Introduction to Integrated Water Meter Management

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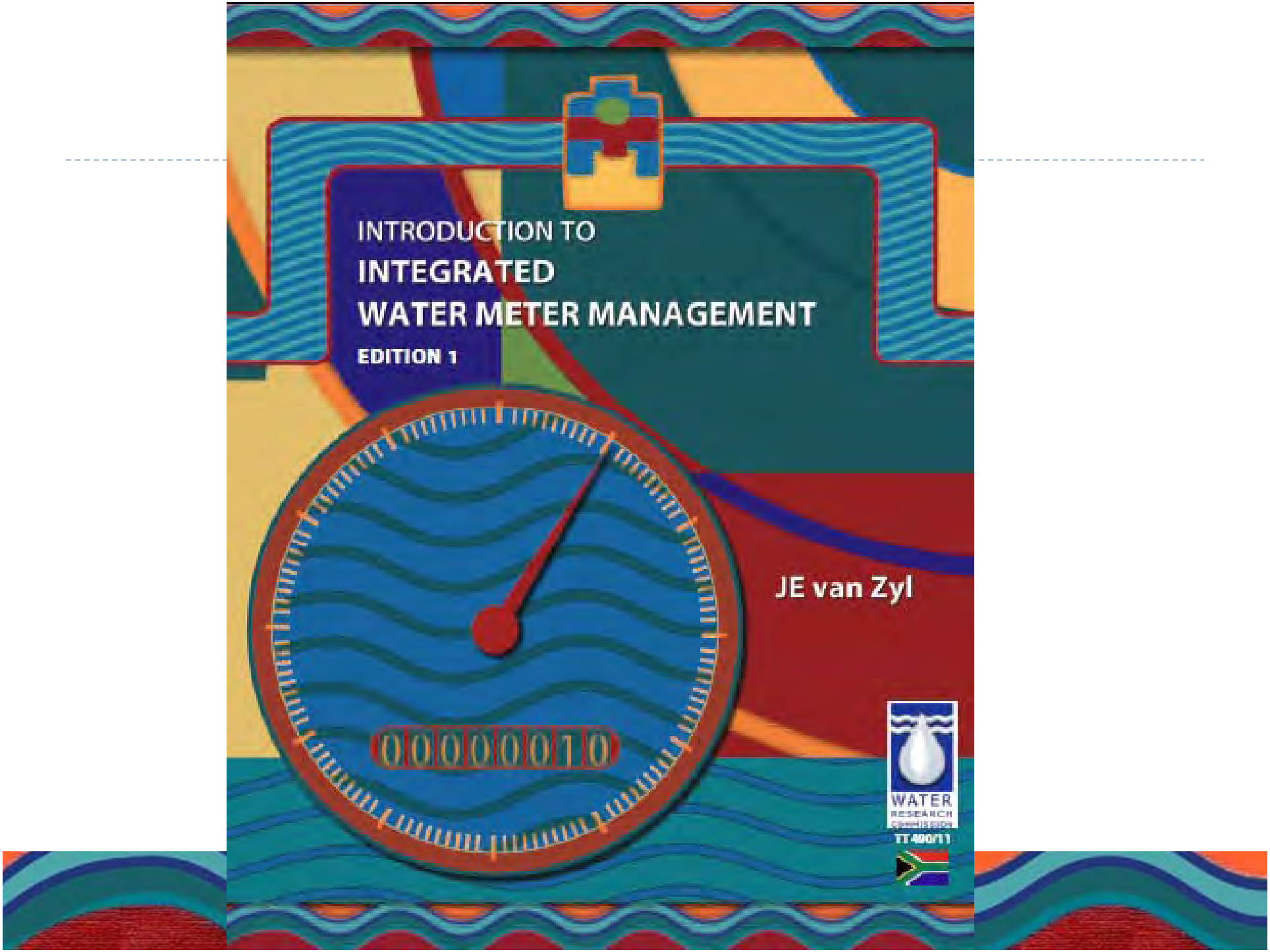
INTRODUCTION TO
INTEGRATED
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Introduction

- 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

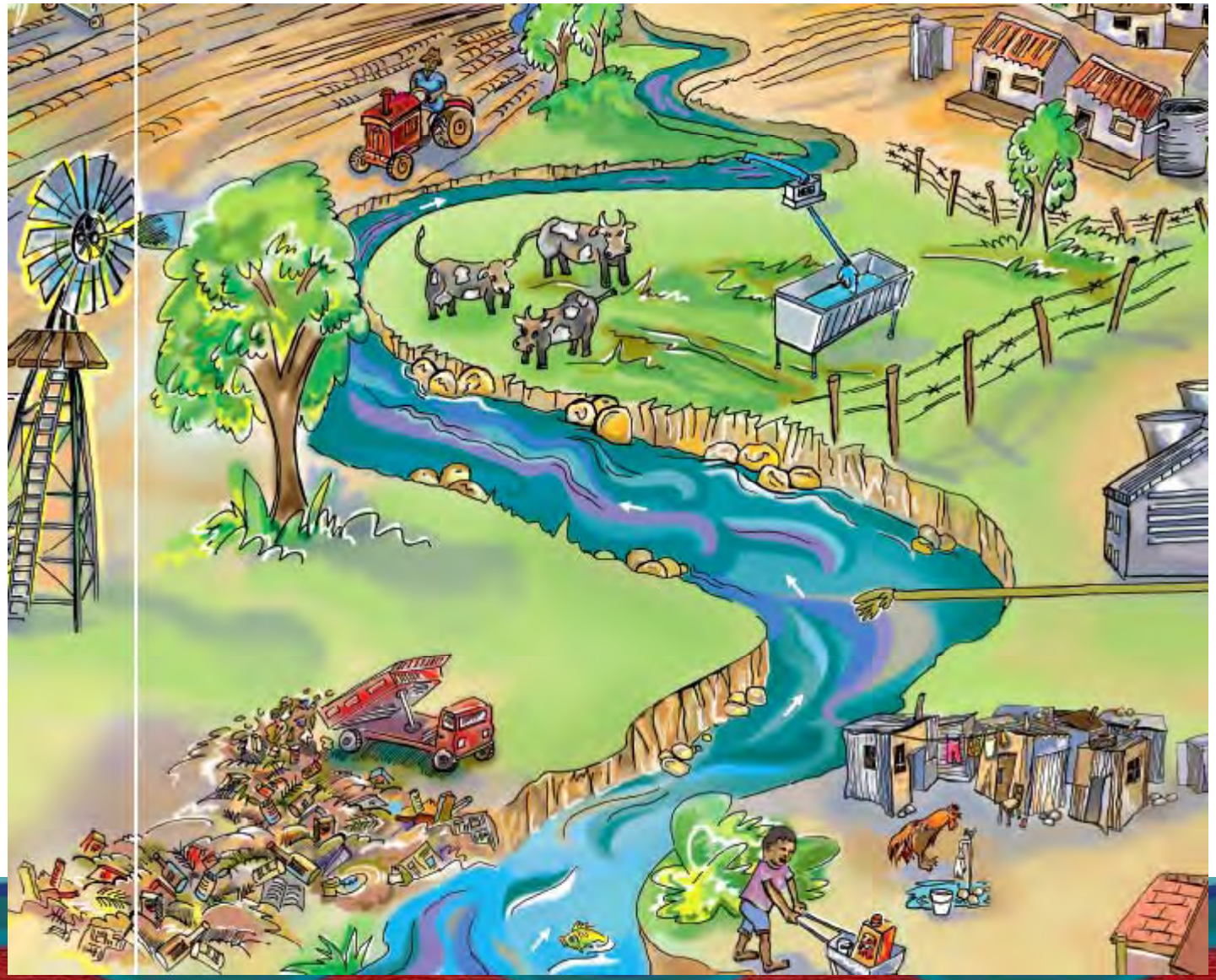
Water Purification

Bulk Supply and Distribution

Plumbing Systems

Waste Water Treatment

Urban Runoff



Where does it all go?

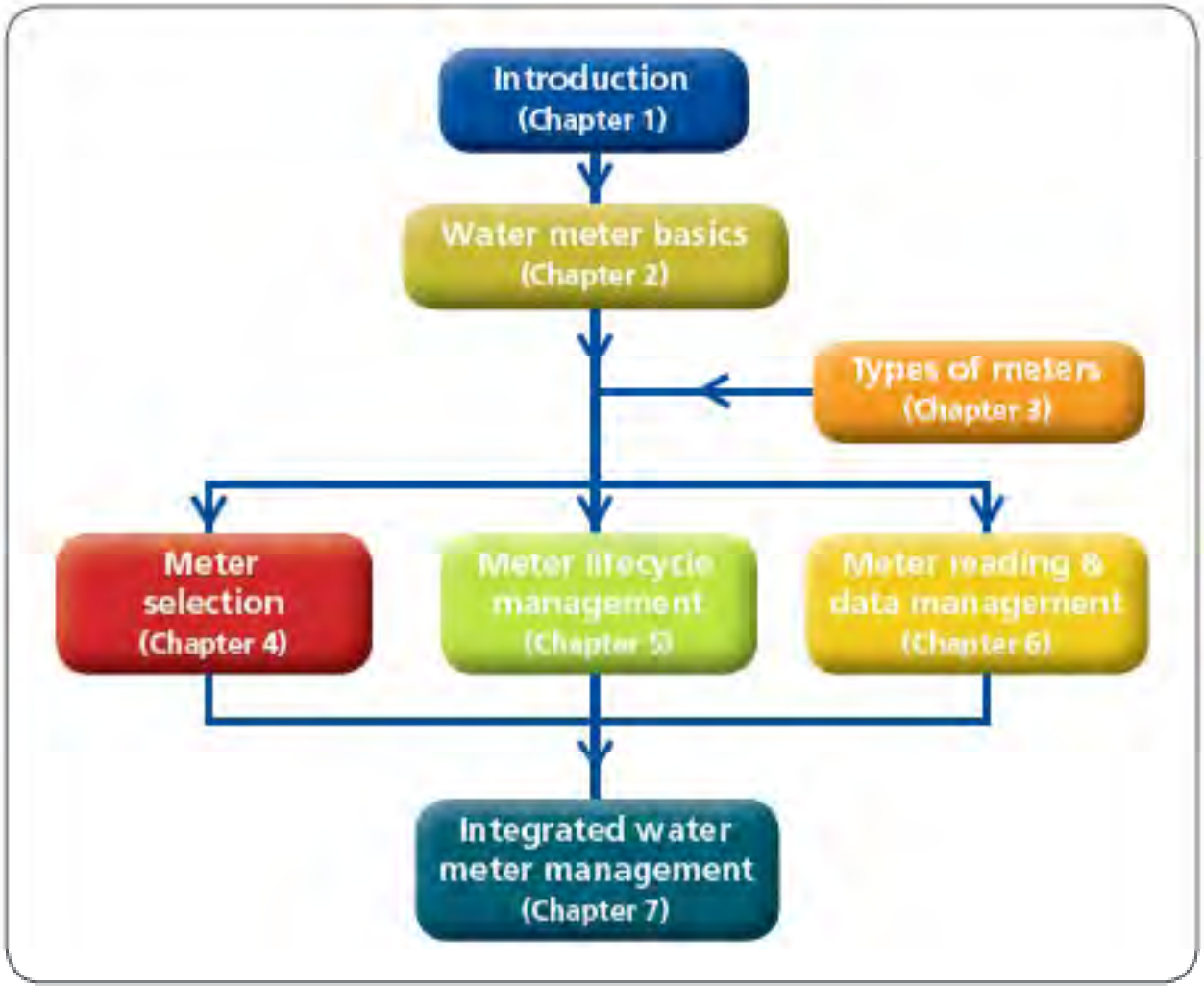
Economic benefits

- 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

APPENDIX A

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*.

APPENDIX B
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
- Intra-Africa Metrology System, http://www.afrimets.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

APPENDIX C
RECOMMENDED READING

Water Meter Management

1. *Establishing a metering plan to account for water use and loss,* by the Federation of Canadian Municipalities and National Research Council, 2003, Downloadable from http://gmf.fcm.ca/files/Infraguide/Potable_Water.

2. *Integrated water meter management,* by F. Arregui, E Cabrera Jr., and R. Cobacho, 2006, IWA Publishing, London

3. *AWWA Manual M6: water meters – selection, installation, testing and maintenance,* 1999, American Water Works Association.

4. *Meter management: best practices for water utilities,* by D.L. Schlenger, 1997, Journal of Water Engineering and Management, March, 33–37.

5. *Flow measurement handbook, industrial design, operating principles, performance, and applications,* by R.C. Baker, 2000, Cambridge University Press, Cambridge.

6. *A compendium of best practices in asset management, by J.N.* Bhagwan, 2009, Global Water Research Coalition, Downloadable from http://www.wrc.org.za/ SiteCollectionDocuments/News%20documents/2009-02-23%20GWRC%20final-Jay.pdf

Water Meter Basics

Integrated Water Meter Management

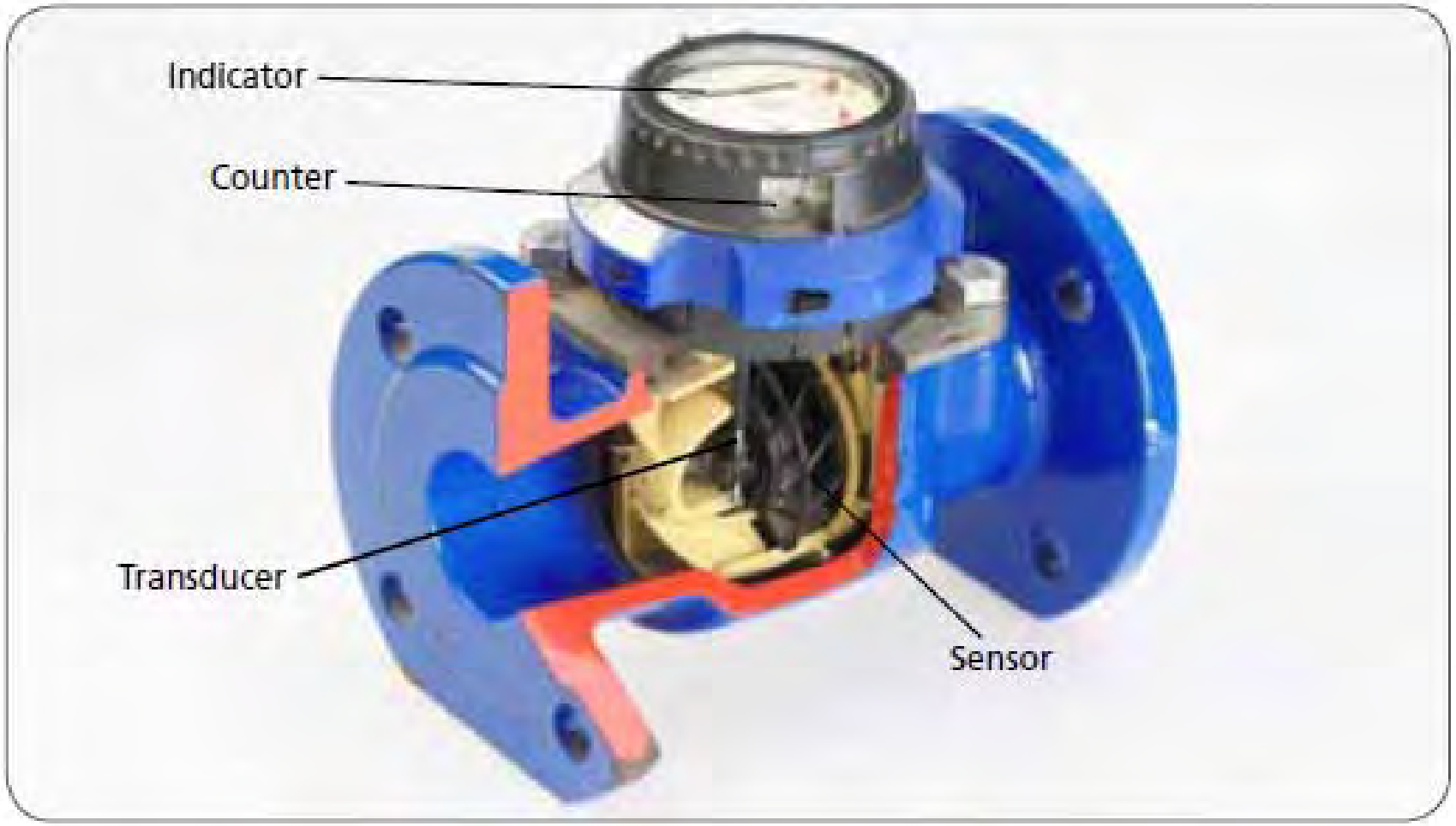
Overview

- 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

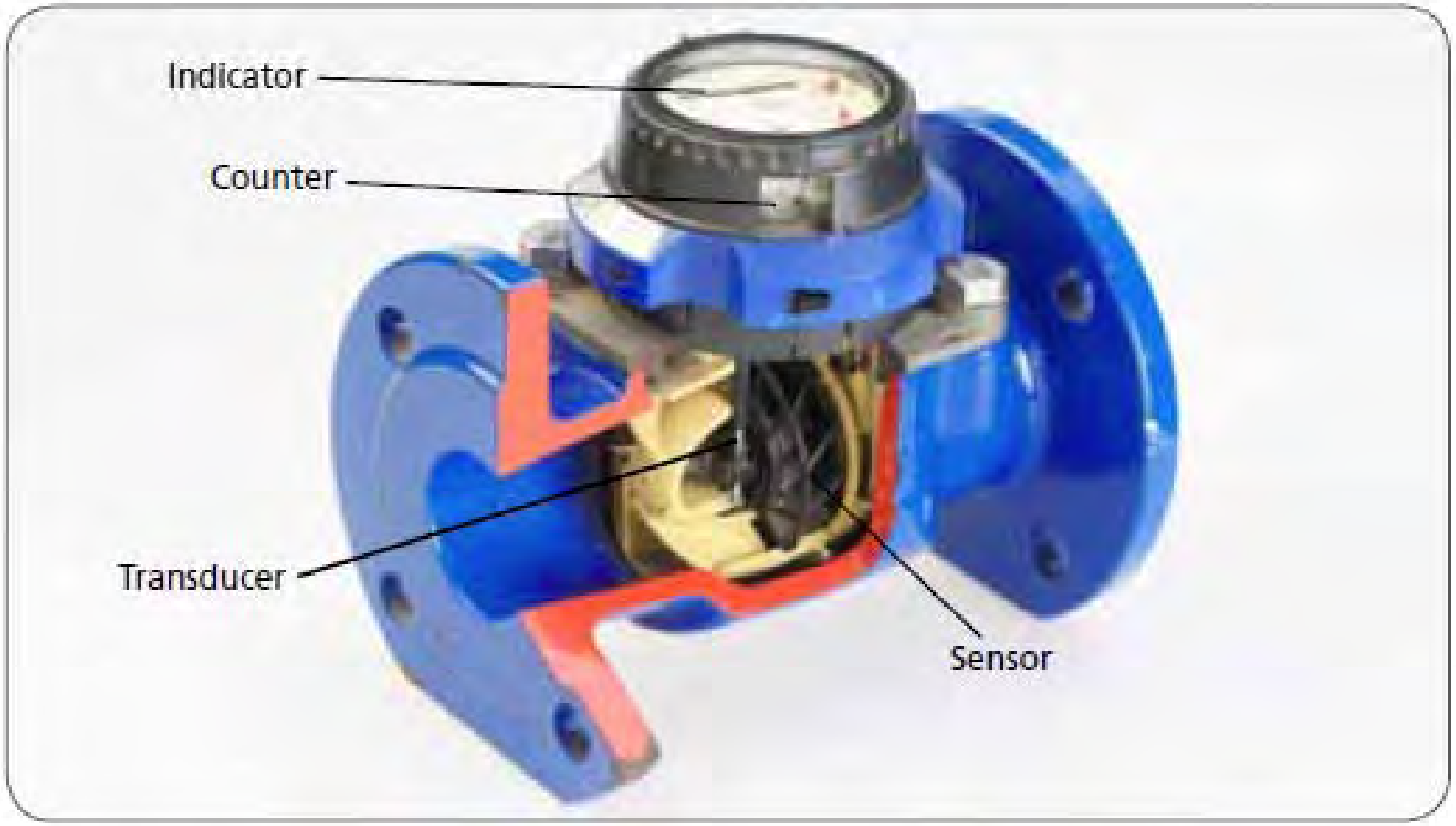
Water meter components



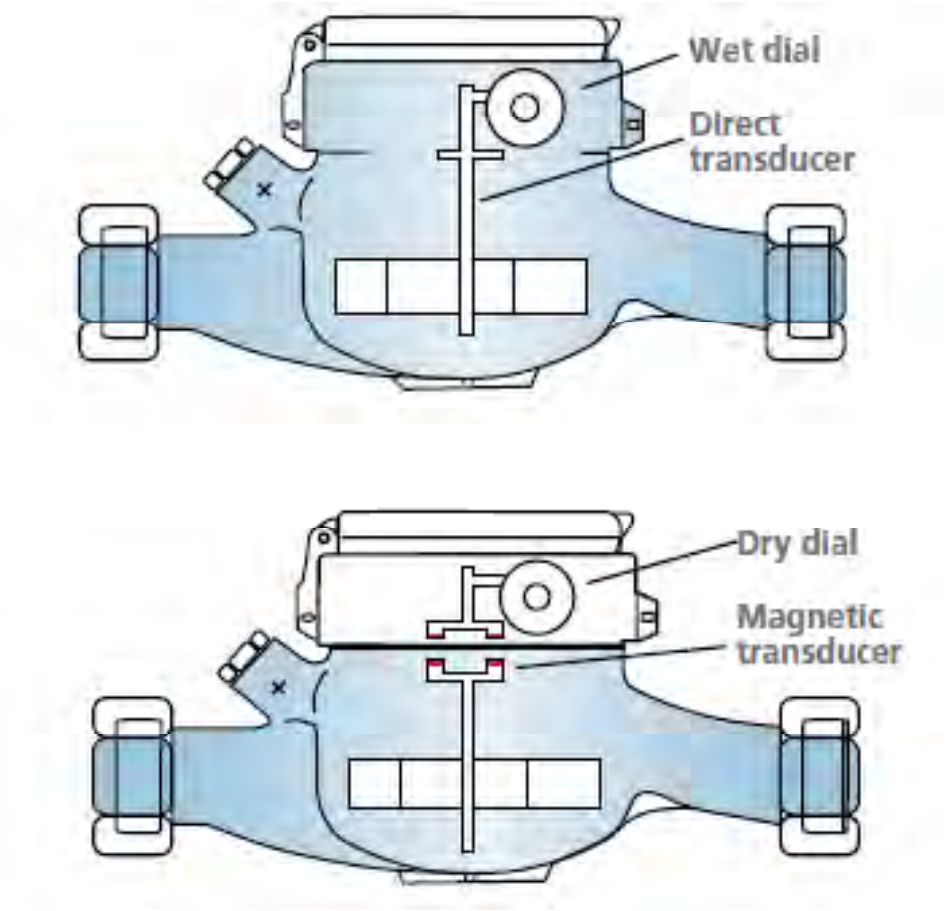
Sensor

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

Transducer



Direct and magnetic transducers



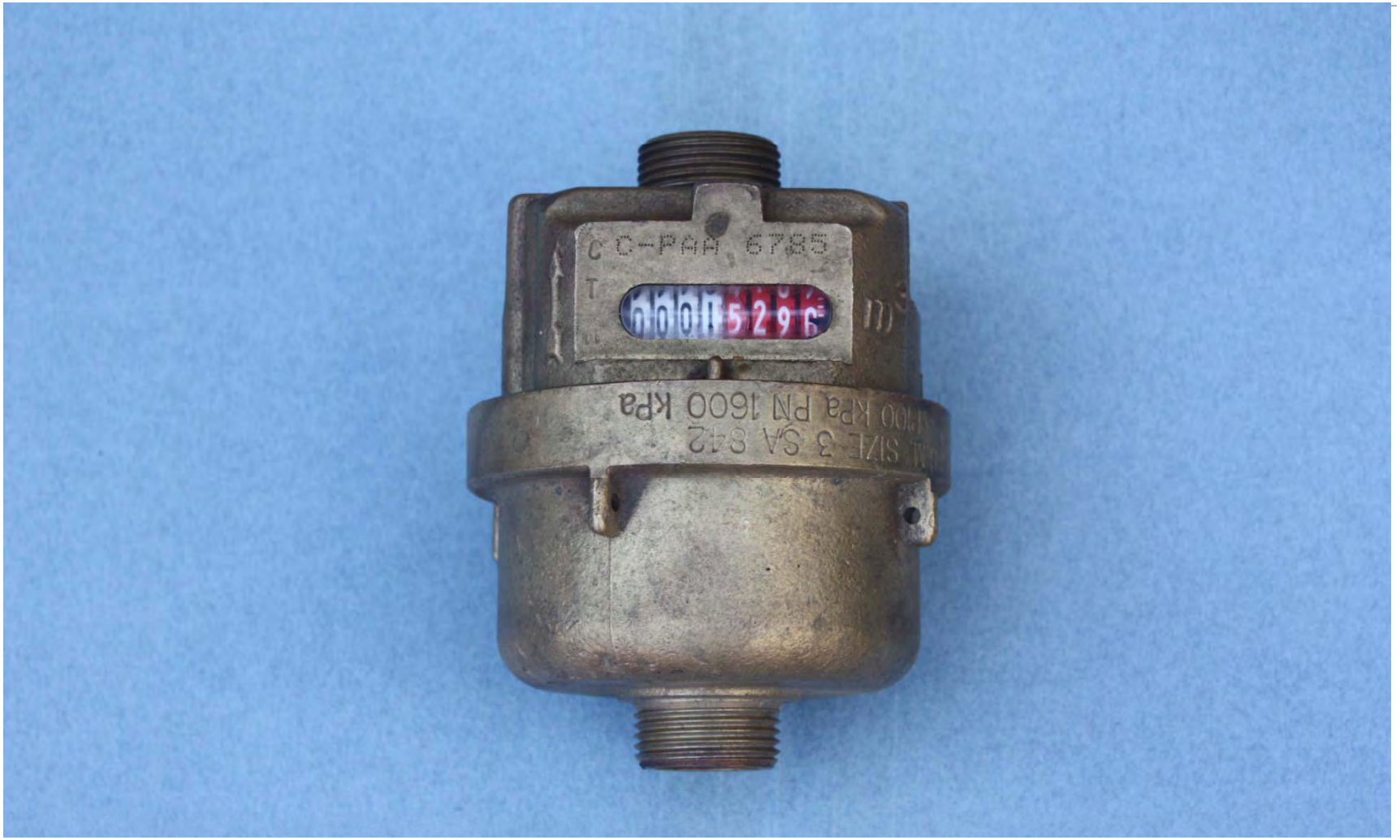
Calculator

- Accumulates volumetric reading through meter

Indicator

- Displays measurement
  - Rotating counter
  - Dials
  - Electronic
- Has to use m^3 as units
- Clear differentiation between full values and fractions required

