Water meters not the solution to all problems

Typical issues
- Staff levels, qualifications and training
- Allocation of responsibilities between departments
- Policies on meter management
- Policies on data management
- Strategies for dealing with problems
- Water tariff design
- Budget requirements
Metering strategy

- Conventional metering
- Pre-paid metering
- Demand restriction
- No metering
Water tariff design

- Fixed rate
- Increasing block rate
- Seasonal pricing
- Fixed plus consumption rate
Information management

- Quality and accessibility of data critical
- Single vs multiple databases

Applications
- Typical water demands of user types and distributions
- Identify meters being estimated (and not read).
- Informative billing
Meter Age

% of sales

Age (Months)

0% 5% 10% 15% 20% 25% 30% 35% 40% 45% 50%

12 24 36 48 60 72 > 72

% of sales
Water demand statistics

![Unit Water Demand per Landuse](image)
Themed Maps: Landuse
Themed Maps: Consumption
Meter reading verification
Themed Maps: No consumption
Themed Maps: No consumption
Themed Maps: No Treasury Data
# Meter Reading Frequency

- **Meter reading frequency**
  - Estimated vs Actual readings (from reading codes)

## Last reading type summary

<table>
<thead>
<tr>
<th>Value</th>
<th>Number meters (Count)</th>
<th>AADD (kl/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated</td>
<td>5 998</td>
<td>19 596</td>
</tr>
<tr>
<td>Actual</td>
<td>39 093</td>
<td>62 151</td>
</tr>
<tr>
<td>Total</td>
<td>45 091</td>
<td>81 747</td>
</tr>
</tbody>
</table>

## Days since last actual reading

<table>
<thead>
<tr>
<th>Value</th>
<th>Number meters (Count)</th>
<th>AADD (kl/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>207</td>
<td>1 083</td>
</tr>
<tr>
<td>90-365</td>
<td>1 041</td>
<td>4 793</td>
</tr>
<tr>
<td>60-90</td>
<td>846</td>
<td>2 117</td>
</tr>
<tr>
<td>30-60</td>
<td>3 759</td>
<td>8 744</td>
</tr>
<tr>
<td>&lt;30</td>
<td>39 238</td>
<td>65 010</td>
</tr>
<tr>
<td>Total</td>
<td>45 091</td>
<td>81 747</td>
</tr>
</tbody>
</table>

## Percentage Actual Readings in last 12 months

<table>
<thead>
<tr>
<th>Value</th>
<th>Number meters (Count)</th>
<th>AADD (kl/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>90-100</td>
<td>27 759</td>
<td>42 164</td>
</tr>
<tr>
<td>80-90</td>
<td>5 854</td>
<td>10 638</td>
</tr>
<tr>
<td>70-80</td>
<td>4 796</td>
<td>9 181</td>
</tr>
<tr>
<td>60-70</td>
<td>2 315</td>
<td>4 950</td>
</tr>
<tr>
<td>50-60</td>
<td>1 298</td>
<td>2 962</td>
</tr>
<tr>
<td>40-50</td>
<td>942</td>
<td>2 385</td>
</tr>
<tr>
<td>30-40</td>
<td>708</td>
<td>2 695</td>
</tr>
<tr>
<td>20-30</td>
<td>464</td>
<td>2 478</td>
</tr>
<tr>
<td>10-20</td>
<td>457</td>
<td>2 057</td>
</tr>
<tr>
<td>0-10</td>
<td>291</td>
<td>1 154</td>
</tr>
<tr>
<td>None</td>
<td>207</td>
<td>1 083</td>
</tr>
<tr>
<td>Total</td>
<td>45 091</td>
<td>81 747</td>
</tr>
</tbody>
</table>
Asset management

- Should be managed just like other assets
- Aspects to cover include
  - Asset register
  - Meter audit
  - Meter testing programme
  - Replacement priorities
  - Identify problem meters
  - Replacement programmes
  - Monitor meter performance
Water management

- Municipal water balance
- Water demand management
- Non-revenue water management
## Municipal water balance

<table>
<thead>
<tr>
<th>System input volume</th>
<th>Authorised consumption</th>
<th>Billed authorised consumption</th>
<th>Billed metered consumption</th>
<th>Revenue Water</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Billed unmetered consumption</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unbilled authorised consumption</td>
<td>Unbilled metered consumption</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unbilled unmetered consumption</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water losses</td>
<td>Apparent losses</td>
<td>Unauthorised consumption</td>
<td></td>
<td>Non Revenue Water</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Metering inaccuracies</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Real losses</td>
<td>Leakage on transmission and / or distribution mains</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Leakage and overflows at storage tanks</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Leakage on service connections up to point of consumer metering</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Where do you start?

- Identify water sources and bulk transfers, and check meters
- Identify top 10% consumers and check meters
- Identify distribution zones and meter
- Log zonal meters for consumption and minimum night flows
- Estimate revenue based on water sales
- Prelim water balance -> Leakage management system
- Initial consumer meter review -> meter audit -> meter management