Rotating counter indicator



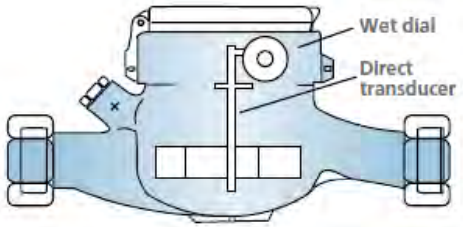
Rotating counter and dials indicator

Electronic indicator

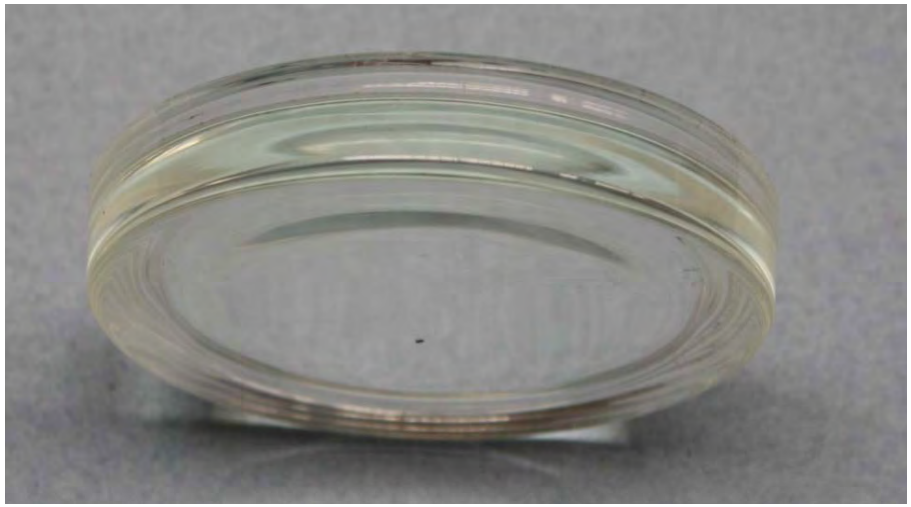
Meter dials can be

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

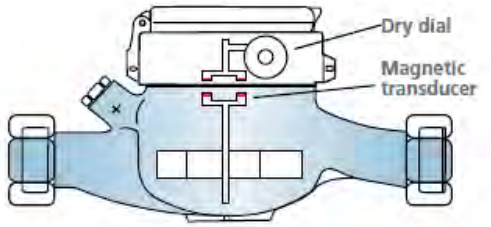
Open wet dial meters



- Advantages
  - Damp not a problem
- Disadvantages
  - Can be susceptible to suspended solids
  - Need strong transparent cover
  - Algae can be a problem

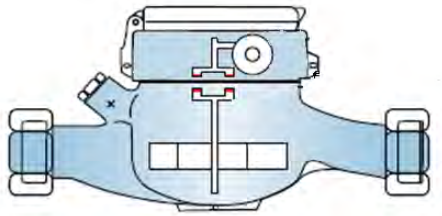


Sealed dry dial meters



- 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 m^3. 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 m^3. 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 m^3. 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 m^3. 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.

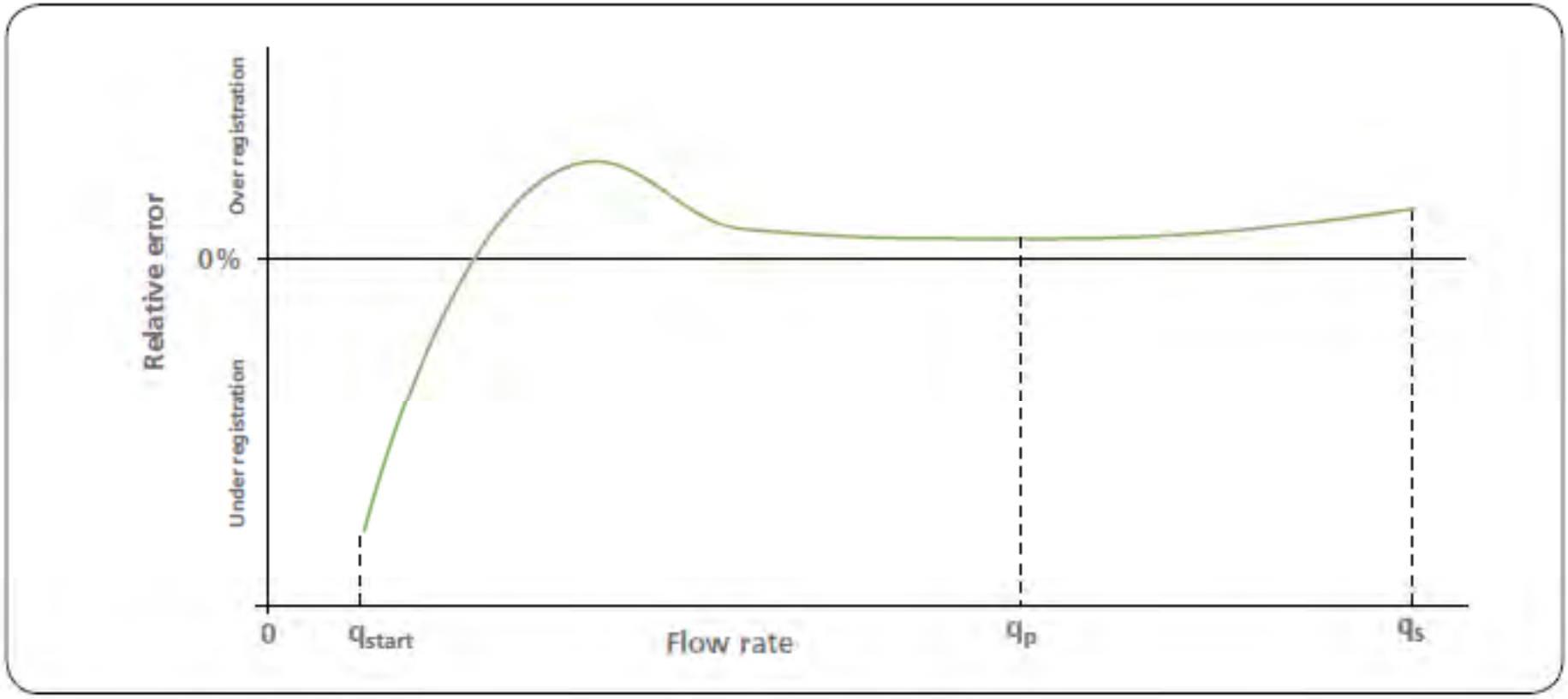
Actual flow rate = ***actual volume*** / time = 200 / 5 = 40 l /min, or 2 400 l /h.

Indicated volume V_i = 123.654 – 123.456 = 0.198 m^3, 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.

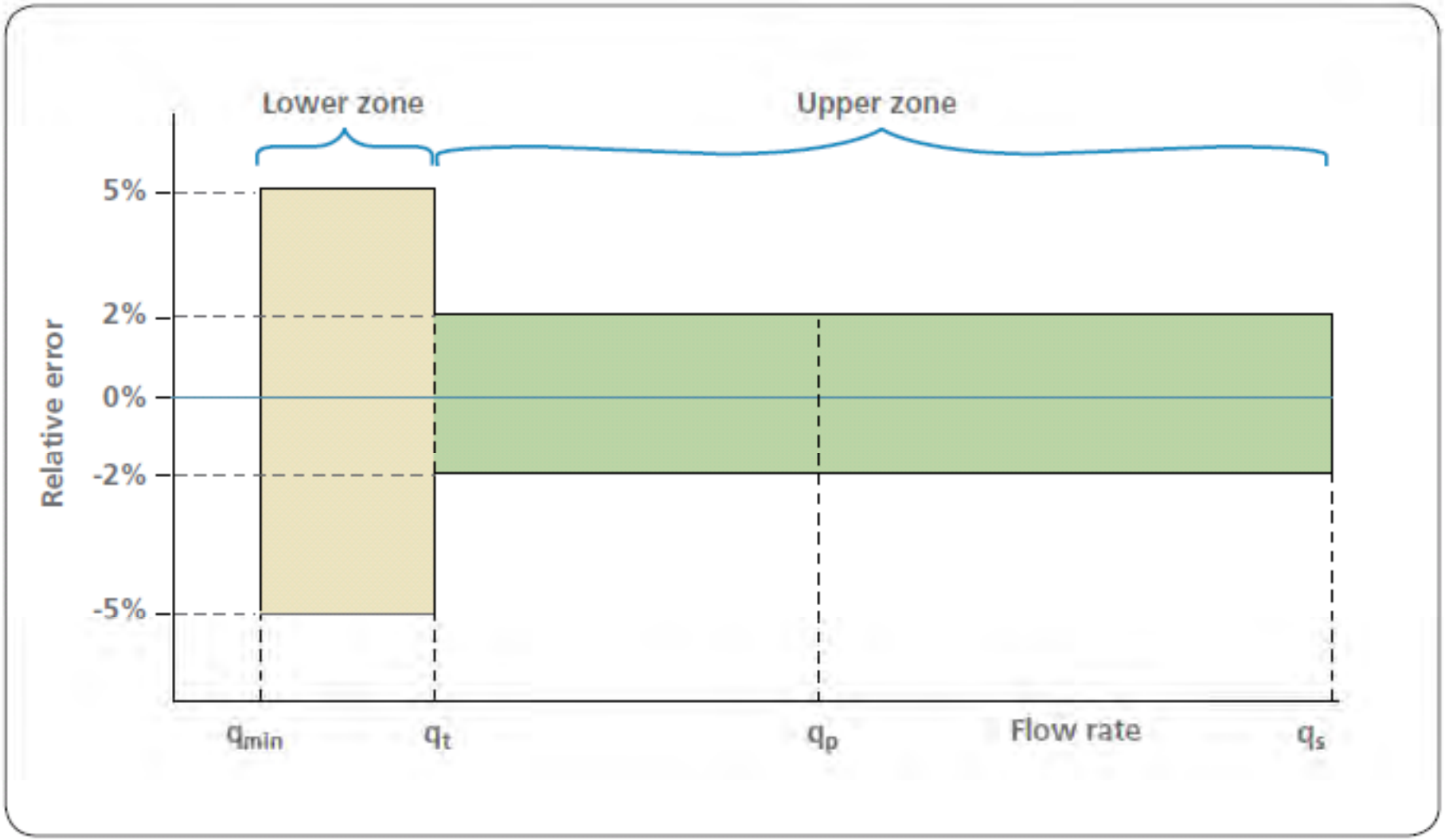
Meter accuracy curve



Terminology

- Permanent flow rate q_p
- Starting flow rate q_{start}
- Overload flow rate q_s

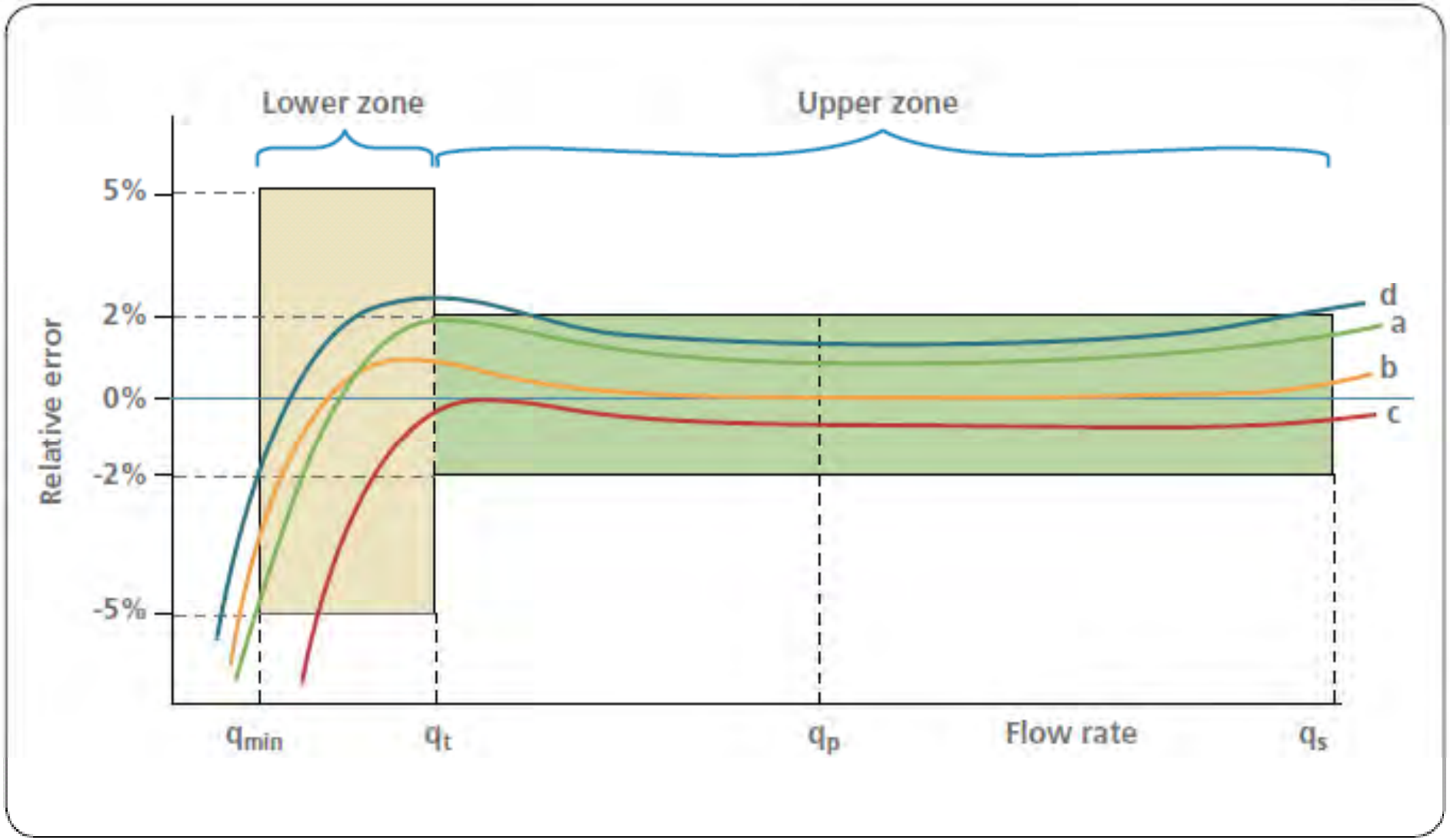
Requirements for meter accuracy



Terminology

- Maximum permissible error
- Minimum flow rate Q_{min}
- Transitional flow rate Q_t
- Lower zone
- Upper zone

Examples of accuracy curves



Conventional meter classes

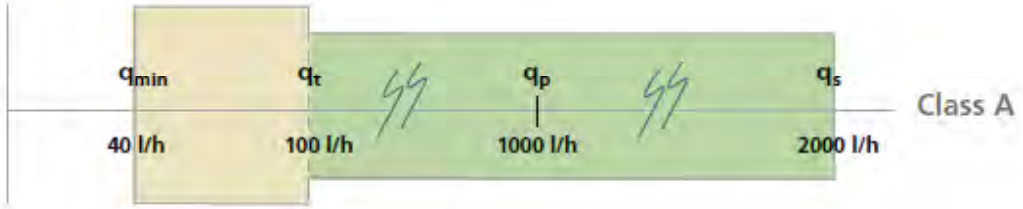
- Maximum permissible errors 5 % in lower zone and 2 % in higher zone.
- Meter classes defined by extent of zones, not accuracy
- Allowed accuracy for used meters is 8 % and 3.5 %

Table 2-1 Meter classes defined by SABS 1529 for permanent flow rates up to 10 m^3/h

Increasing stringency ↓

Meter class	Minimum flow rate (q_{min})	Transitional flow rate (q_t)
A	0.04 q_p	0.10 q_p
B	0.02 q_p	0.08 q_p
C	0.01 q_p	0.015 q_p
D	0.0075 q_p	0.0115 q_p

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.



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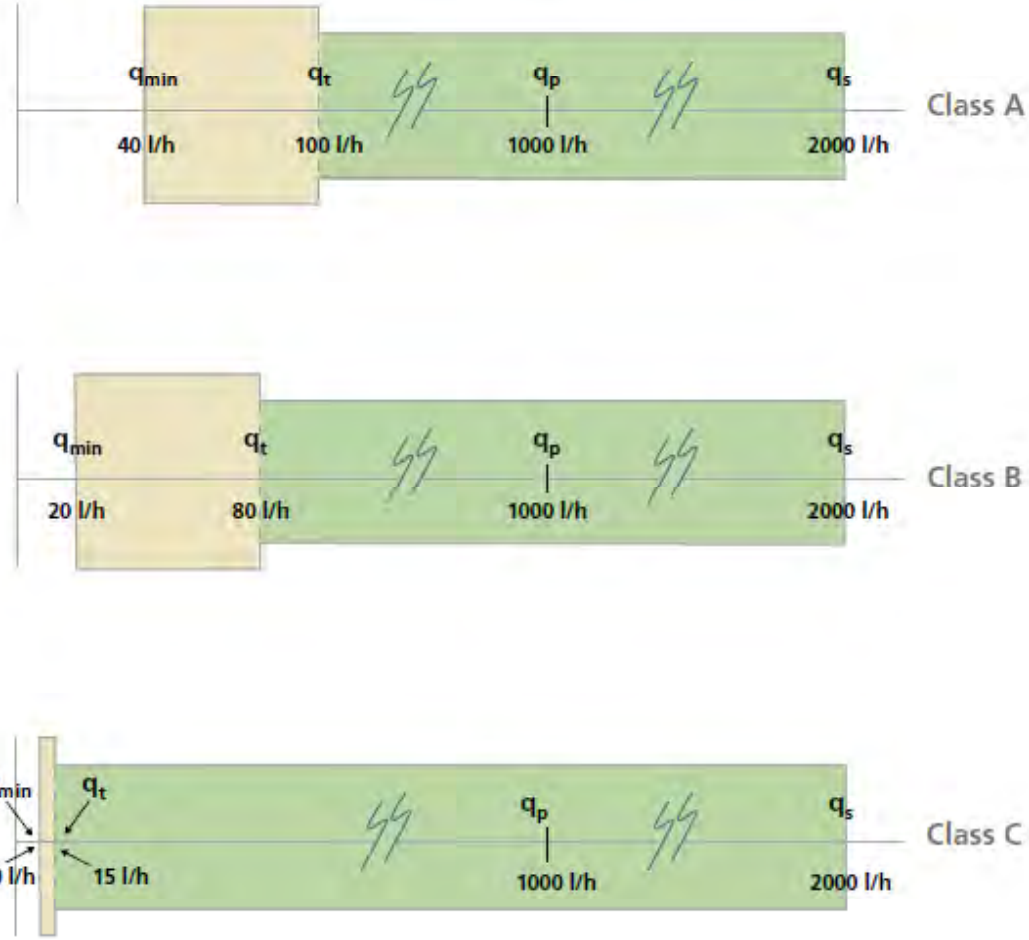


Example: Consider a meter with a permanent flow rate of 1 m3/h or 1 000 l/h. The minimum accuracy requirements for this meter is shown in Figure 2 10 for classes A to D.

New meter classes

- Use Q_1, Q_2, Q_3 and Q_4 instead of q_{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

Meter Class	Applicable to	Maximum permissible error	
		Lower zone	Higher zone
1	Only meters with $Q_p \geq 100$ m³/h.	3%	1%
2	All meters with $Q_p < 100$ m³/h. May be applied to meters with $Q_p \geq 100$ m³/h	5%	2%

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

Group	Maximum pressure loss
P100	100 kPa
P60	60 kPa
P30	30 kPa
P10	10 kPa

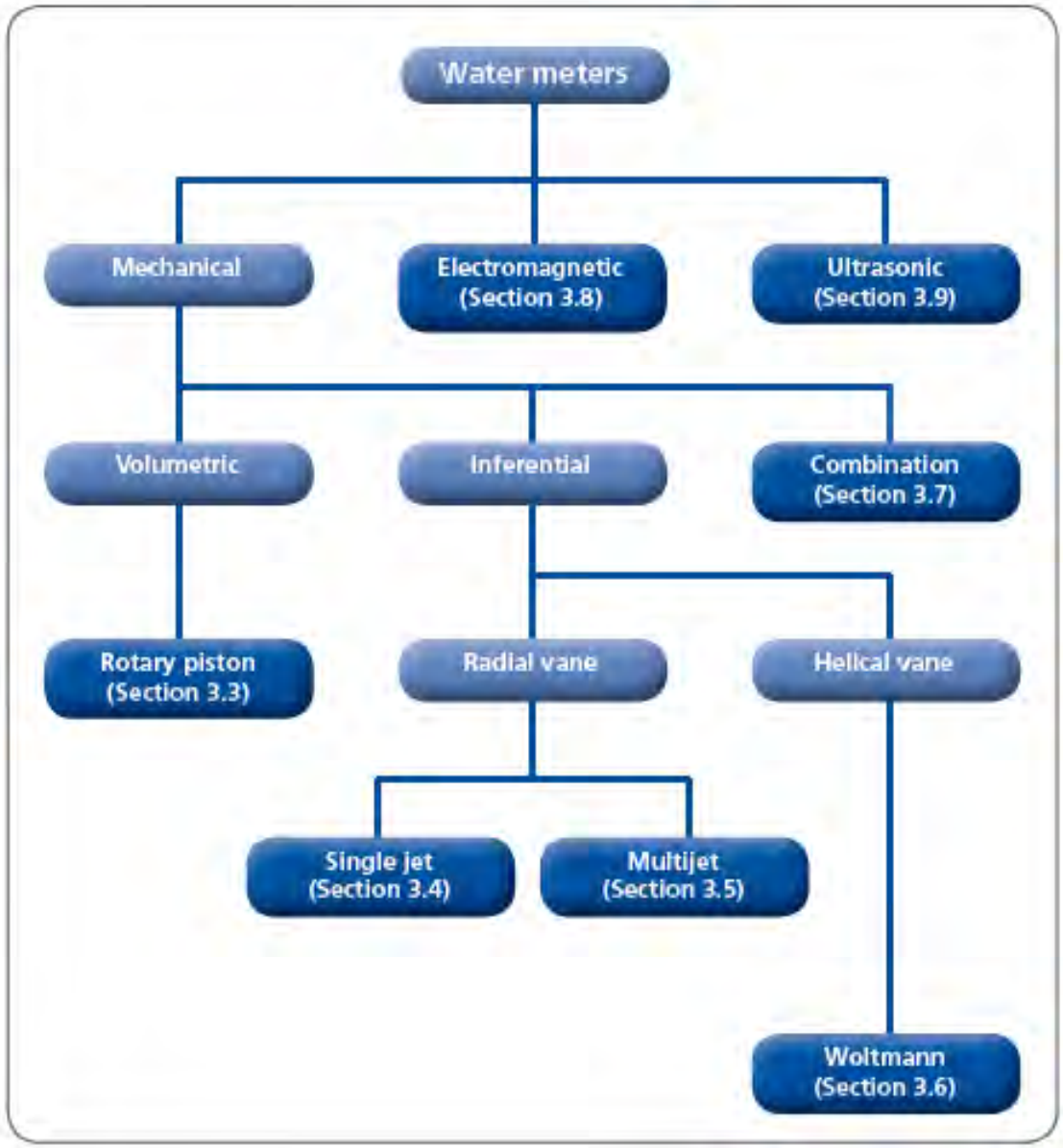
Required Seals and markings

- Manufacturer
- Permanent flow rate in m^3/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

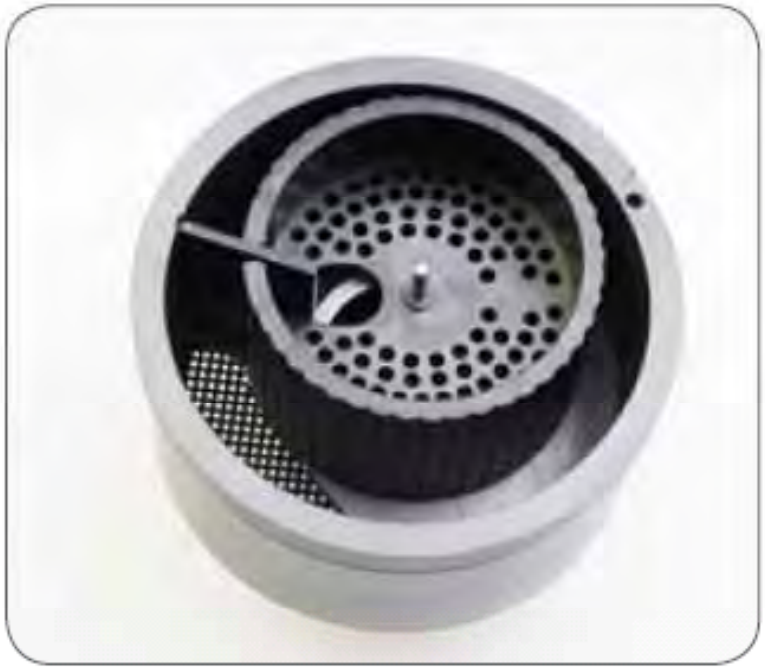
Types of Water Meters

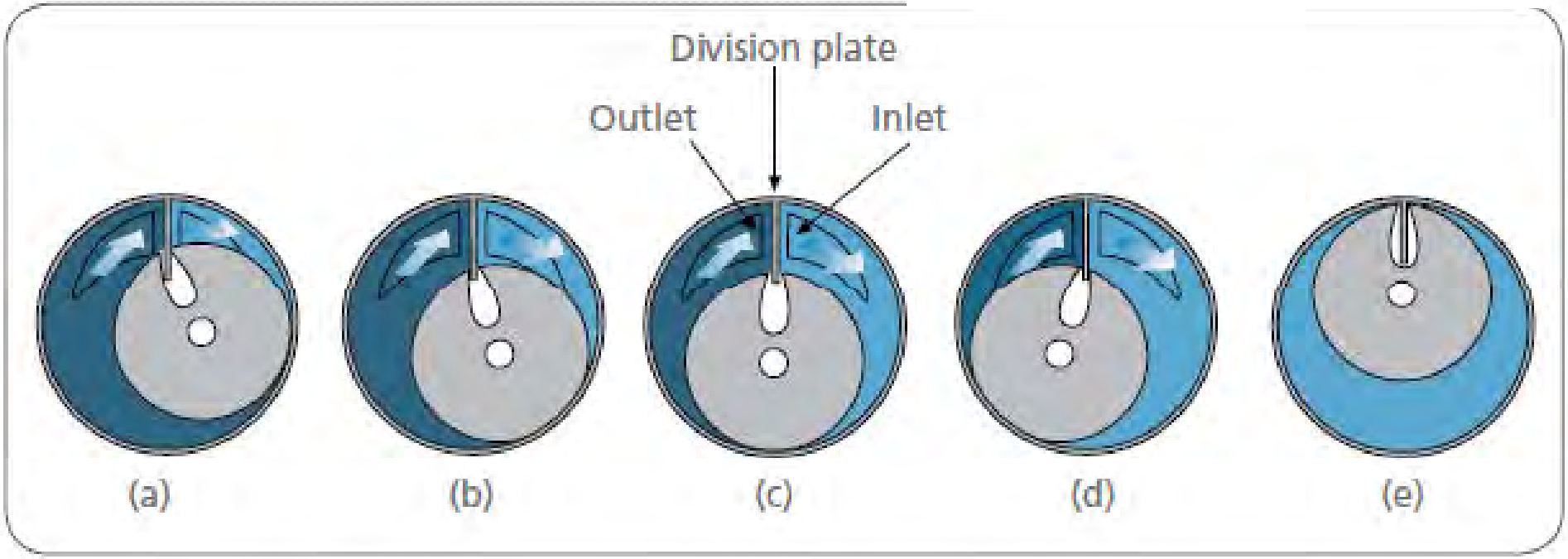
Integrated Water Meter Management

Classification of water meters



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 3-1 Metrological characteristics of common rotating piston meters

Class	Size (mm)	q_{start} (l/h)	q_{min} (l/h)	q_t (l/h)	q_p (l/h)	q_s (l/h)
C	15	1	10	15	1000	2000
C	15	3	15	22.5	1500	3000
C	20	4	25	37.5	2500	5000
C	25	6	35	52.5	3500	7000
C	30	11	50	75	5 000	10 000
C	40	18	100	150	10 000	20 000
D	15	3	7.5	11.5	1000	2000
D	20	6	18.75	28.75	2500	5000

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 horisontal
- Sensitive to disturbances in flow profile, e.g. bend or partially blocked strainer

Metrological characteristics of common single jet meters

Table 3-2 Metrological characteristics of common single jet meters

Class	Size (mm)	q_{start} (l/h)	q_{min} (l/h)	q_t (l/h)	q_p (l/h)	q_s (l/h)
B	15	8	30	120	1500	3000
B	20	13	50	200	2500	5000
C	15	5	15	22.5	1500	3000
C	20	6	25	37.5	2500	5000
C	40	22	100	150	10000	20000

Multijet meters

Examples of Multijet meters

Characteristics of Multijet meters

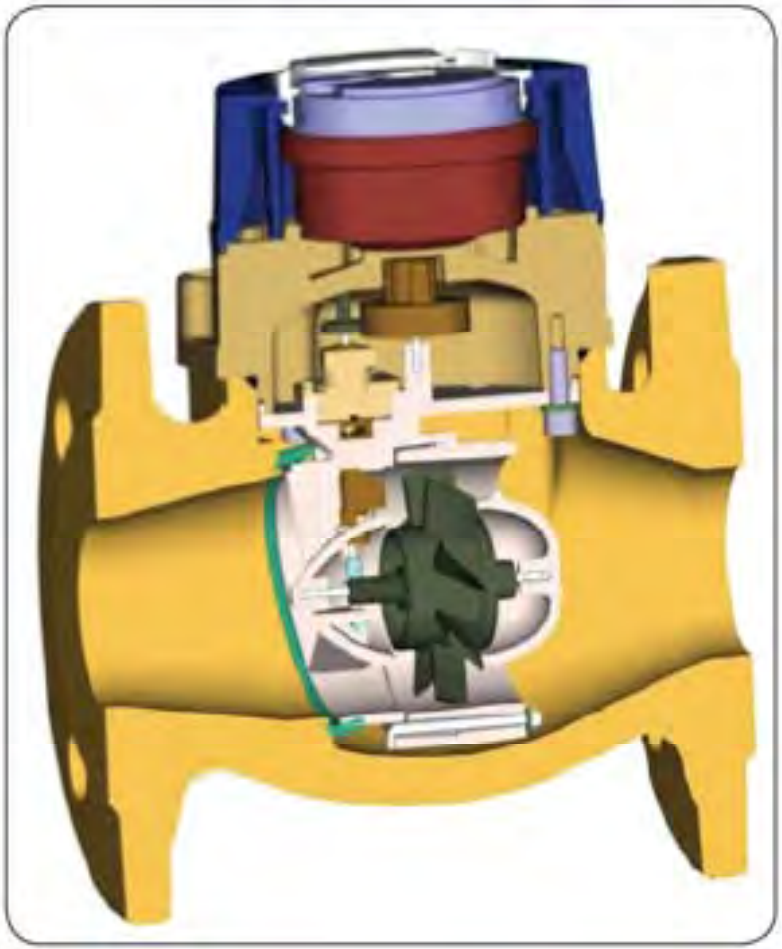
- Inferential
- Similar to single jet except for number of jets on impeller
- Uses internal bypass with regulating screw
- Often available as cartridge meters
- Longer life due to balanced forces on impeller
- Not sensitive to velocity profile
- Must be installed upright and horisontal
- Clogged strainer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

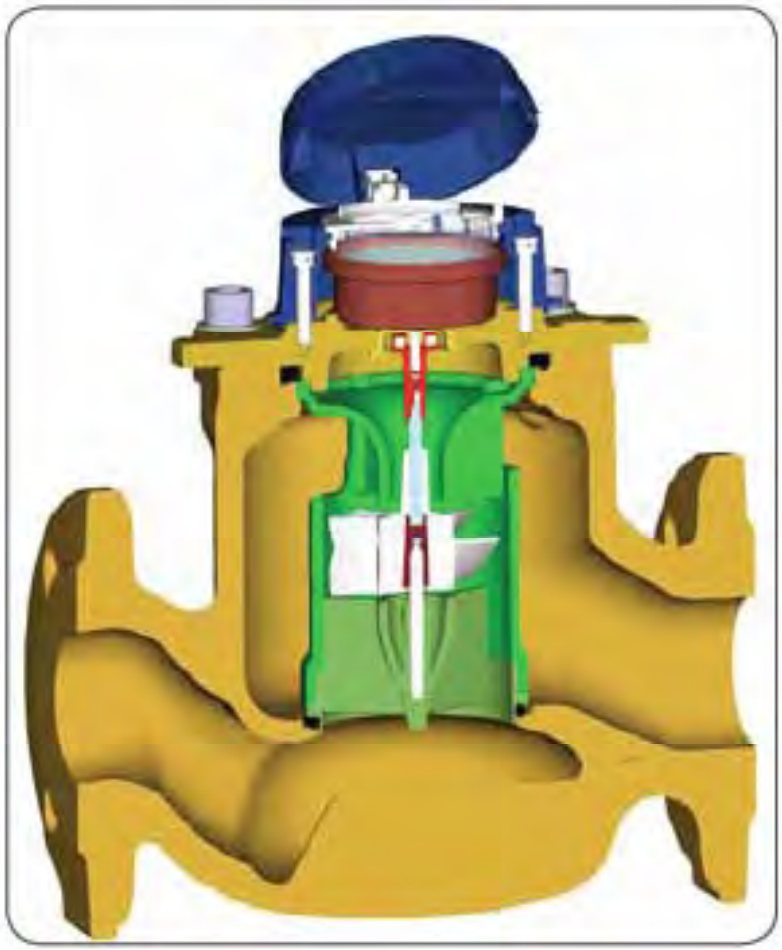
Metrological characteristics of common multijet meters

Table 3-3 Metrological characteristics of common multijet meters

Class	Size (mm)	q_{start} (l/h)	q_{min} (l/h)	q_t (l/h)	q_p (l/h)	q_s (l/h)
B	15	10	30	120	1500	3000
B	20	15	50	200	2500	5000
B	25	25	70	280	3500	7000
B	30	25	100	400	5000	10000
B	40	53	200	800	10000	20000
B	50	68	450	3000	15000	30000
C	15	10	15		1500	3000
C	20	12	25	37.5	2500	5000
C	25	15	35	52.5	3500	7000
C	32	15	40	90	6000	12000
C	40	20	100	150	10000	20000
C	50	30	75	150	15000	30000

Woltmann meters: Horizontal (WP) and Vertical (WS)





Examples of Woltmann meters

Characteristics of Woltmann meters

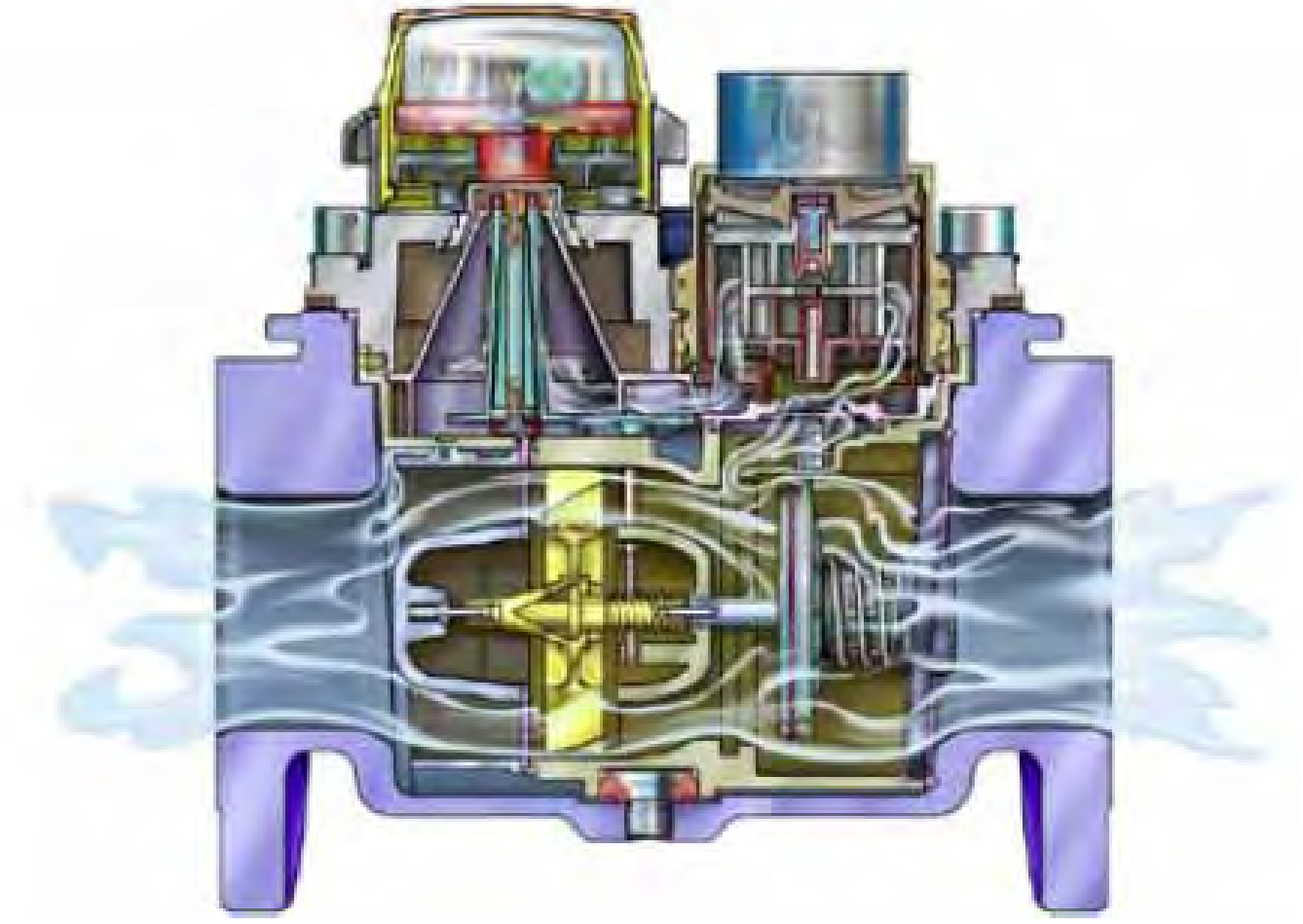
- Inferential meters with helical vane impellers
- Horizontal (WP)
  - By far the most common type of Woltmann
  - Low pressure loss through meter
  - Not good sensitivity at low flow rates
  - Typically only class B, but better than minimum performance
  - Often as cartridge meters
  - Can handle dirty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

Metrological characteristics of common WP Woltmann meters

Table 3-4 Metrological characteristics of common Horizontal (WP) Woltmann meters

Class	Size (mm)	q_{start} (l/h)	q_{min} (l/h)	q_t (l/h)	q_p (l/h)	q_s (l/h)
B	50	200	450	3000	15000	30000
B	50	200	750	5000	25000	50000
B	80	300	1200	8000	40000	80000
B	80	300	1800	12000	60000	120000
B	100	400	1800	12000	60000	120000
B	100	400	3000	20000	100000	200000
B	150	1100	4500	30000	150000	300000
B	150	1100	7500	50000	250000	500000
B	200	1600	7500	50000	250000	500000
B	200	1600	12000	80000	400000	800000
B	250	3000	12000	80000	400000	800000
B	250	3000	18000	120000	600000	1200000
B	300	10000	18000	120000	600000	1200000
B	300	10000	30000	200000	1000000	2000000
B	400	15000	30000	200000	1000000	2000000
B	400	15000	45000	300000	1500000	3000000
B	500	20000	45000	300000	1500000	3000000
B	500	20000	75000	500000	2500000	5000000

Combination meters

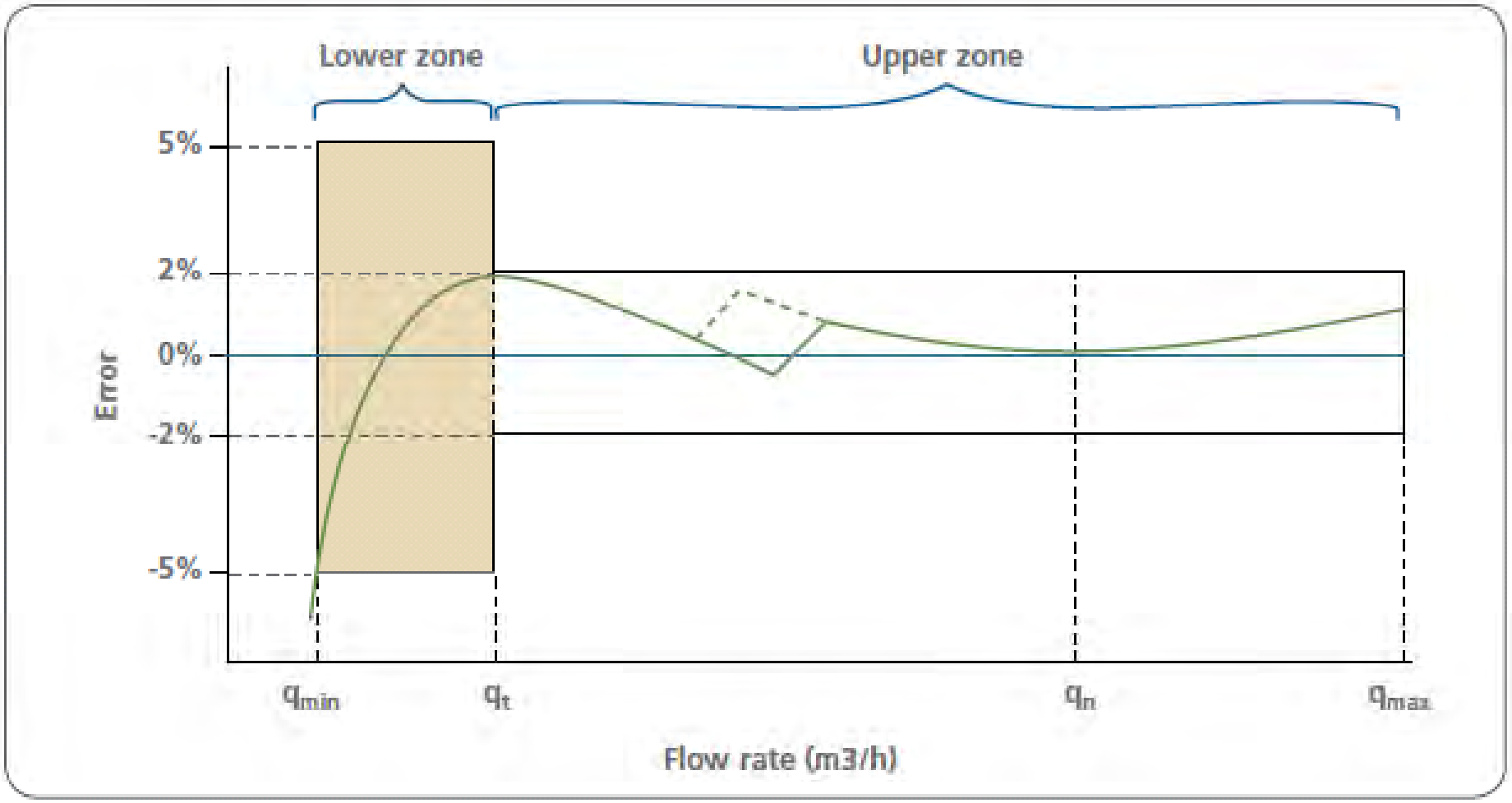


Examples of combination meters

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



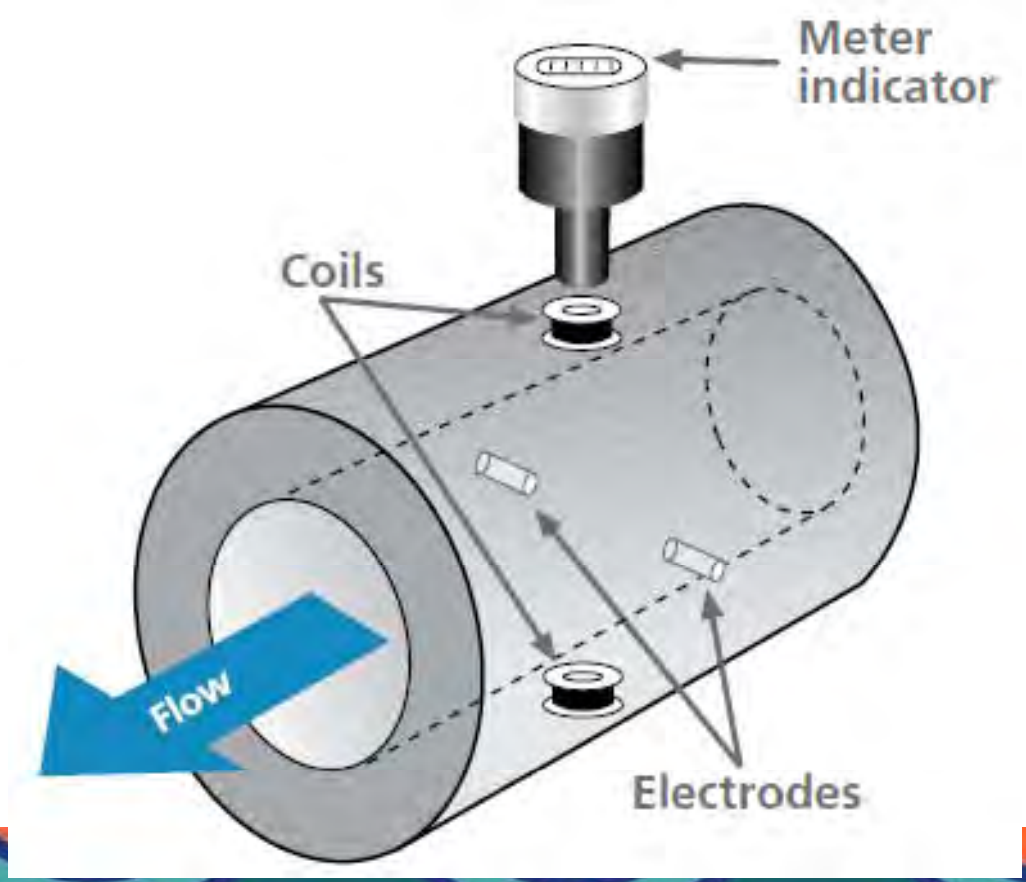
Metrological characteristics of common combination meters

Table 3.5 Metrological characteristics of common combination meters

Class	Size (mm)	Q_{start} (l/h)	Q_{min} (l/h)	Q_t (l/h)	Q_p (l/h)	Q_s (l/h)
B	50 x 20	10	25	37.5	25 000	50 000
B	60 x 20	10	25	37.5	25 000	50 000
B	80 x 20	10	25	37.5	60 000	120 000
B	100 x 25	13	35	52.5	60 000	120 000
B	140 x 40	38	60	2 000	150 000	300 000

Electromagnetic meters

- Uses Faraday's induction law: conductor moving through a magnetic field will induce a voltage



Electromagnetic meters (cont)

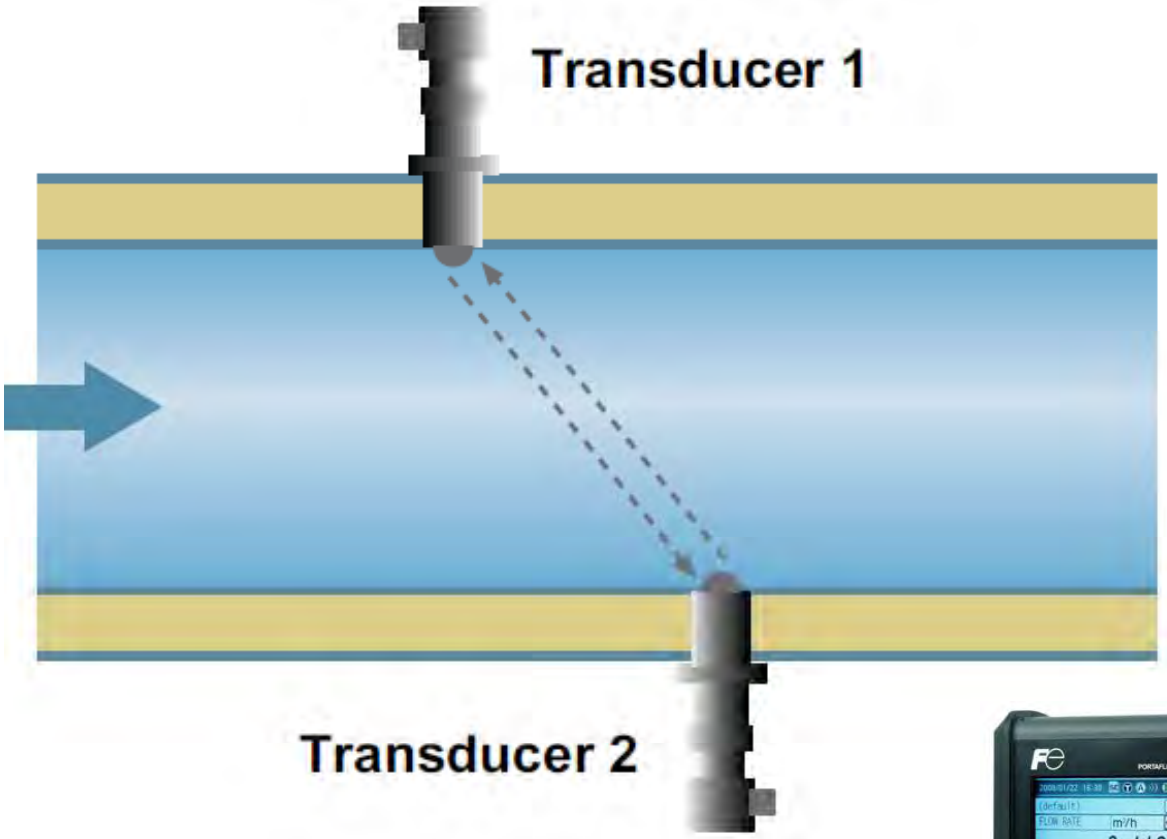
- Very accurate within range (0.5 – 0.1 %)
- Electromagnets can use DC or AC power
- No obstruction to flow
- Accuracy can be affected by
  - Deposits on electrodes
  - Air in fluid
  - Turbulence and water hammer
  - Sediments
- Electrical connection required

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

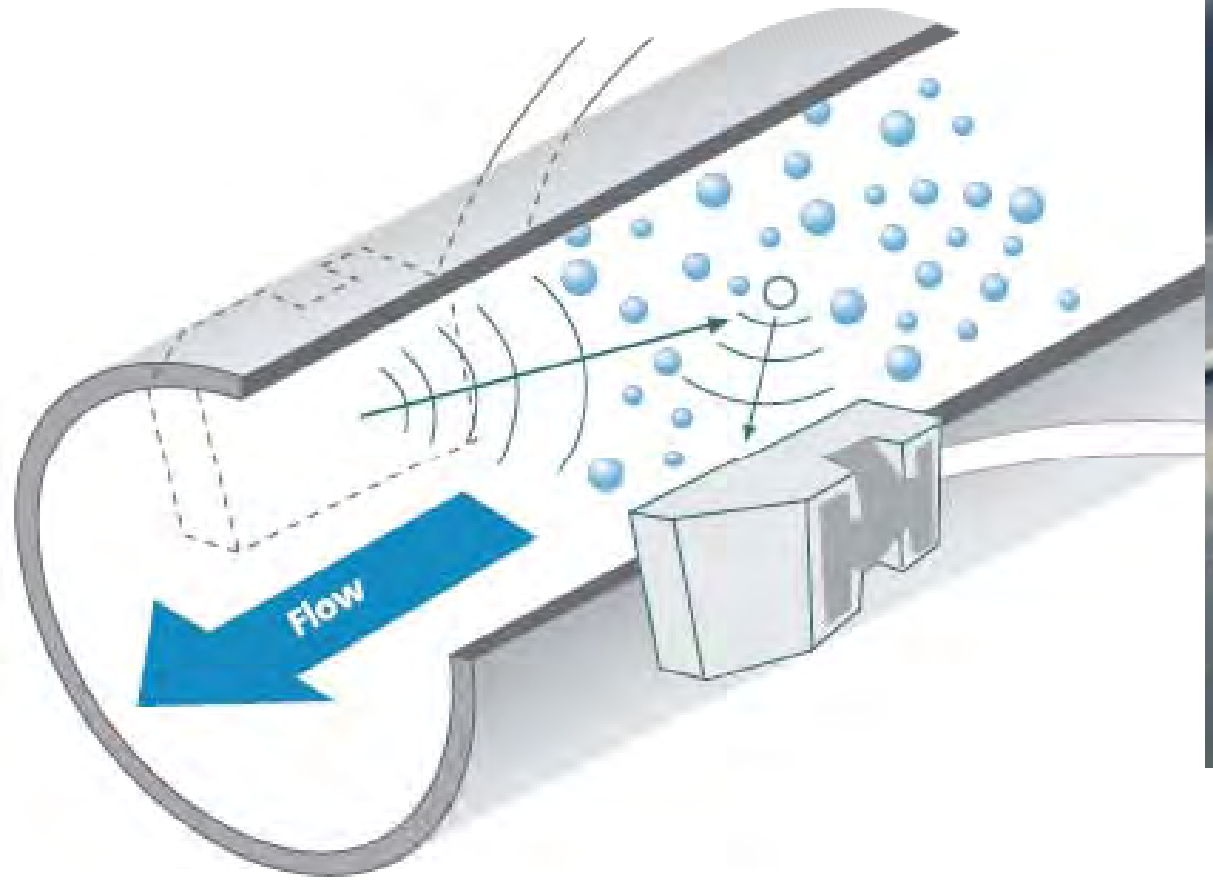
Operation of transit time ultrasonic meter



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



Property	Meter Type						
	Rotary Piston (Section 3.3)	Single Jet (Section 3.4)	Multi Jet (Section 3.5)	Horizontal (WP) Wolt-mann (Section 3.6)	Comb-ination (Section 3.7)	Electro-magnetic (Section 3.8)	Ultrasonic (Section 3.9)
Classification	Mechanical Volumetric	Mechanical Inferential	Mechanical Inferential	Mechanical Inferential	Mechanical Varies*	Electro-magnetic Inferential	Ultrasonic Inferential
Sizes commonly used (mm)	15 – 40	15 - 40	15 - 40	40 - 500	50x20 -150x40	300 - 2000	400 - 4000
Sensitivity to velocity profile	Insensitive	Medium	Low	High	Medium*	Medium	High
Sensitivity to water quality	High	Medium	Medium	Low	Medium*	Very Low	Low
Typical classes	B, C and D	B and C	B and C	B	B	Not cate-gorised	Not cate-gorised
Pressure loss	High	Low	Medium	Medium	High*	Very low	Very low
Orientation	Any	Mainly horizontal	Horizontal	Almost any	Horizontal	Almost any	Almost any
Minimum straight length upstream	None	0 - 5 d	None	5 d	5 d	5-10 d	10 d
Minimum straight length downstream	None	0 - 3 d	None	3 d	3 d	3 d	3 d
Electricity required?	No	No	No	No	No	Yes	Yes

Typical meter replacement cost

Table 3-7 Typical replacement costs of meters[4]

Nominal Diameter (mm)	Typical replacement cost (R)
15	R1 700,00
20	R1 800,00
25	R2 000,00
40	R2 200,00
50	R3 800,00
80	R5 000,00
100	R10 000,00
150	R16 000,00
200	R32 000,00
250	R50 000,00
300	R100 000,00
400	R200 000,00
450	R380 000,00

Water Meter Selection

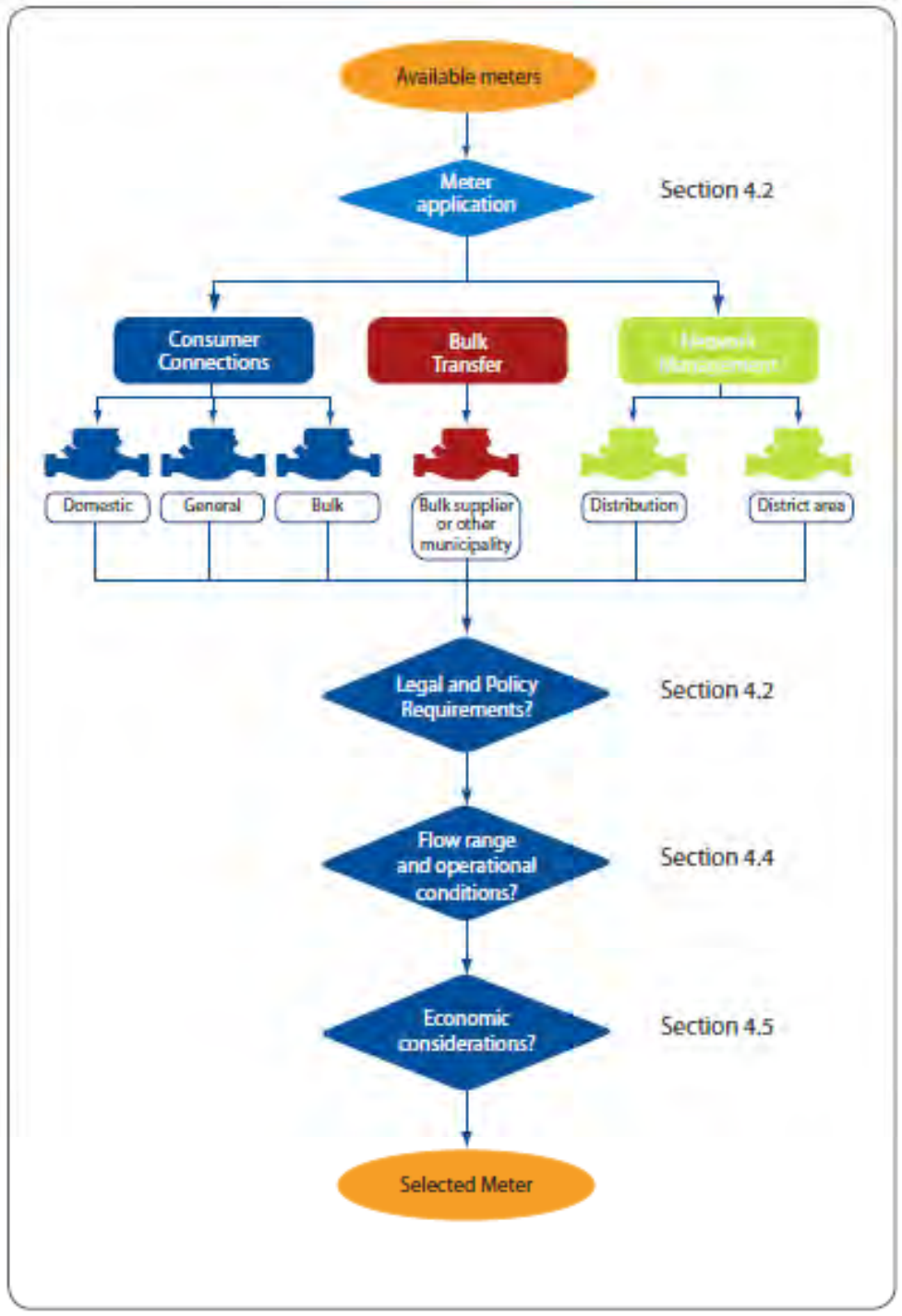
Integrated Water Meter Management

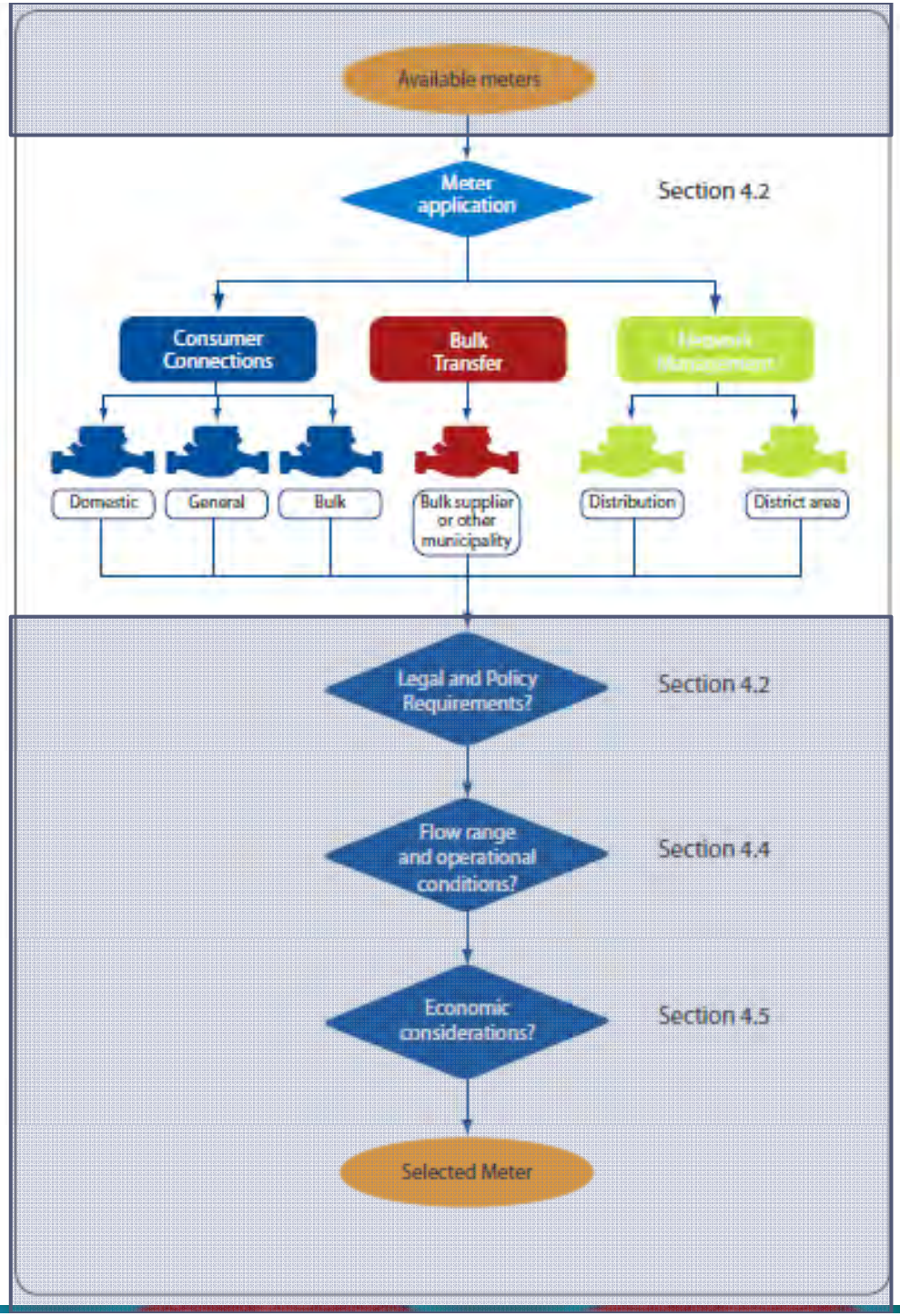
Meter sizing is very important

- 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?


Available meters
Meter application
Section 4.2
Consumer Connections
Bulk Transfer
Domestic
General
Bulk
Bulk supplier or other municipality
Distribution
District area
Legal and Policy Requirements?
Section 4.2
Flow range and operational conditions?
Section 4.4
Economic considerations?
Section 4.5
Selected Meter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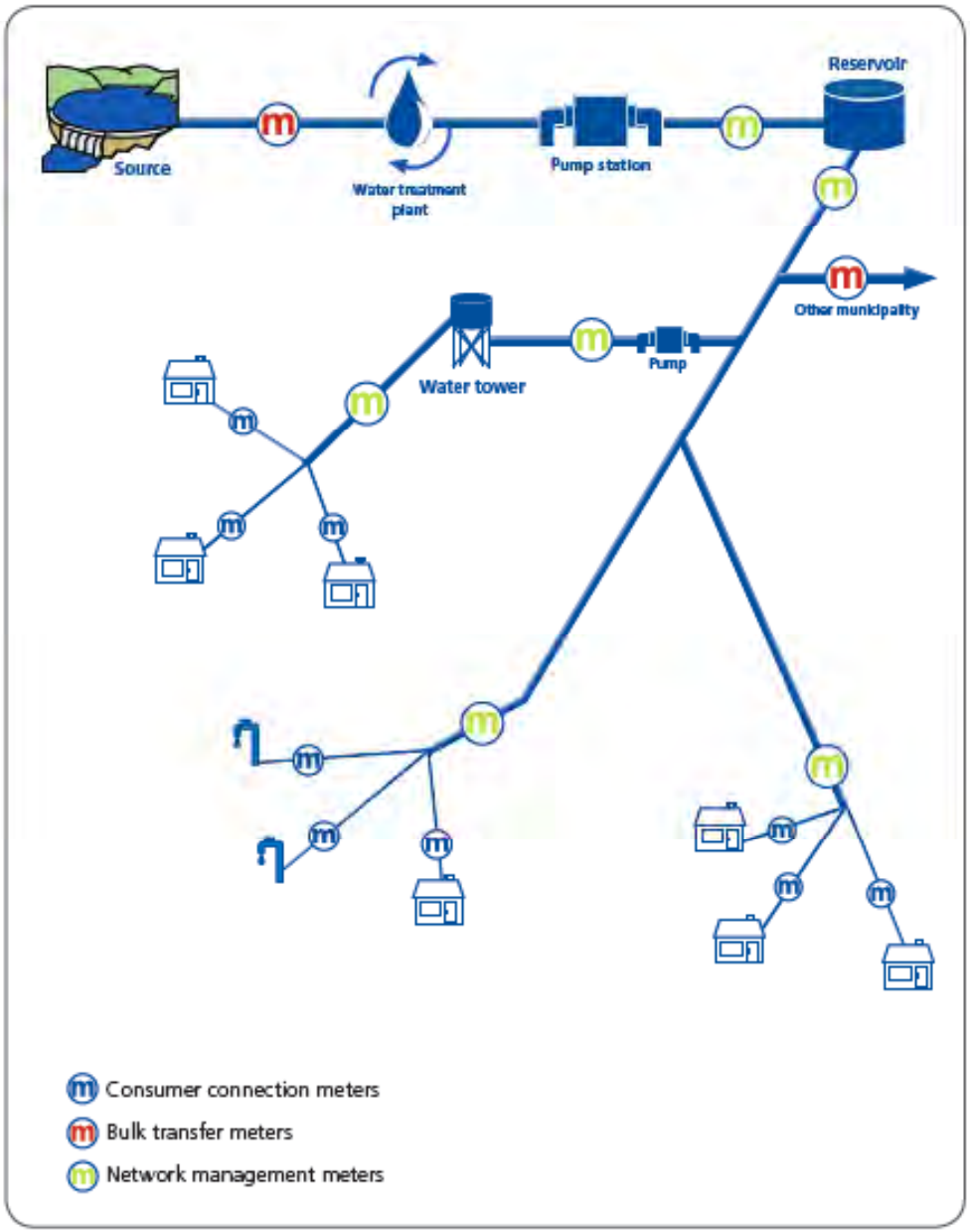
Selected Meter

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

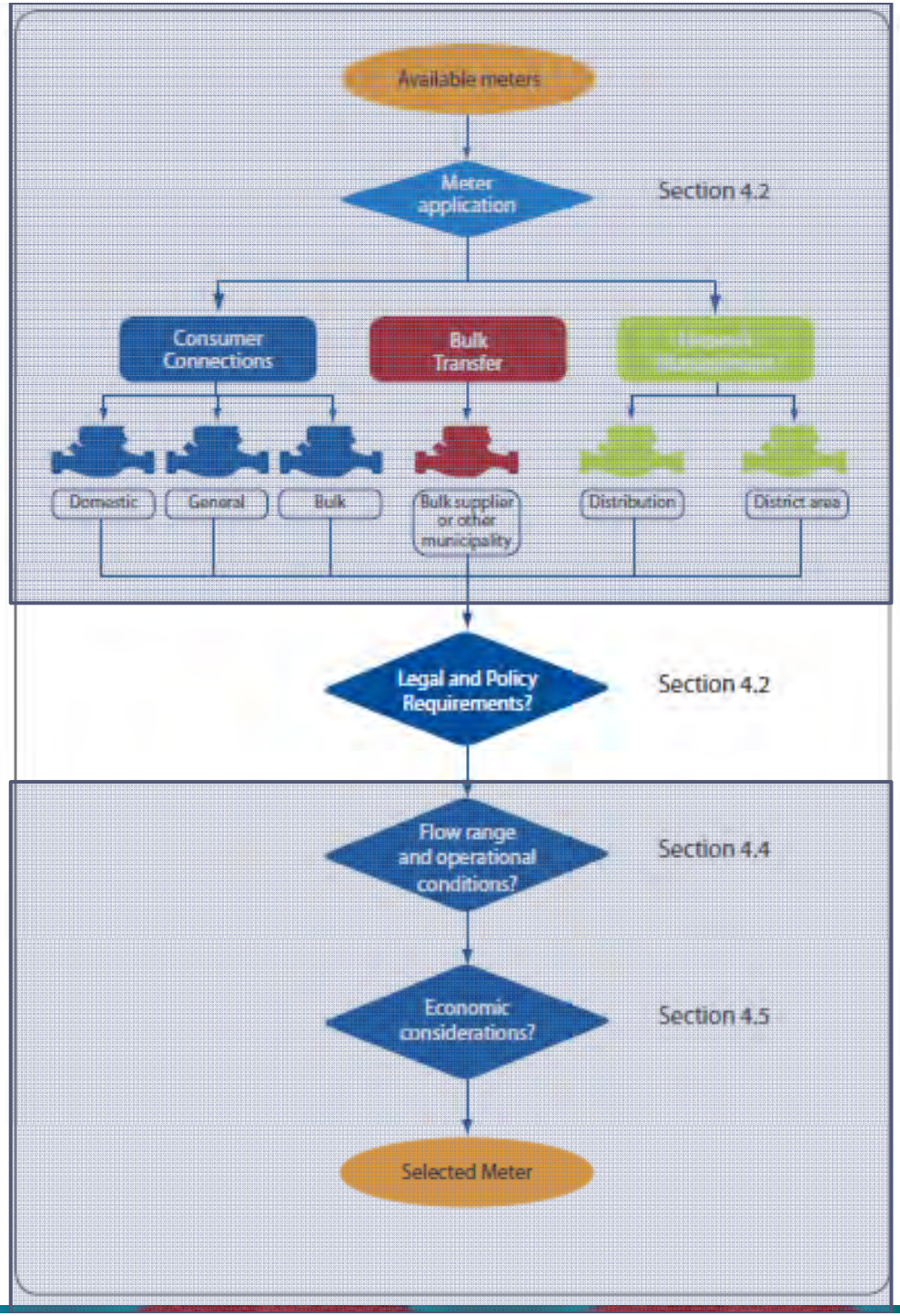
- Cash register – important!
- Even use where payment for water does not exist or isn't linked to consumption.
- Two categories: Small and Large
- Small connections (≤ 25 mm)
  - Domestic and low consumption ICI
  - Standard procedures for domestic consumers
  - On-site leakage often occurs on these 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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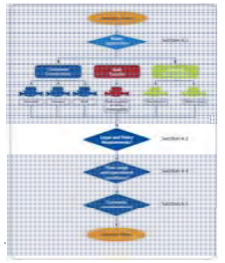
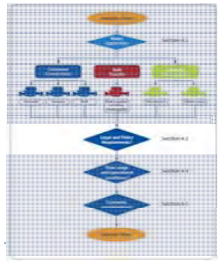
Legal and policy requirements

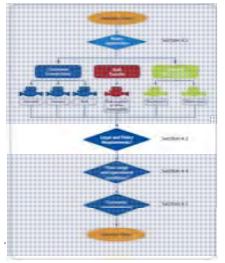


- National legislation requires consumer meters to comply with SANS 1529 – non negotiable.
- SANS 1529 tests include
  - Type approval
  - Initial verification
  - Individual meter verification
- SABS approval number must be shown on meter body
- Each consumer meter sold in SA must be verified by accredited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

Meter seals



Policy requirements



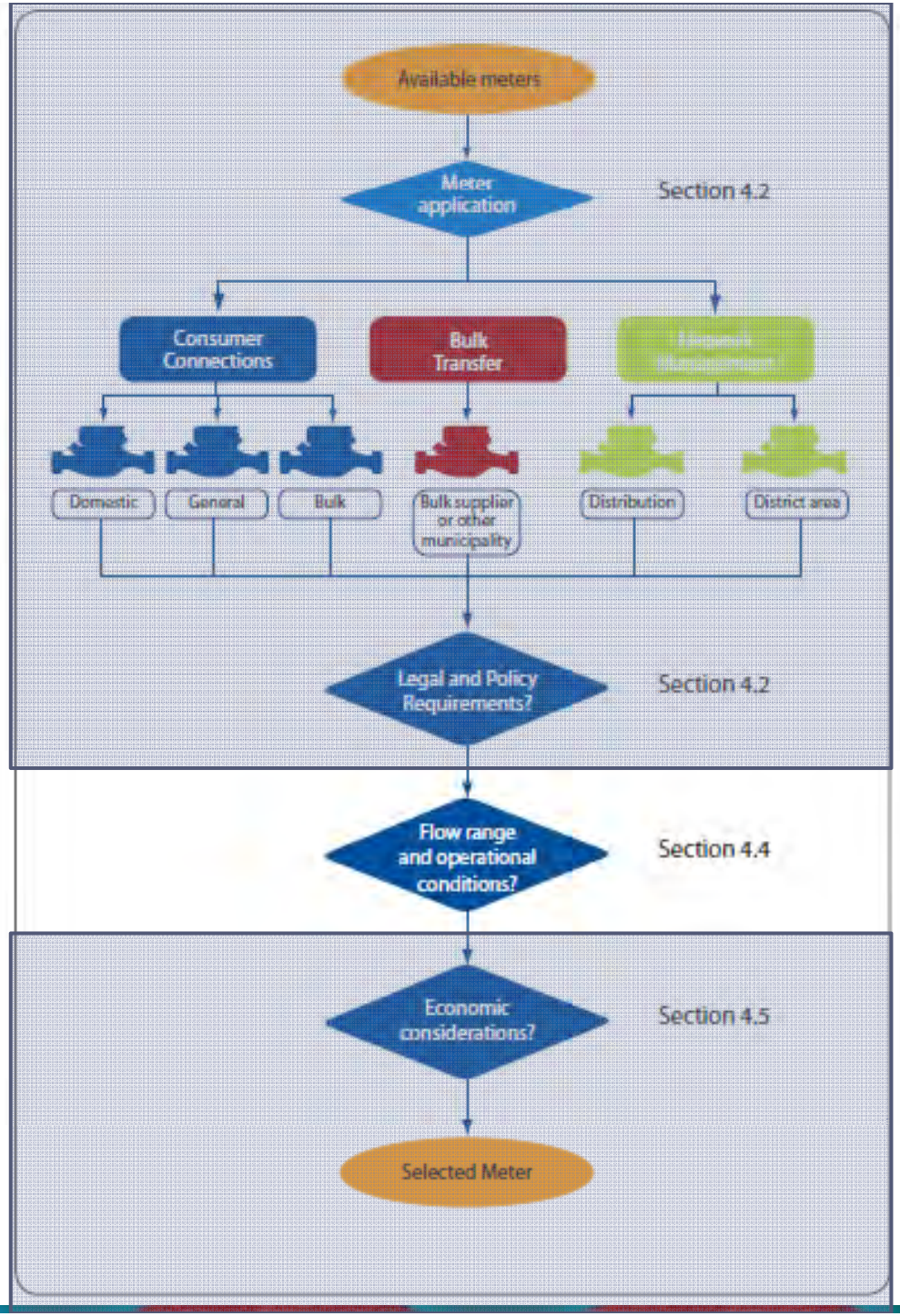
- Each municipality is unique and should develop its own policies on water metering based on local conditions
- Policy may include
  - Meter classes for different applications
  - Types of meters for different applications
  - Preferred and prohibited meters
  - Minimum installation requirements
  - Logging requirements

Example: Tshwane's list of allowable and preferred meter types for different applications.

Application	Typical meter size range (mm)	Allowable meter types (preferred meter type in bold)
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)

Meter			Application
Size (mm)	Type	Flow range (L/min)	
15	Positive displacement	1 – 55	Single family, duplex, small business (up to 10 staff)
20	Positive displacement	2 – 110	Large residences, homes with irrigation systems or swimming pools, flats with up to 6 units, petrol station without car wash, churches, small institutional users.
25	Positive displacement	3 - 185	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).
38	Positive displacement	5 - 375	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.
50	Woltmann WP	7 - 600	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.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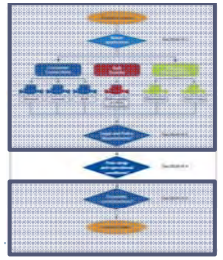
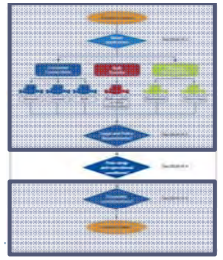
Economic considerations?
Section 4.5
Selected Meter

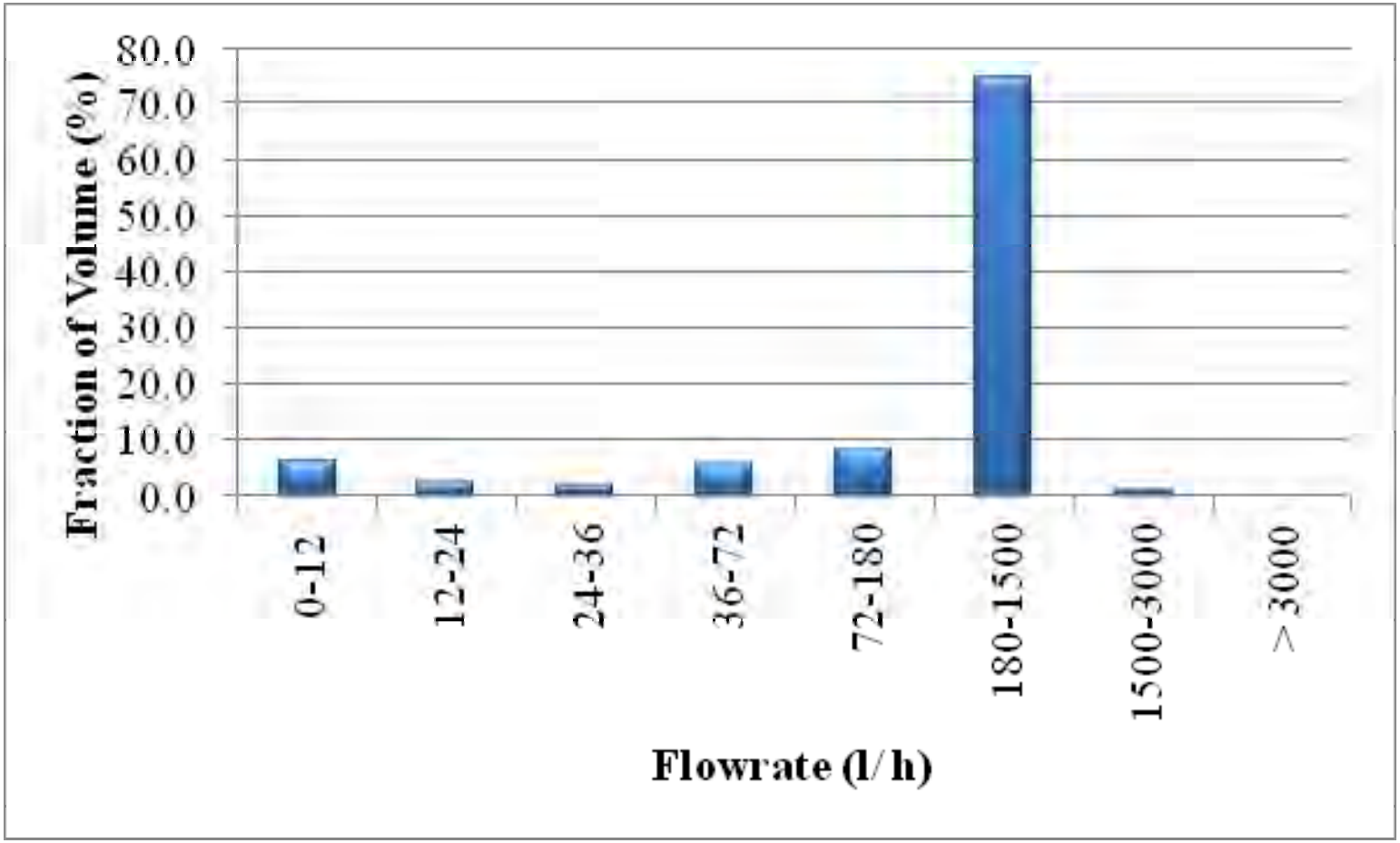
Flow range and operating conditions



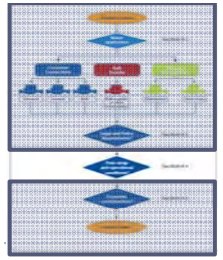
- Flow range determined by user characteristics
- Can be measured, but don't log old meter that may have large errors
- Consider type of user, application of water, number of units served, number of employees, etc.
- Look at similar users
- Consider annual average demand and seasonal and diurnal patterns.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

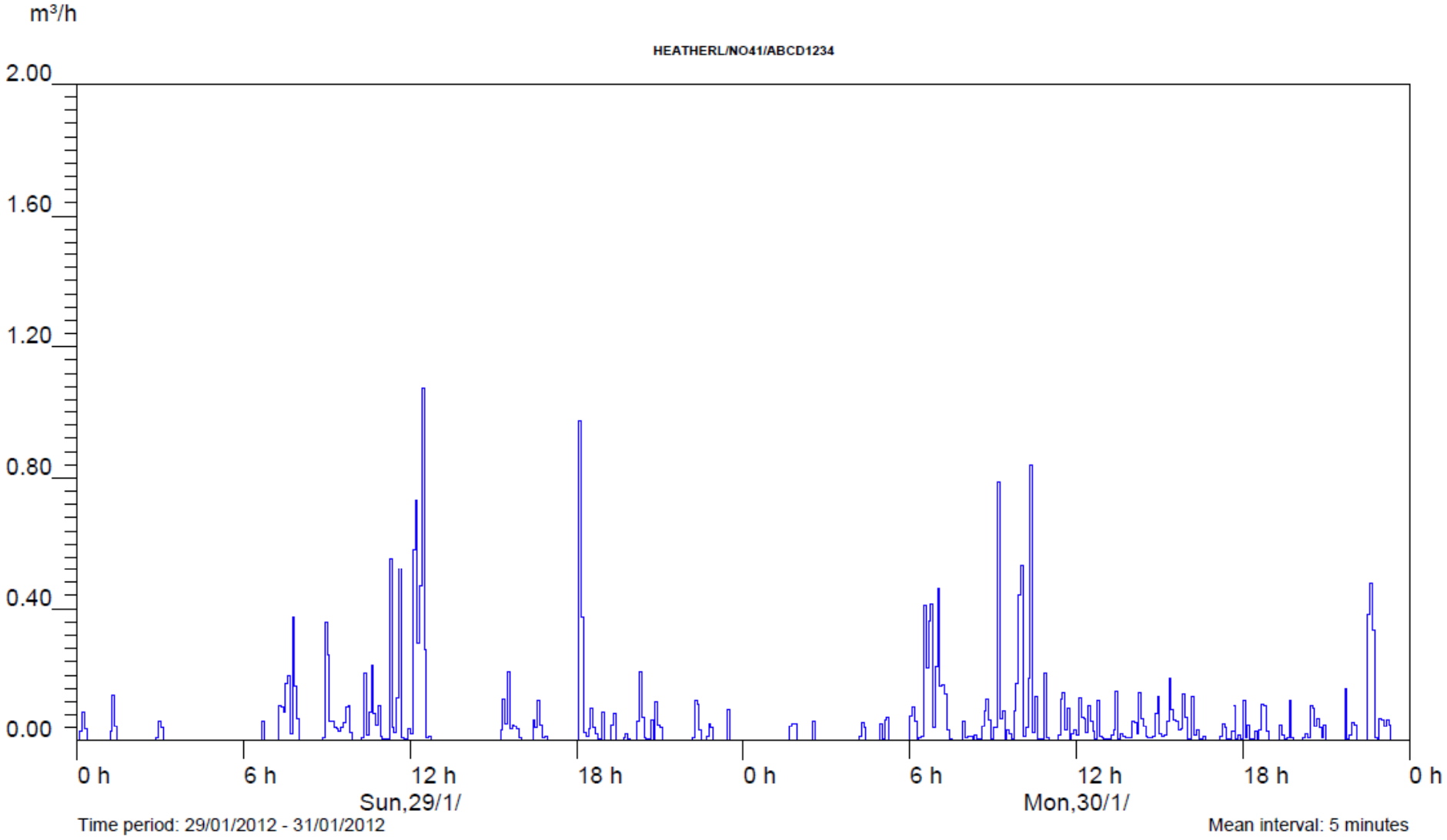
Typical domestic demand distribution



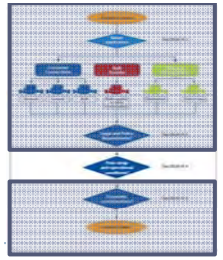


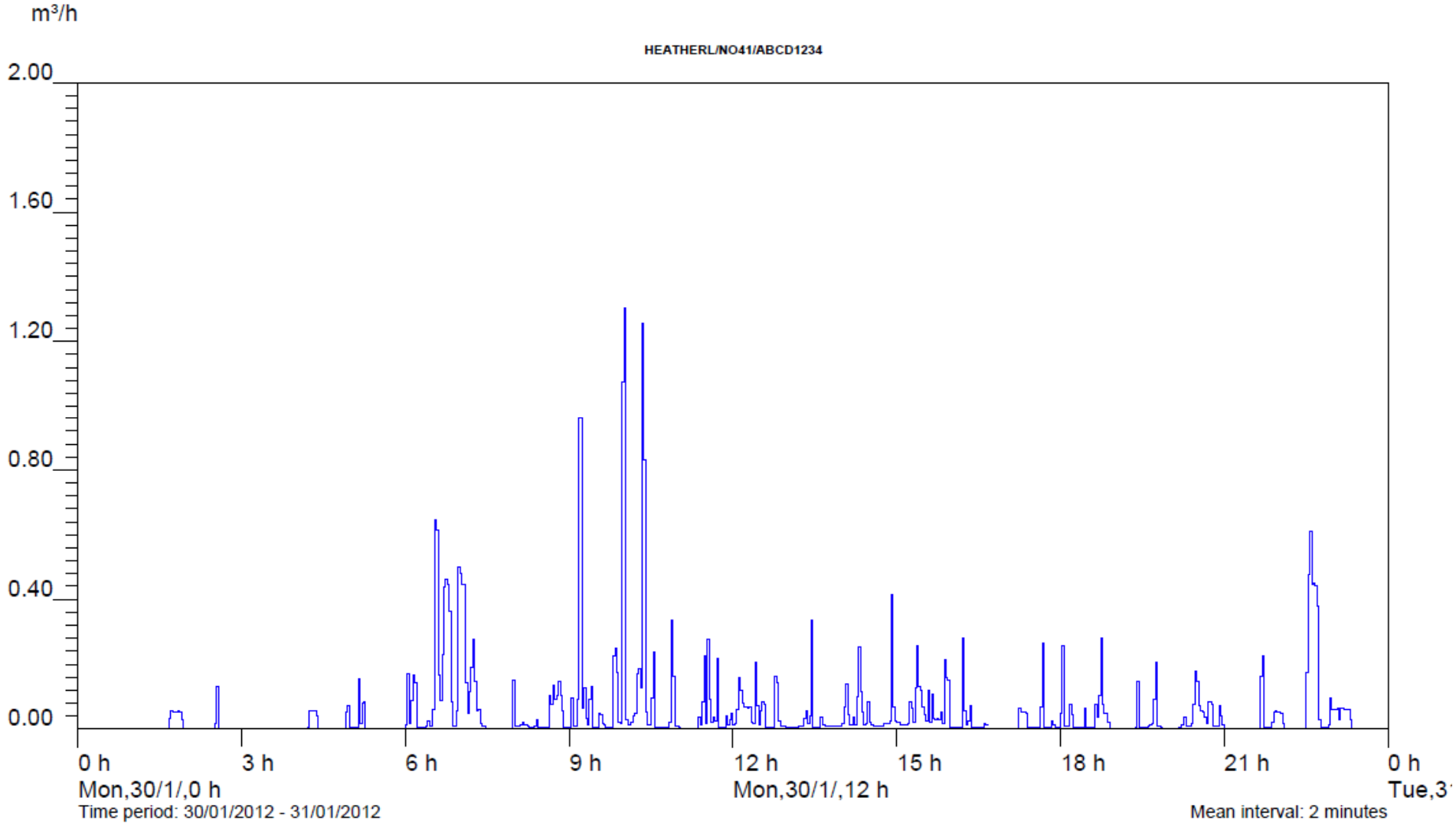
Typical Domestic Water Consumption



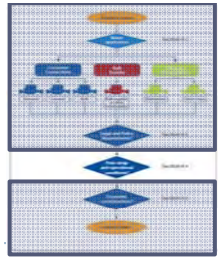


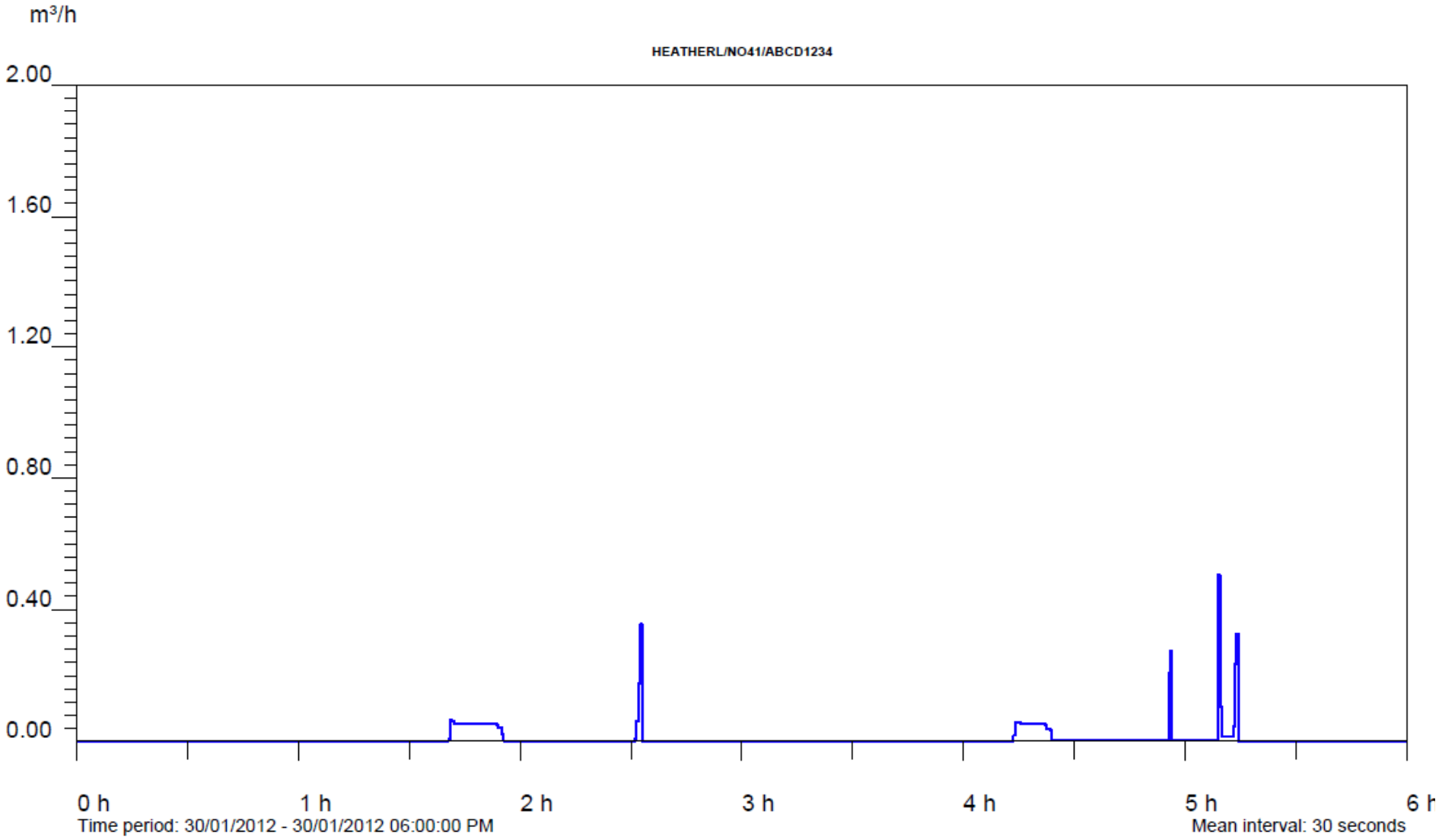
Consumption on Monday, 31 Jan 2012



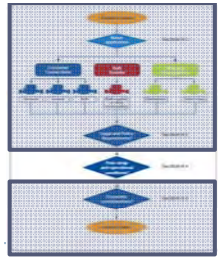


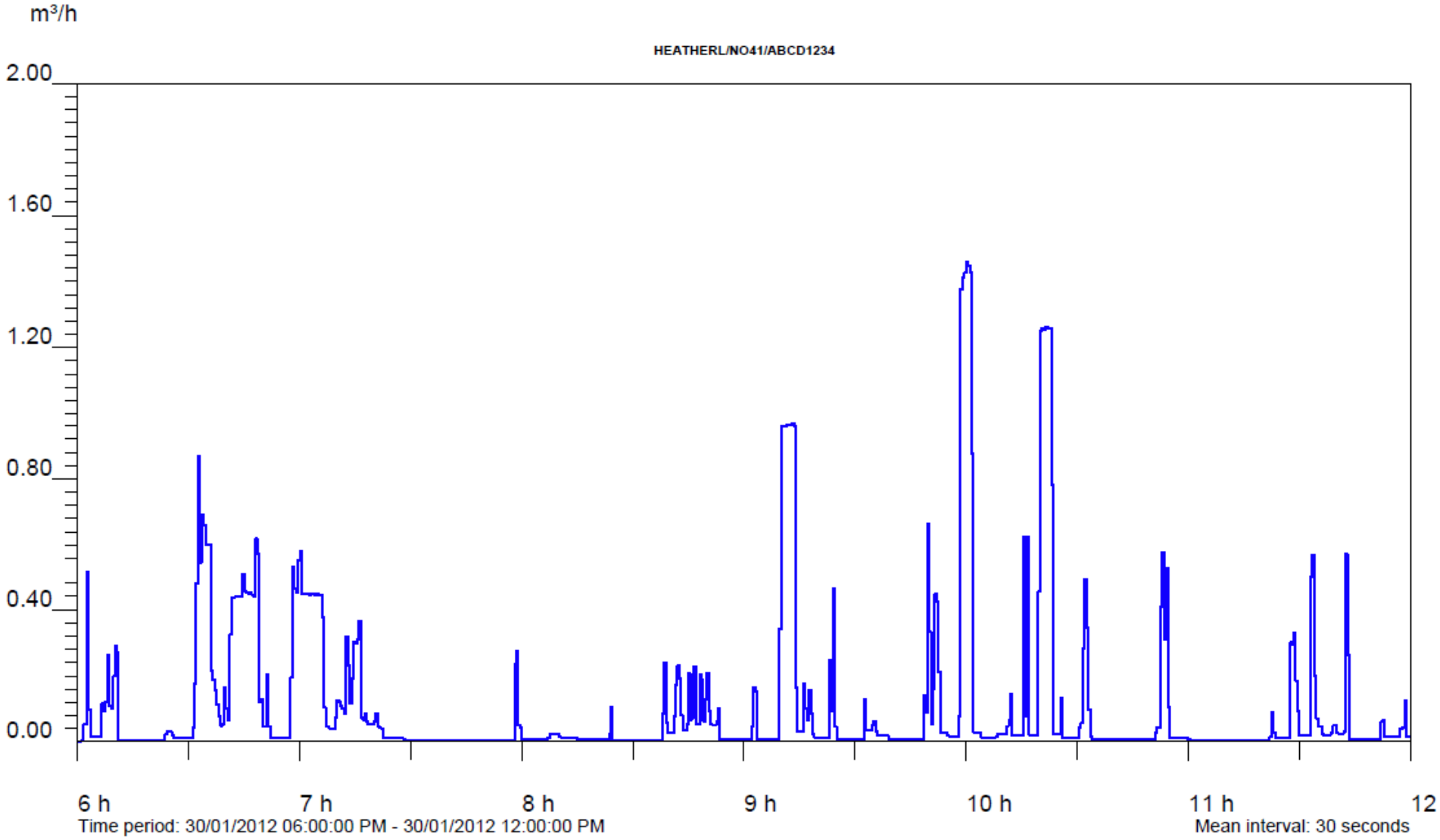
Consumption between 0:00 and 6:00



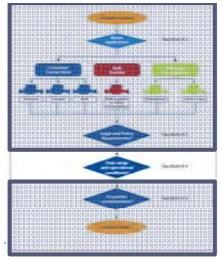


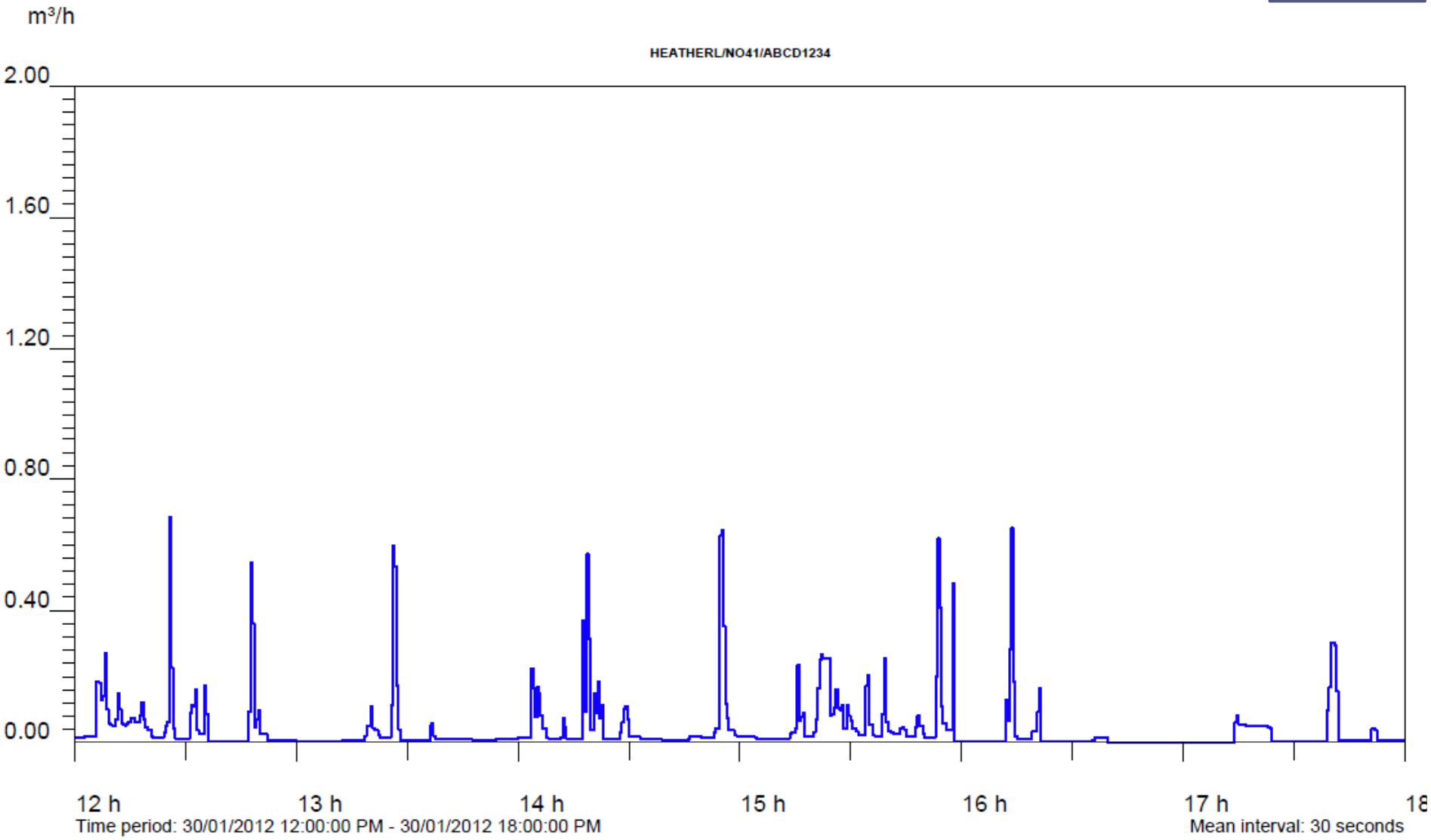
Consumption between 6:00 and 12:00



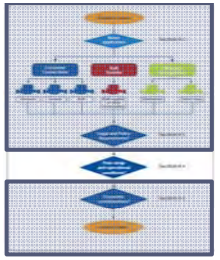


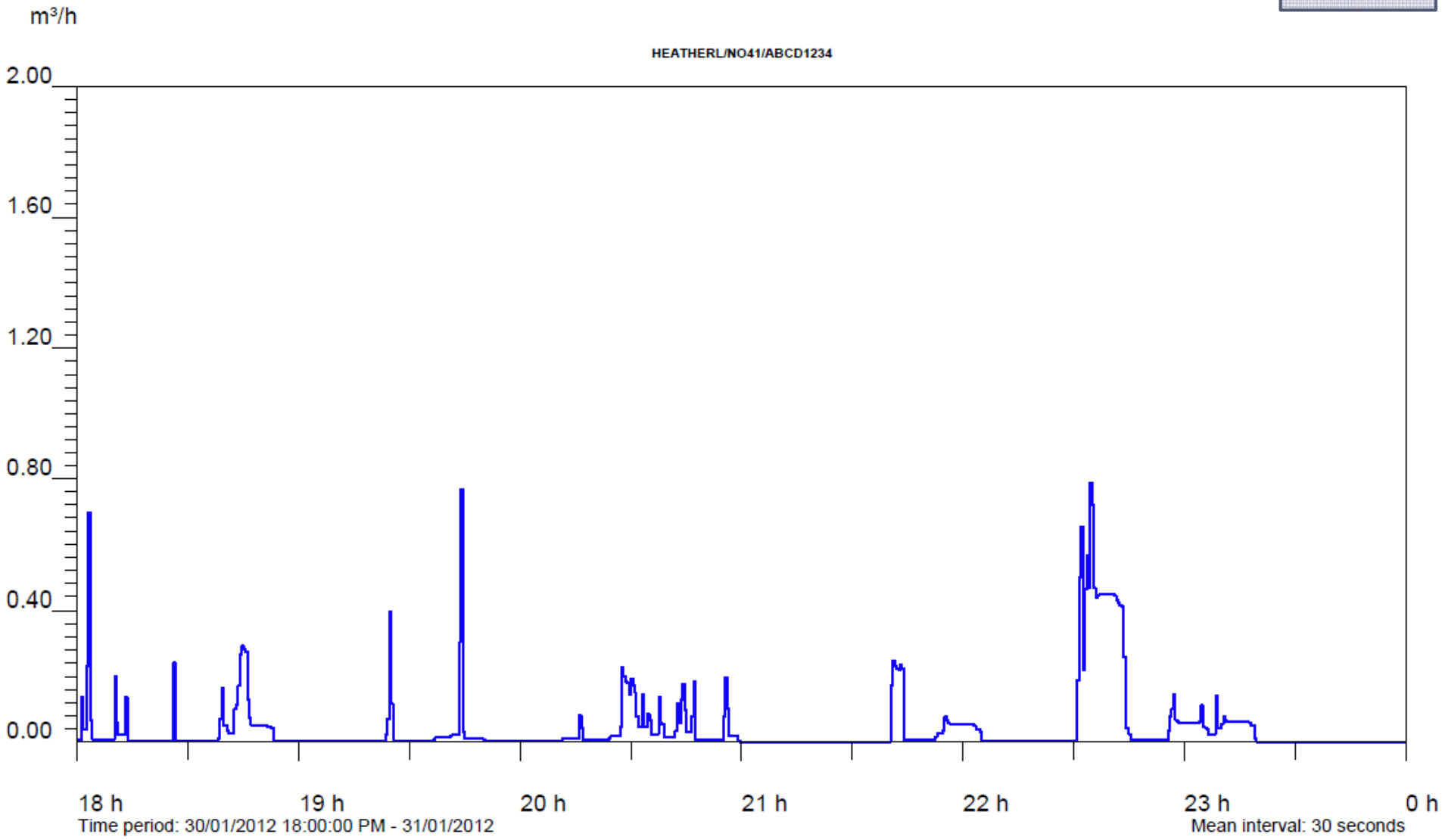
Consumption between 12:00 and 18:00



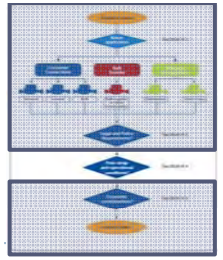


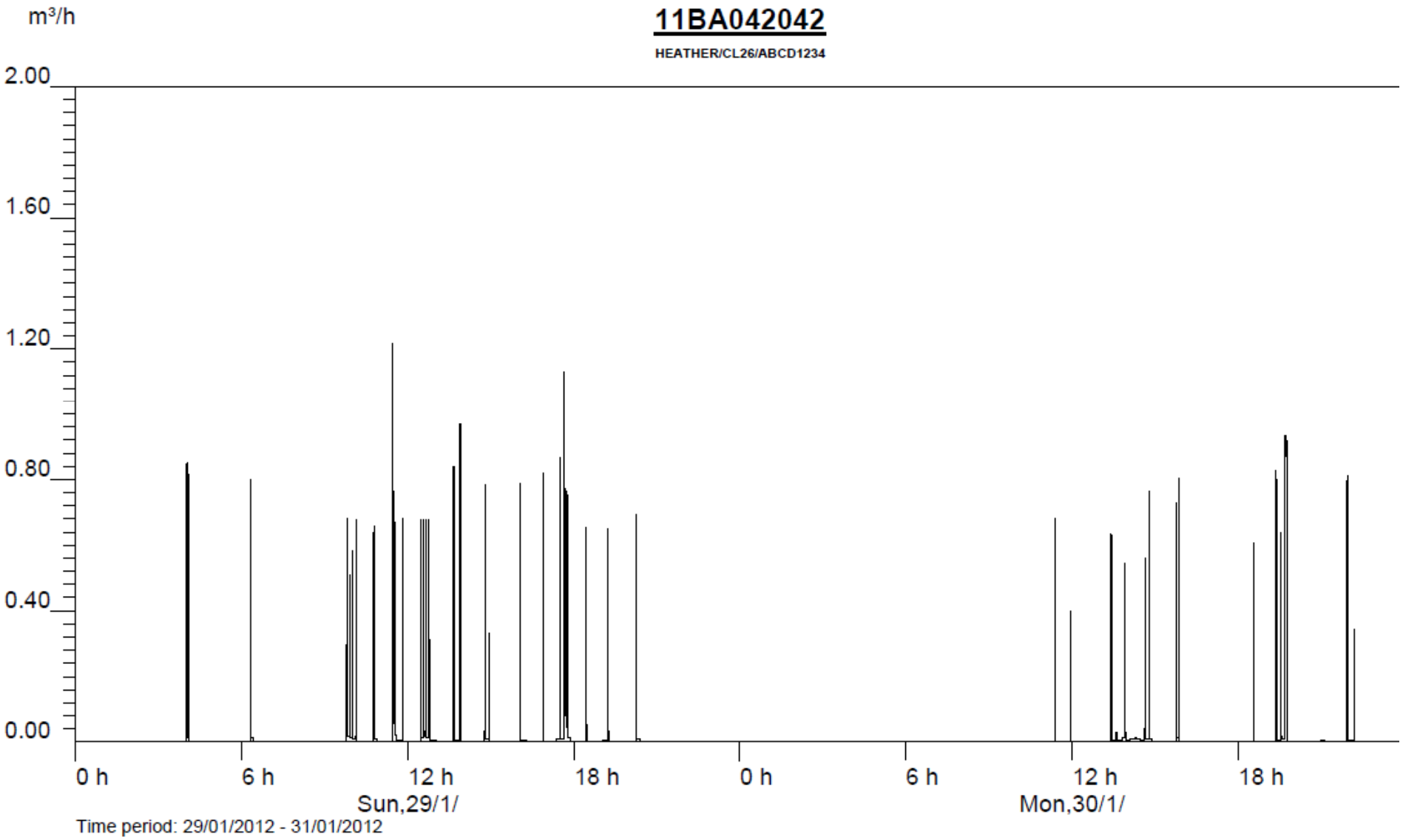
Consumption between 18:00 and 24:00



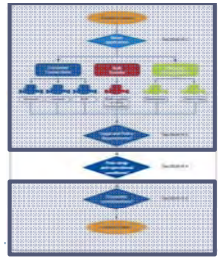


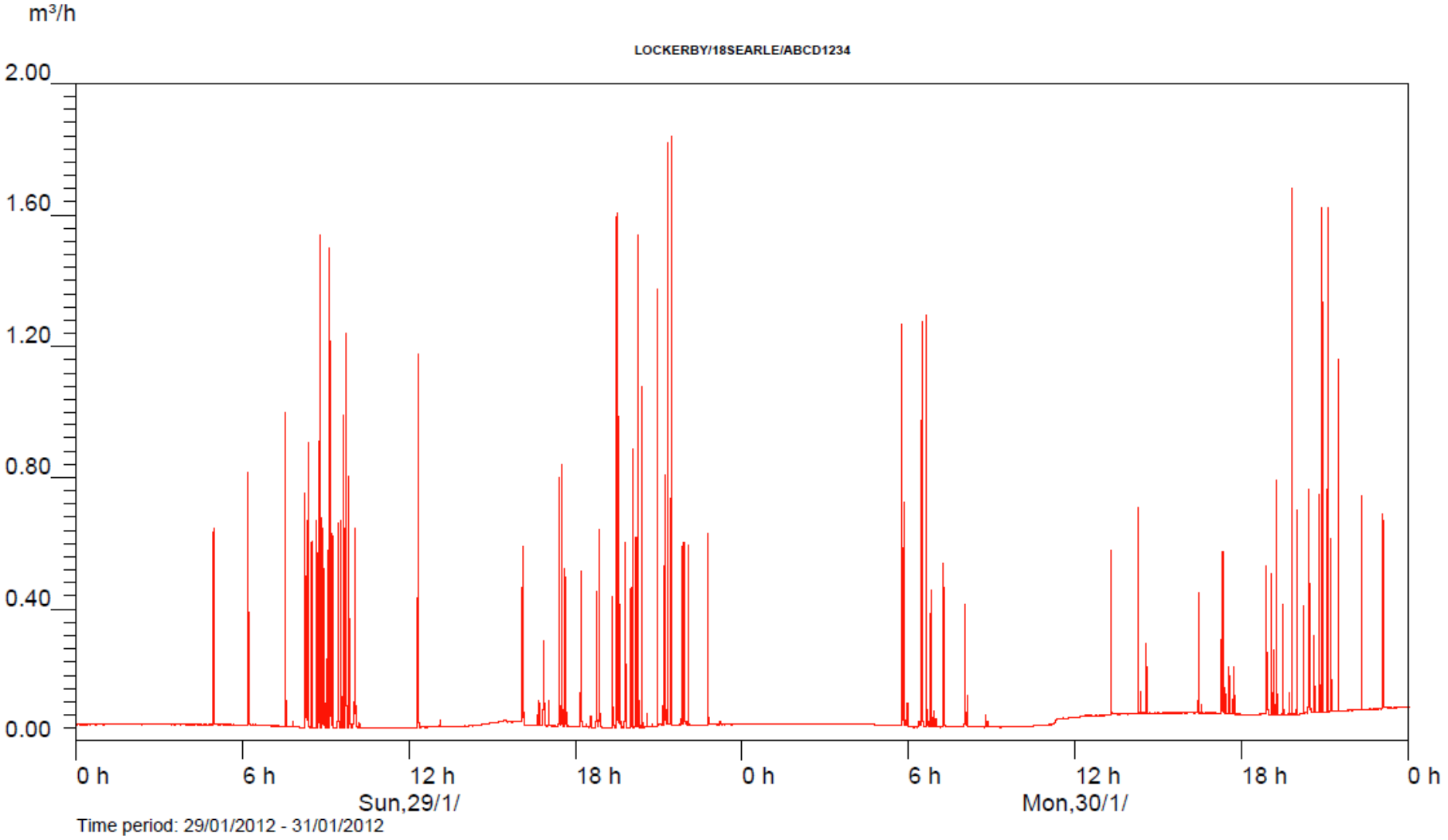
Domestic consumption (low frequency)



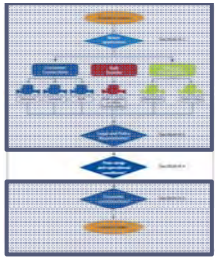


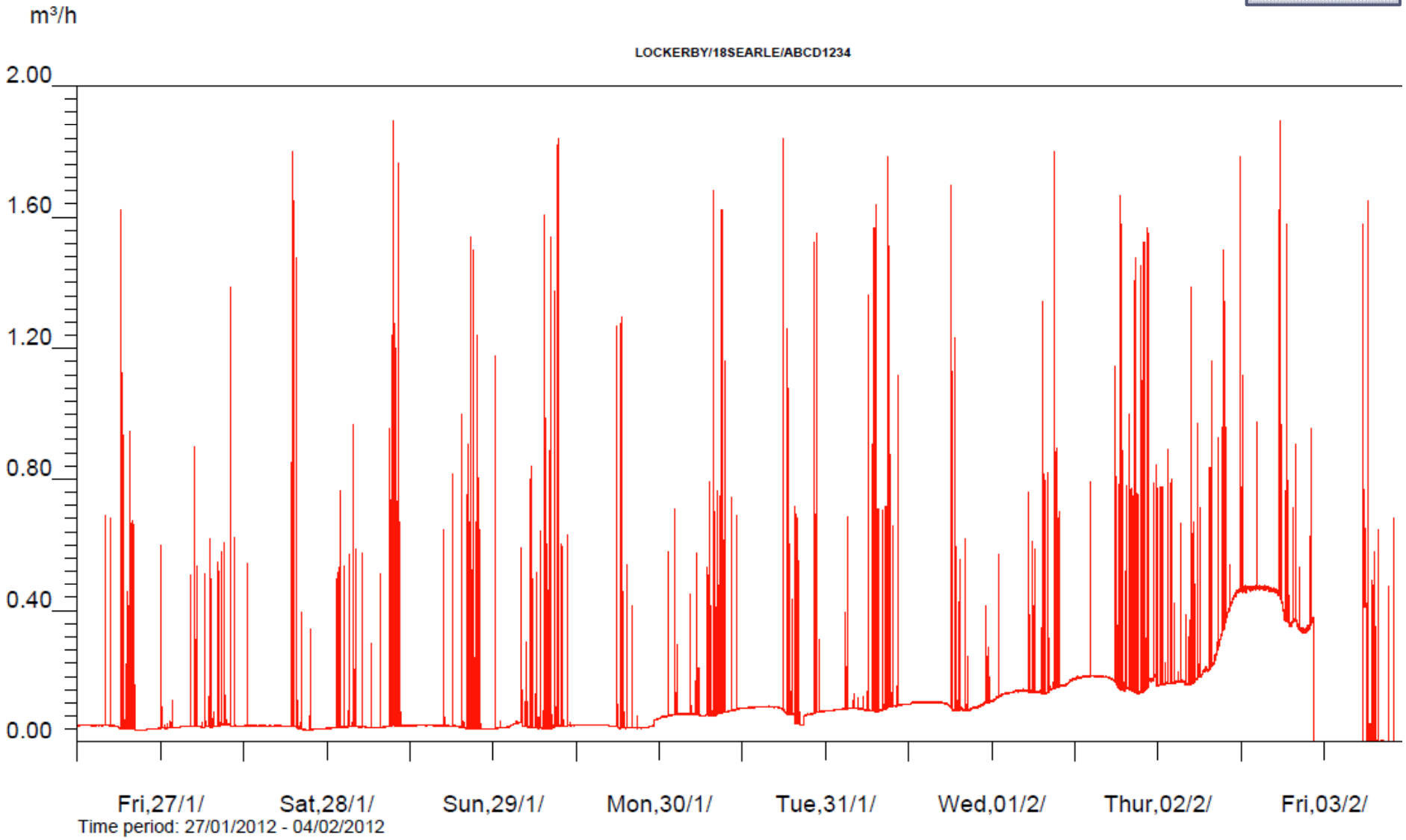
Domestic consumption with leakage



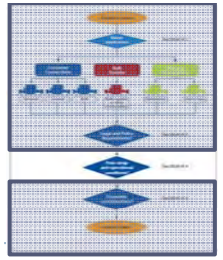


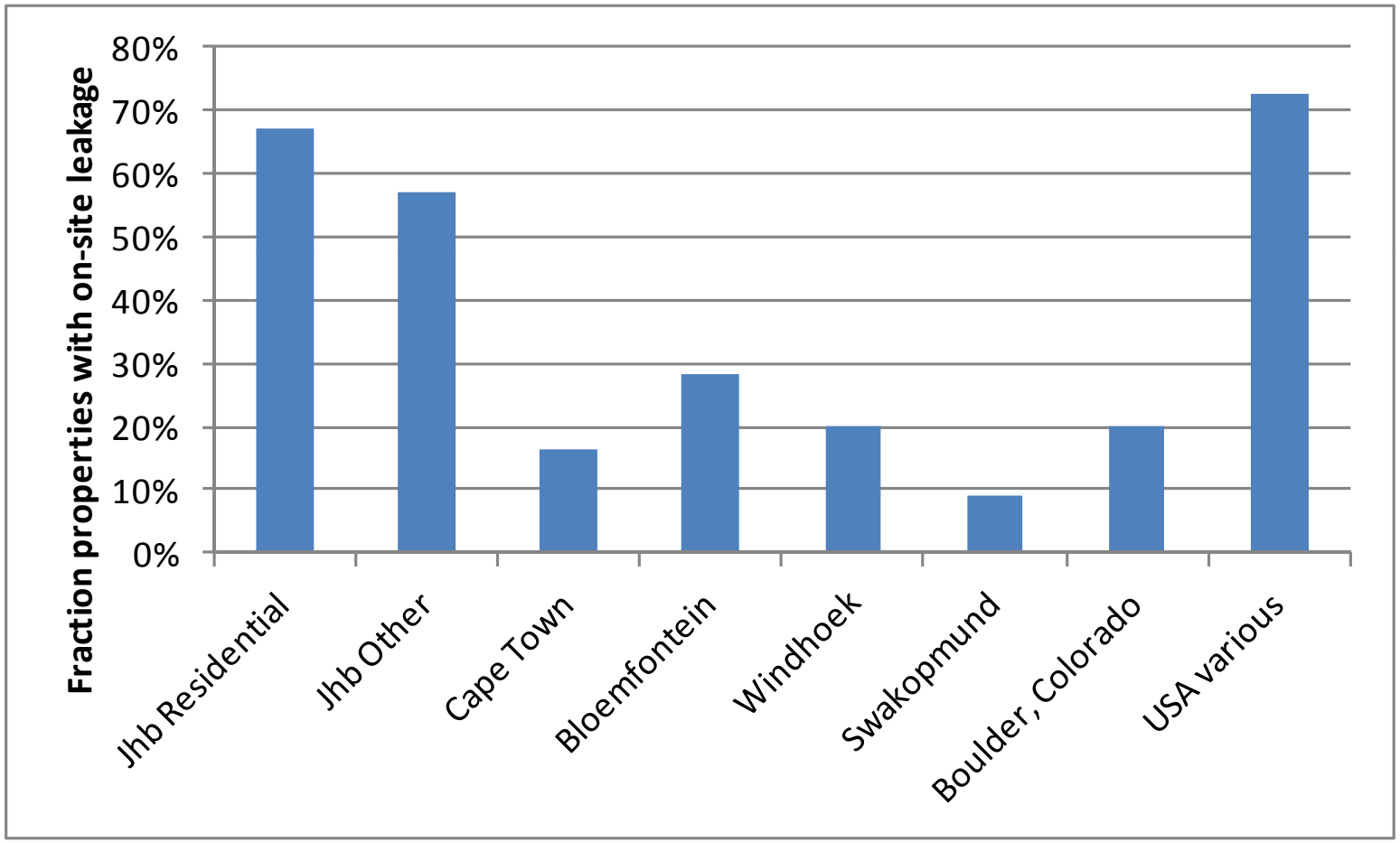
Leak development



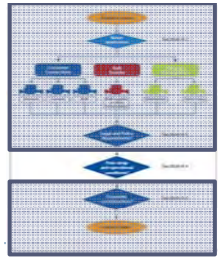


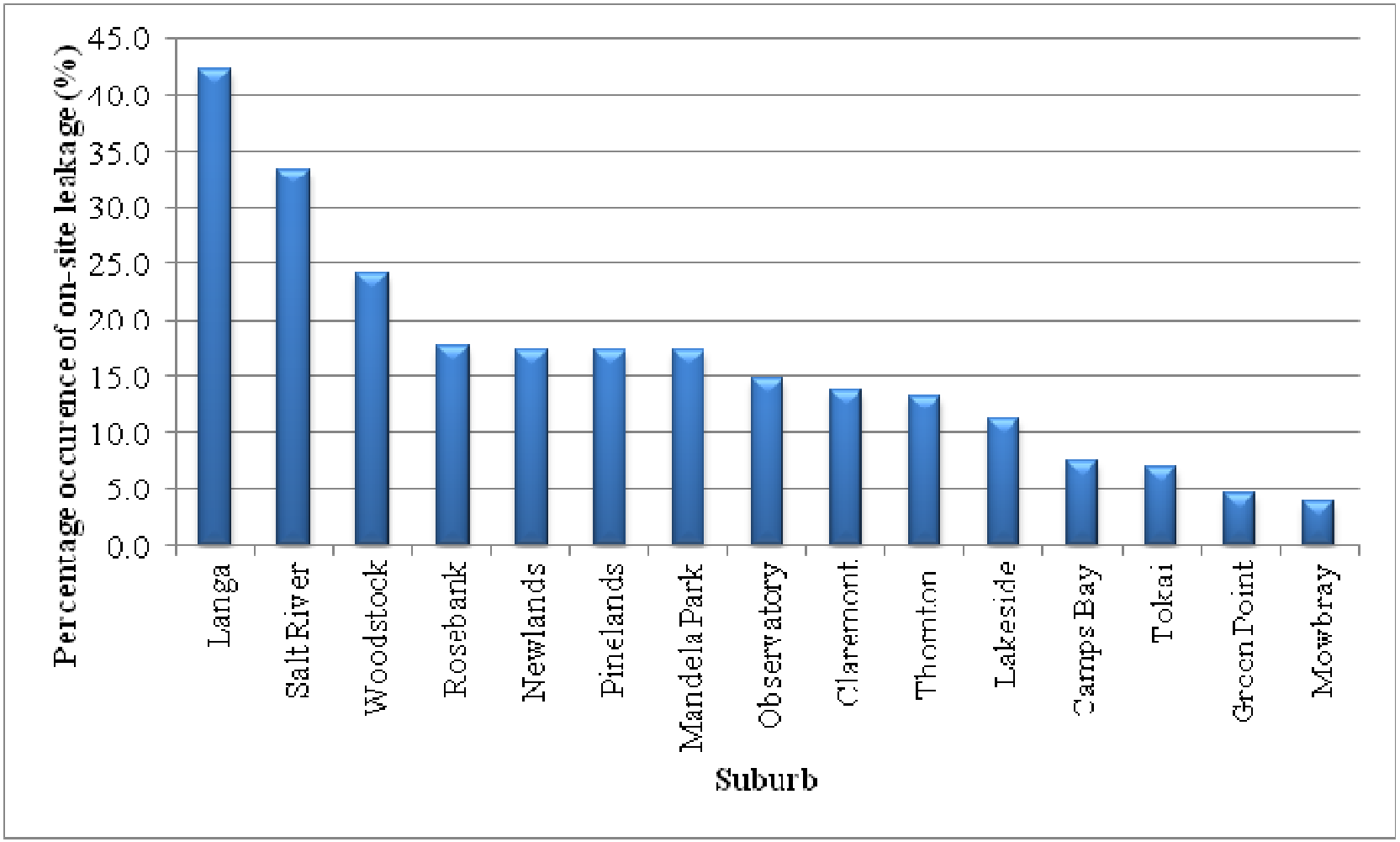
Occurrence of on-site leaks



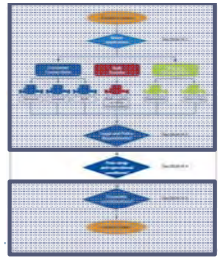


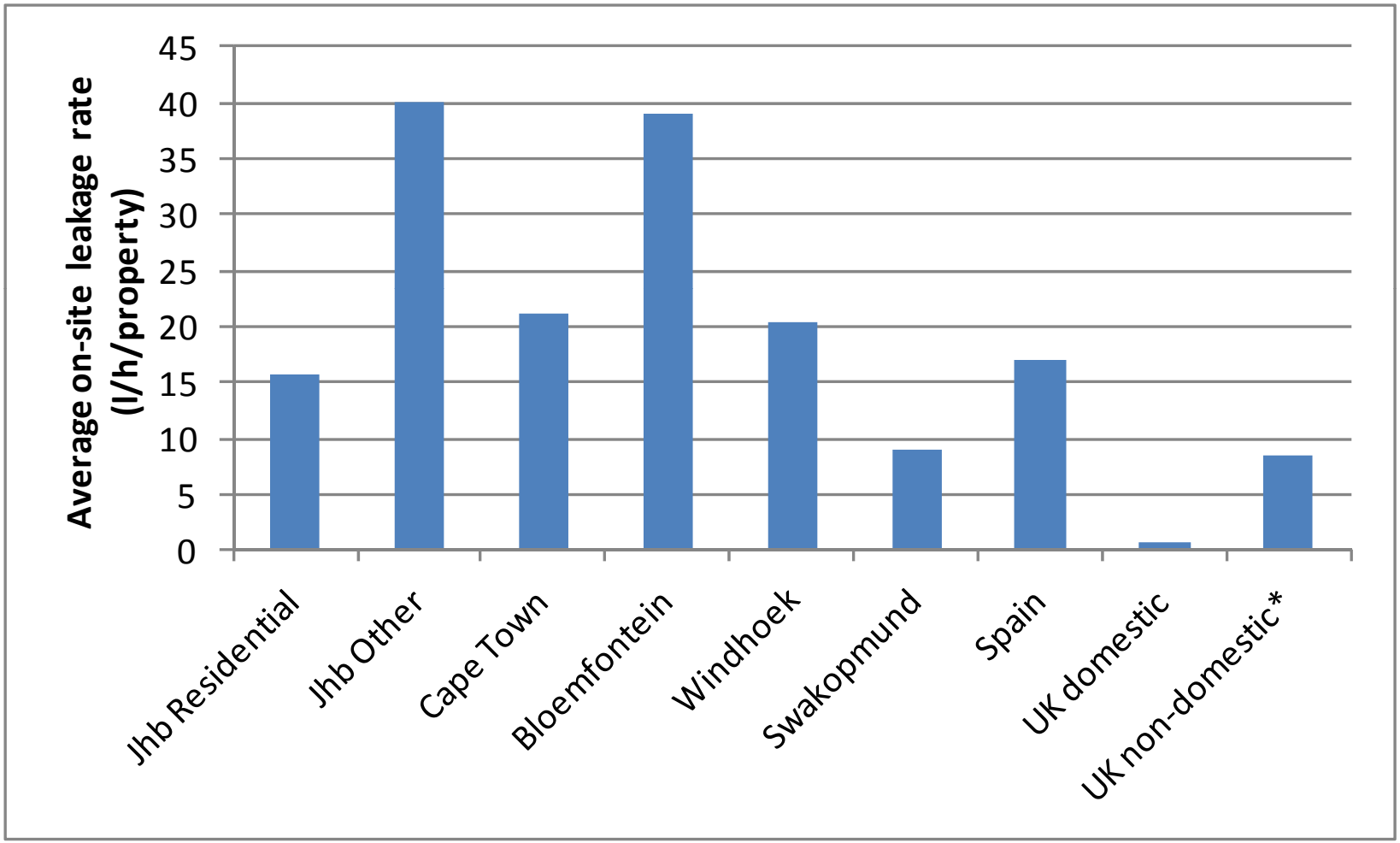
Occurrence of on-site leaks in CT



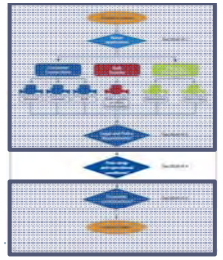


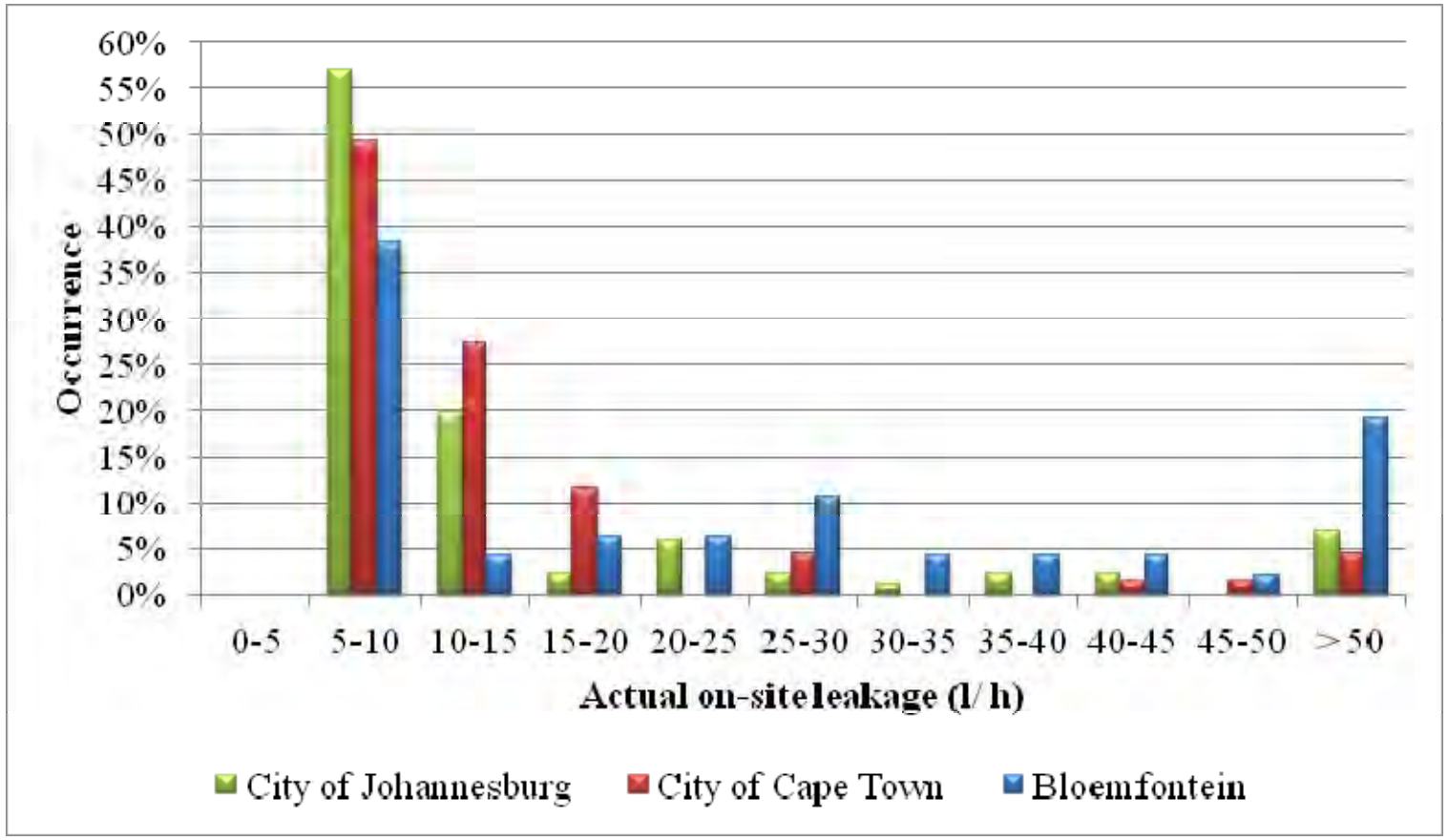
Mean on-site leakage rates



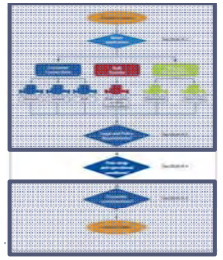


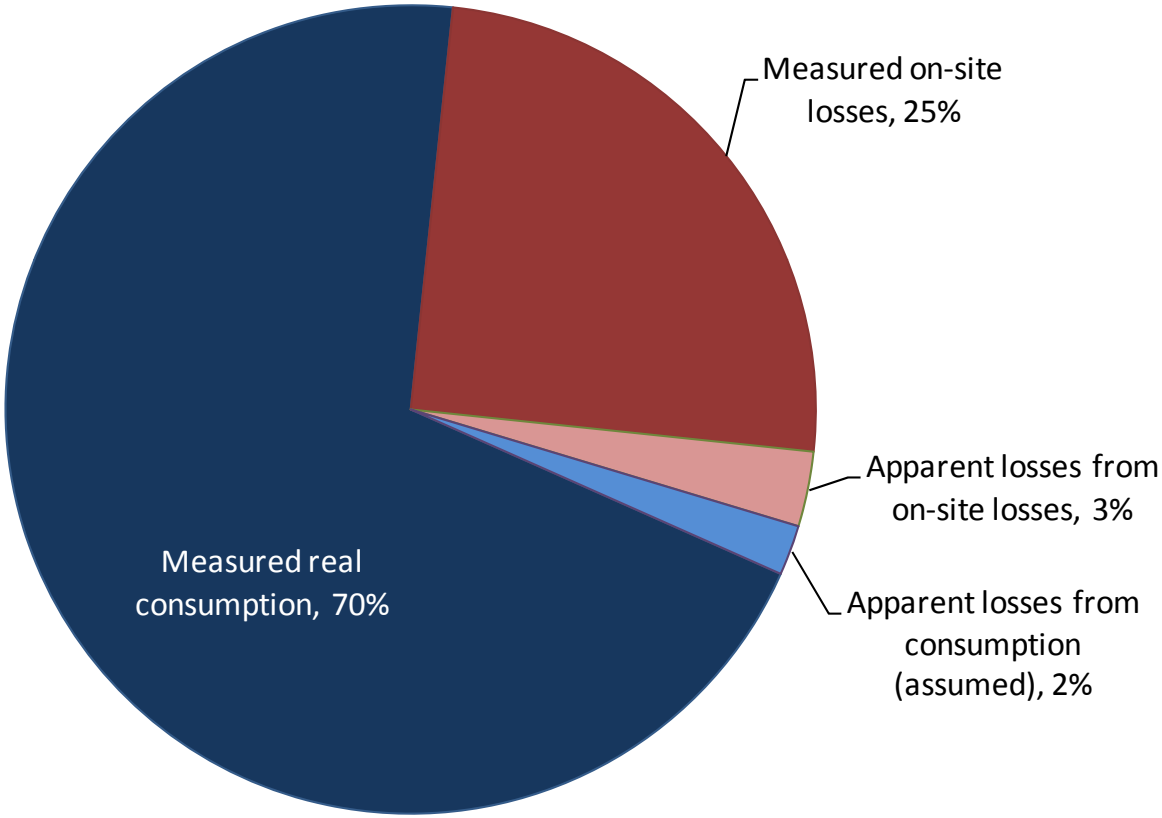
Distribution of on-site leakage rates



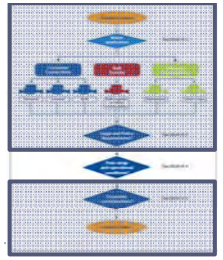


Consumption in Johannesburg



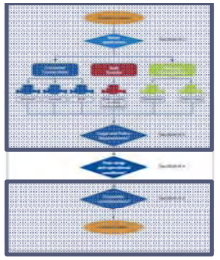


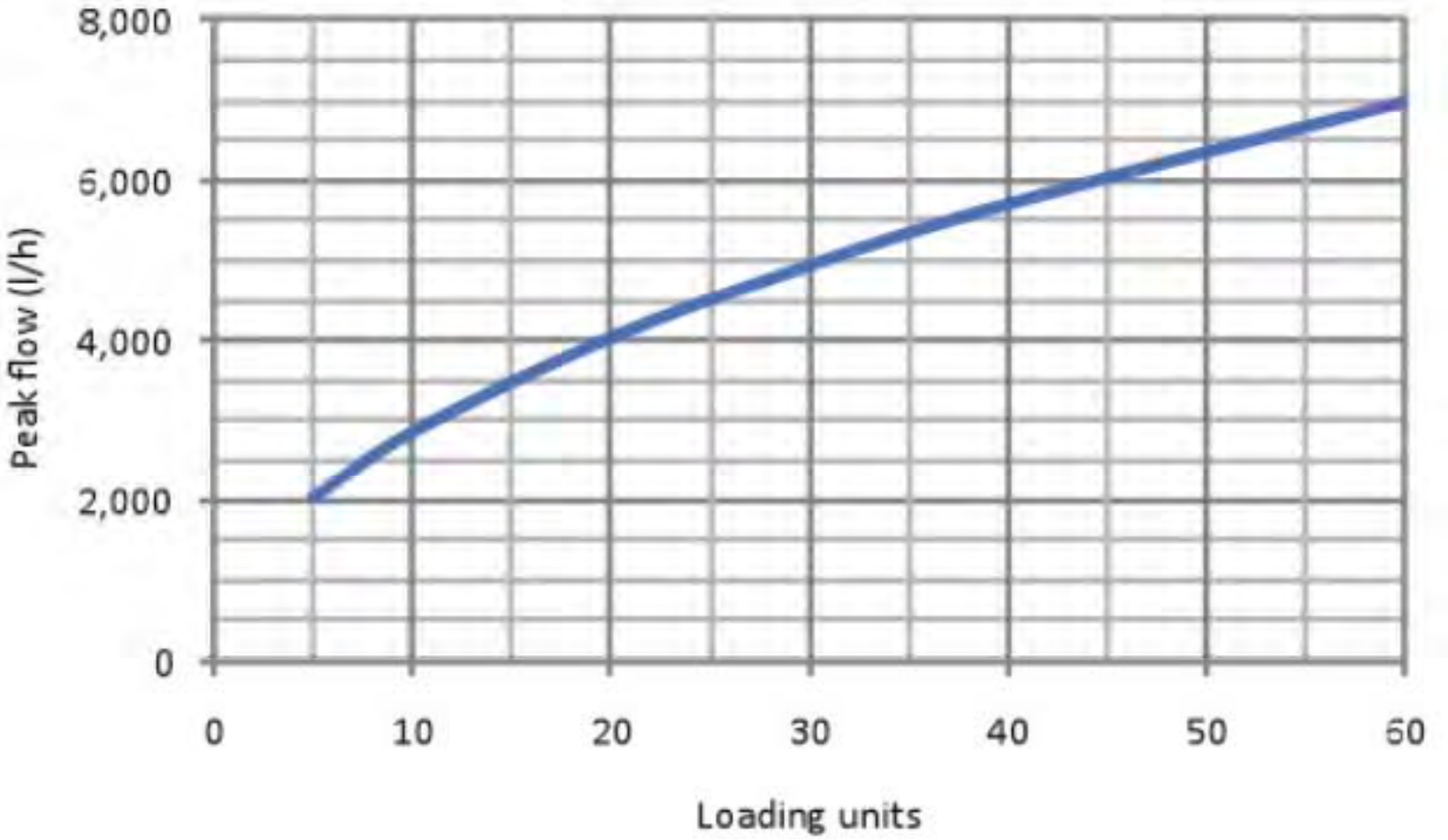
Estimate peak flow using loading units

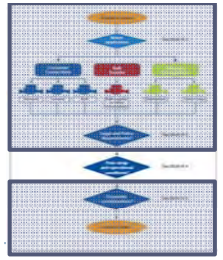


Fixture Type	Loading Units
Bath mixer	4.0
Toilet with cistern	0.3
Toilet with flush valve	16
Shower head	0.6
Sink mixer	0.6
Basin mixer	0.4
Bidet mixer	0.2
Washing machine	0.6
Urinal	0.2
15 mm tap	0.3
20 mm tap	1.0

Peak flow from loading units







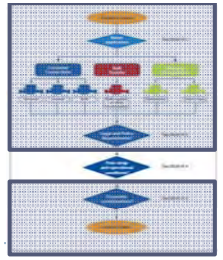
Example: Determining the peak flow through a meter based on fixture loading units

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:

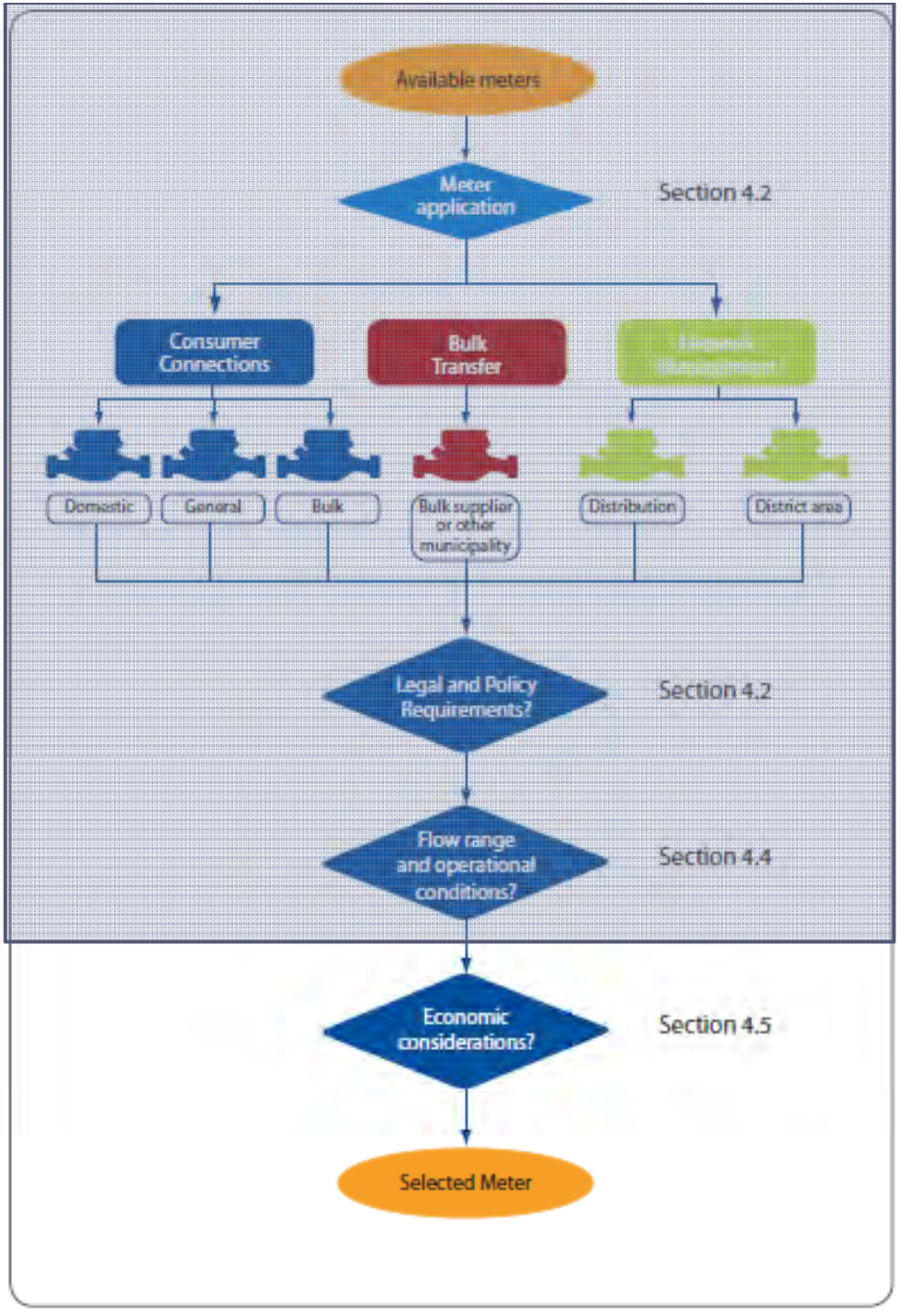
Fixture	Fixture loading units (from Table 4-2)	No of fixtures	Total fixture loading units
Bath mixer	4.0	1	4.0
Shower heads	0.6	2	1.2
Toilet with cistern	0.3	3	0.9
Wash basin mixer	0.4	2	0.8
Sink mixer	0.6	2	1.2
Washing machine	0.6	1	0.6
20 mm Garden tap	1.0	3	3.0
Total loading units for the house			11.7

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

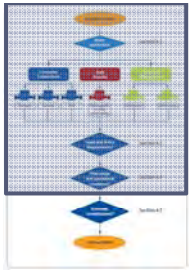
Operating conditions



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


Available meters
Meter application
Section 4.2
Consumer Connections
Bulk Transfer
Domestic
General
Bulk
Bulk supplier or other municipality
Distribution
District area
Legal and Policy Requirements?
Section 4.2
Flow range and operational conditions?
Section 4.4
Economic considerations?
Section 4.5
Selected Meter

Economic considerations

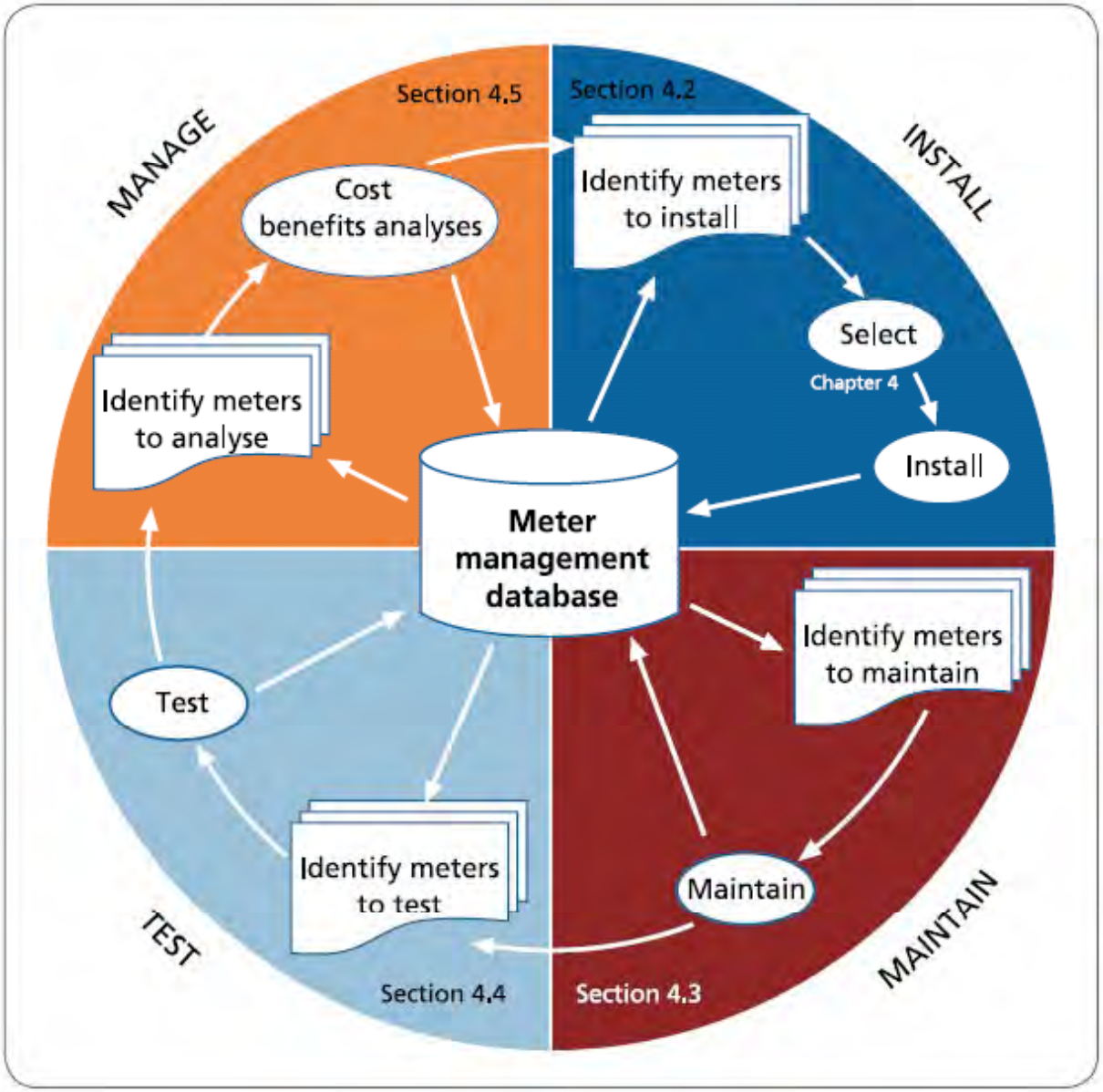


- Consider various of meter over its lifetime
  - Price of meter
  - Installation cost
  - Expected service life
  - Cost of meter under-registration
  - Water price
  - Lost sewage charge
  - Maintenance costs
  - Operational costs
  - Meter reading costs

Getting the Most out of Meters: Operation and Maintenance

Integrated Water Meter Management

Meter management process



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

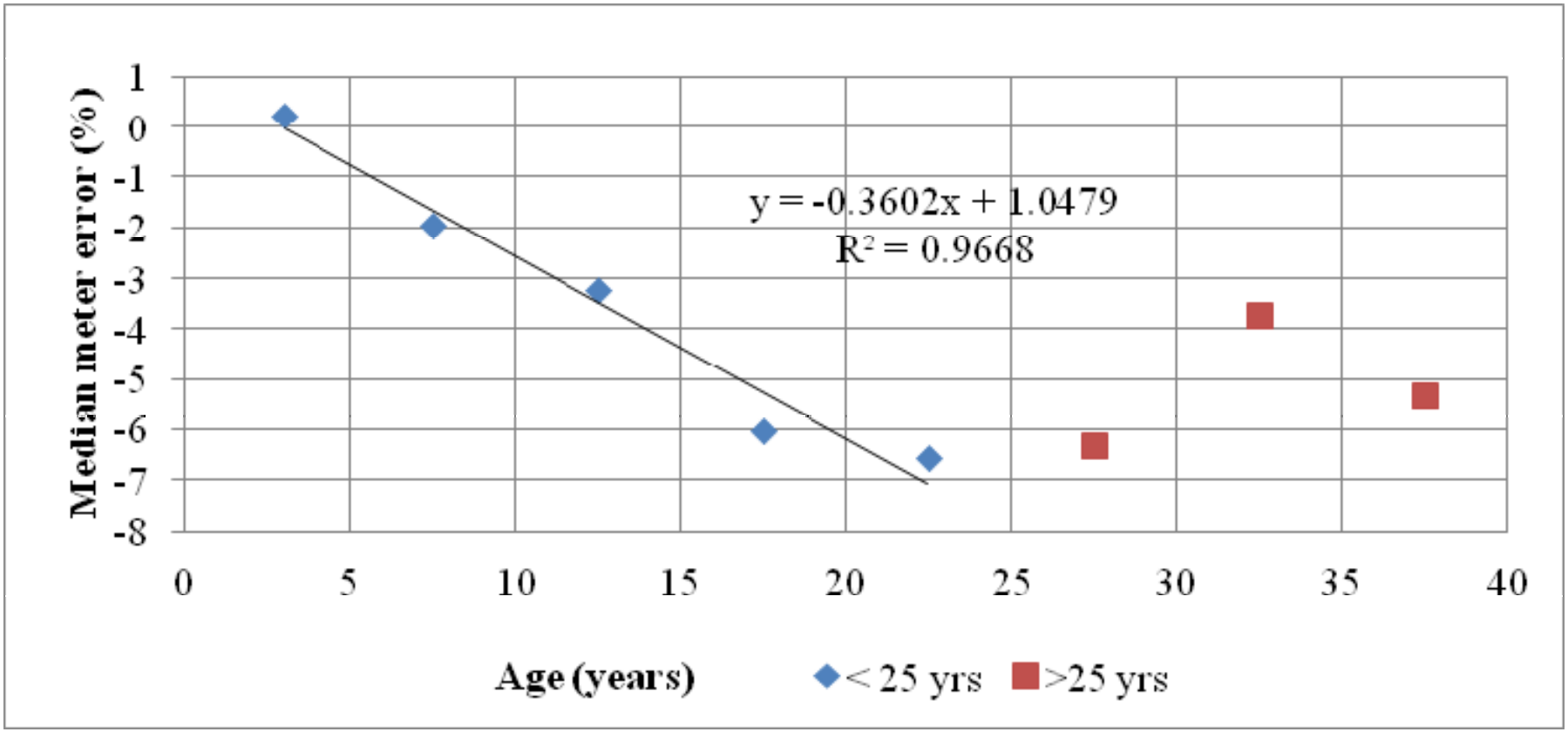
Maintenance

- 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

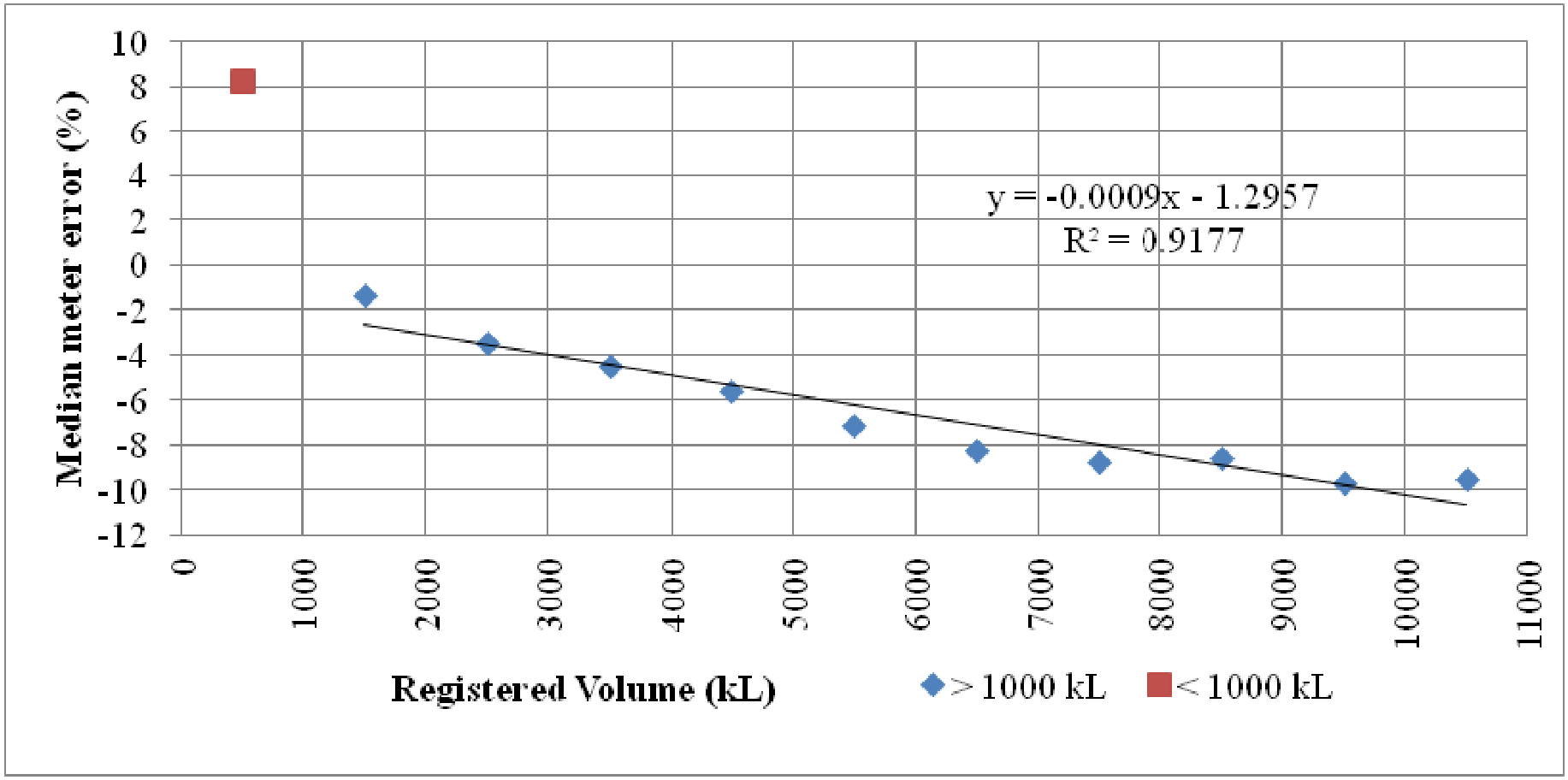
Meter testing

- 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)



Median domestic meter error in CT (volume)



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

Field	Item	Comments
1	Account number	A unique account number.
2	Stand ID	A unique identification number for the stand, often made up of the Town, Suburb, Stand, Portion and Sub portion.
3	Stand number	The registered number of the stand.
4	Stand portion	Portion a stand is divided into more than one portion.
5	Ward	Number of the ward the stand is situated in.
6	Area Code	A code indicating which area of the town the stand is situated.
7	Suburb	The name or a code for the suburb the stand is part of.
8	GIS Code	Location of the stand
9	Owner's name	The stand owner's full name and title.
10	Physical address	The full street address of the stand.
11	Postal address	The owner's postal address.
12	Phone numbers	Fields for office, work, fax and cell phone numbers.

Required consumer fields (cont)

13	Land use	A code indicating the registered land use of the property, for instance residential or industrial.
14	Zone	A code indicating the zoning of the stand.
15	Value of land	Value of the stand from the valuation roll.
16	Value of improvements	Value of the stand plus buildings.
17	Stand size	The area of the stand in standardised units.
18	Floor space	The total floor space of buildings on the stand.
19	Allowable floor space ratio	The ratio of floor space to stand size that is allowed for this area.
20	Occupied	A code indicating whether the stand is occupied or vacant.
21	Debtor	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.
22	Basic tariff	The tariff structure for the basic (fixed) part of the water bill. tariff structure used for the stand.
23	Consumption tariff	The consumption tariff structure (including block rates).

Required meter reading fields

Field	Item	Comments
1	Meter serial number	The serial number on the meter.
2	Meter count	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.
3	Number of units	The number housing units served by the meter.
4	Installation date	Date the meter was installed.
5	Number of digits	Number of digits on the meter dial. Only full m^3 digits are included. Typically 4 for small meters and 5 or 6 for larger meters.
6	Meter measurement unit	Should be m^3.
7	Meter size	Meter size in mm.
8	Meter route number	The meter reader route the meter forms part of. Sometimes referred to as the meter book number.
9	Meter location	Location of the meter on the stand.
10	Average Consumption	The average daily demand for the current month.
11	Meter reading data	Repeat for a given number of meter readings, for instance the last 25 readings.
11.1	Reading date	Date the reading was taken.
11.2	Meter reading	The reading on the meter.
11.3	Reading type	A code describing the type of reading that was done, for instance for instance a 'reading' or 'estimate'.

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 m^3
  - Meter must differentiate between full m^3 and fractions
  - Only read full m^3
- Beware of meters using x10 m^3

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 link in to SCADA system
- AMR
  - Bulk meters more for AMR suitable 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

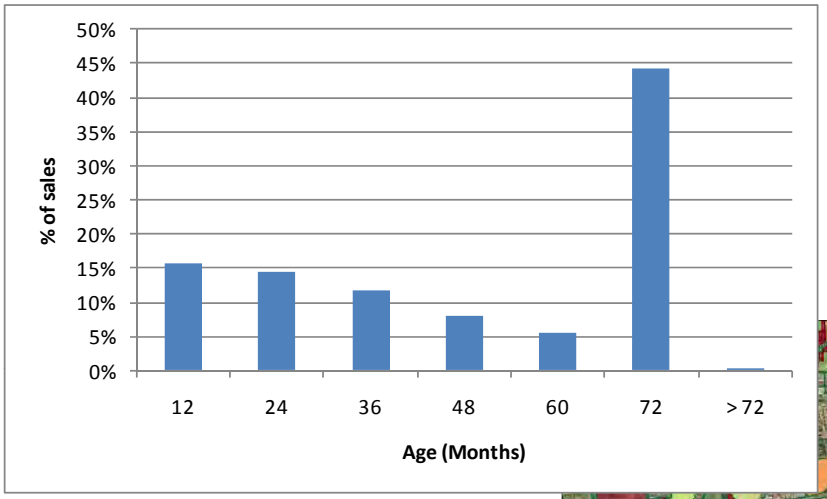
Water tariff design

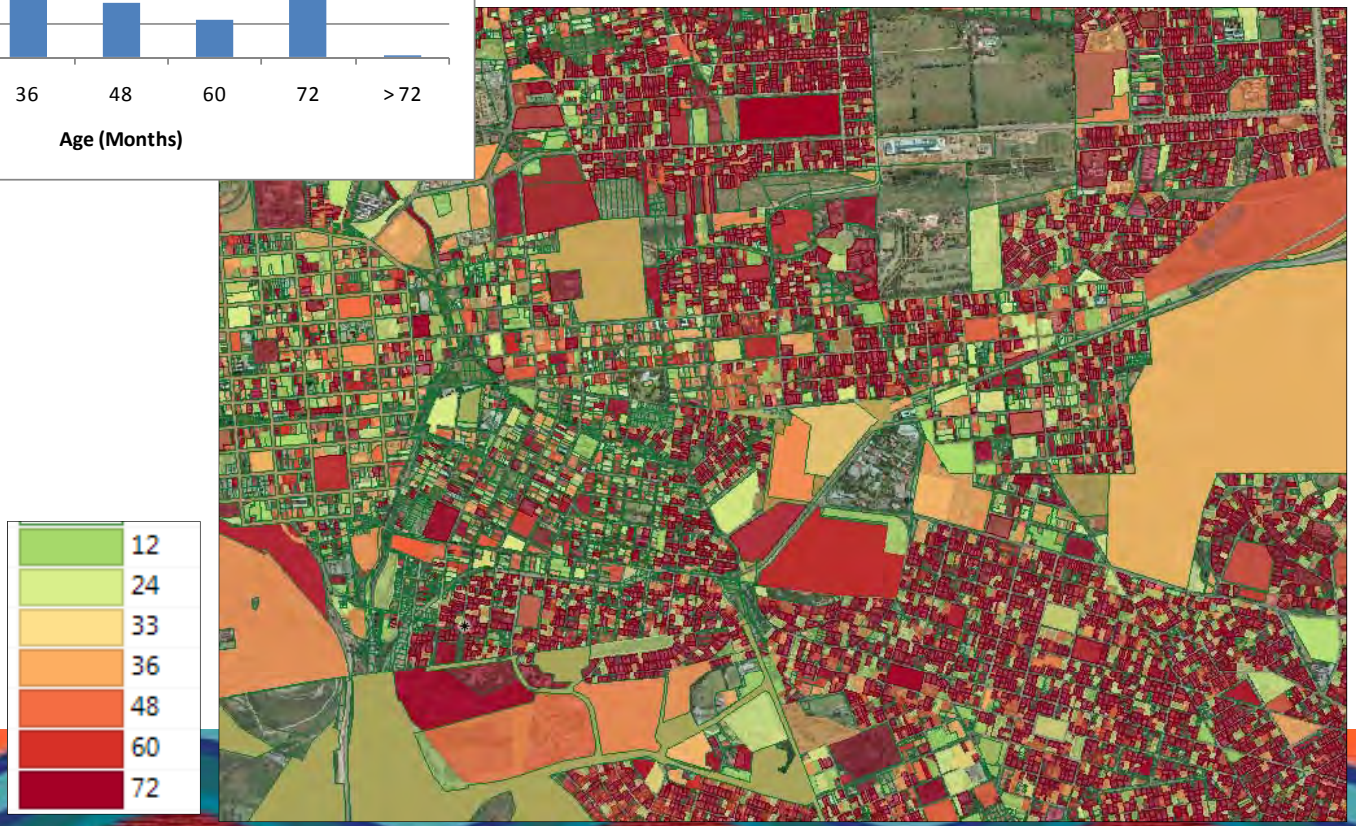
- Fixed rate
- Increasing block rate
- Seasonal pricing
- Fixed plus consumption rate

Information management

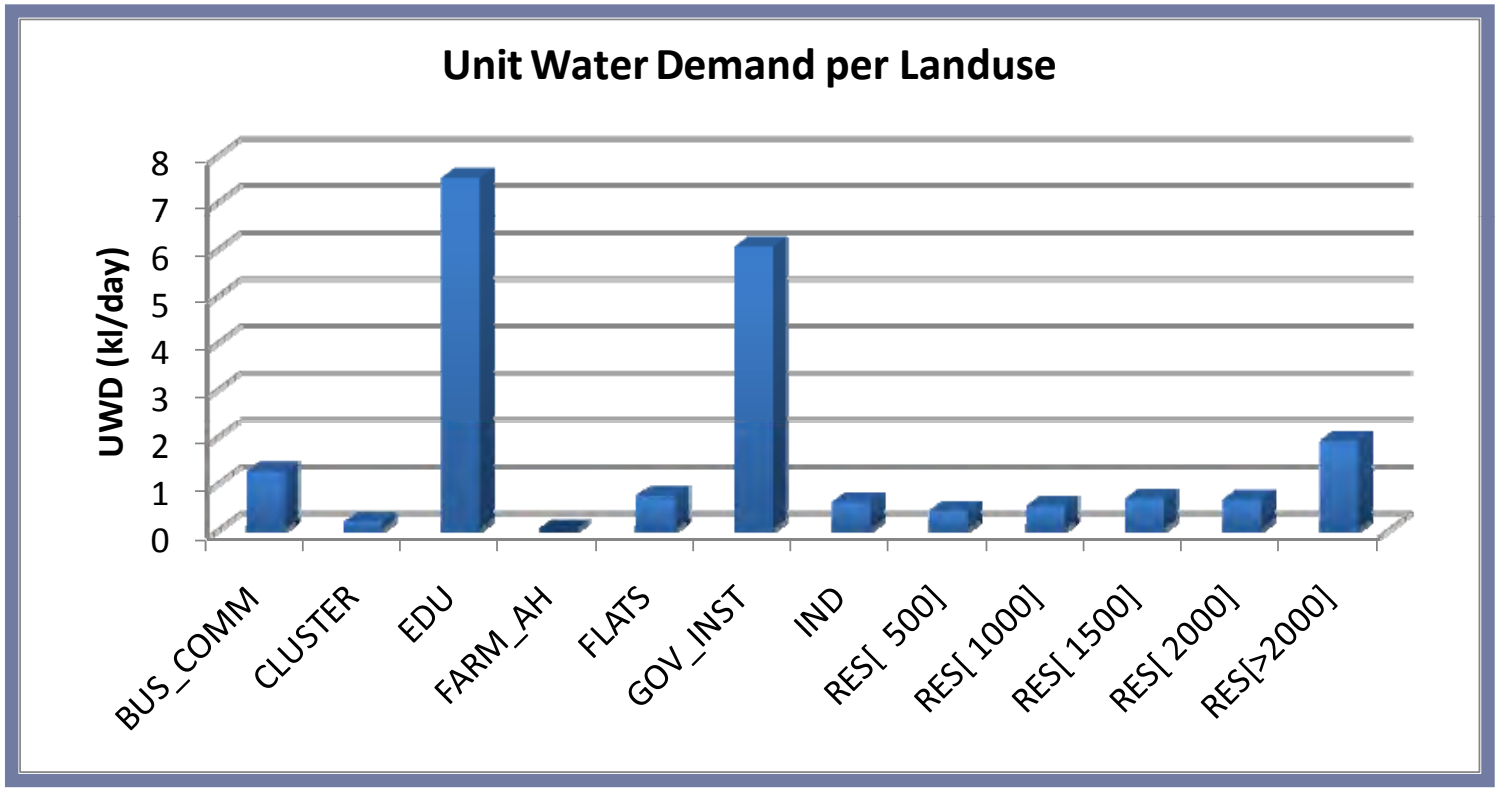
- Quality and accissibility of data critical
- Single vs multiple databases
- Applications
  - Typical water demands of user types and distributions
  - Identify meters being estimated (and not read).
  - Informative billing

Meter Age

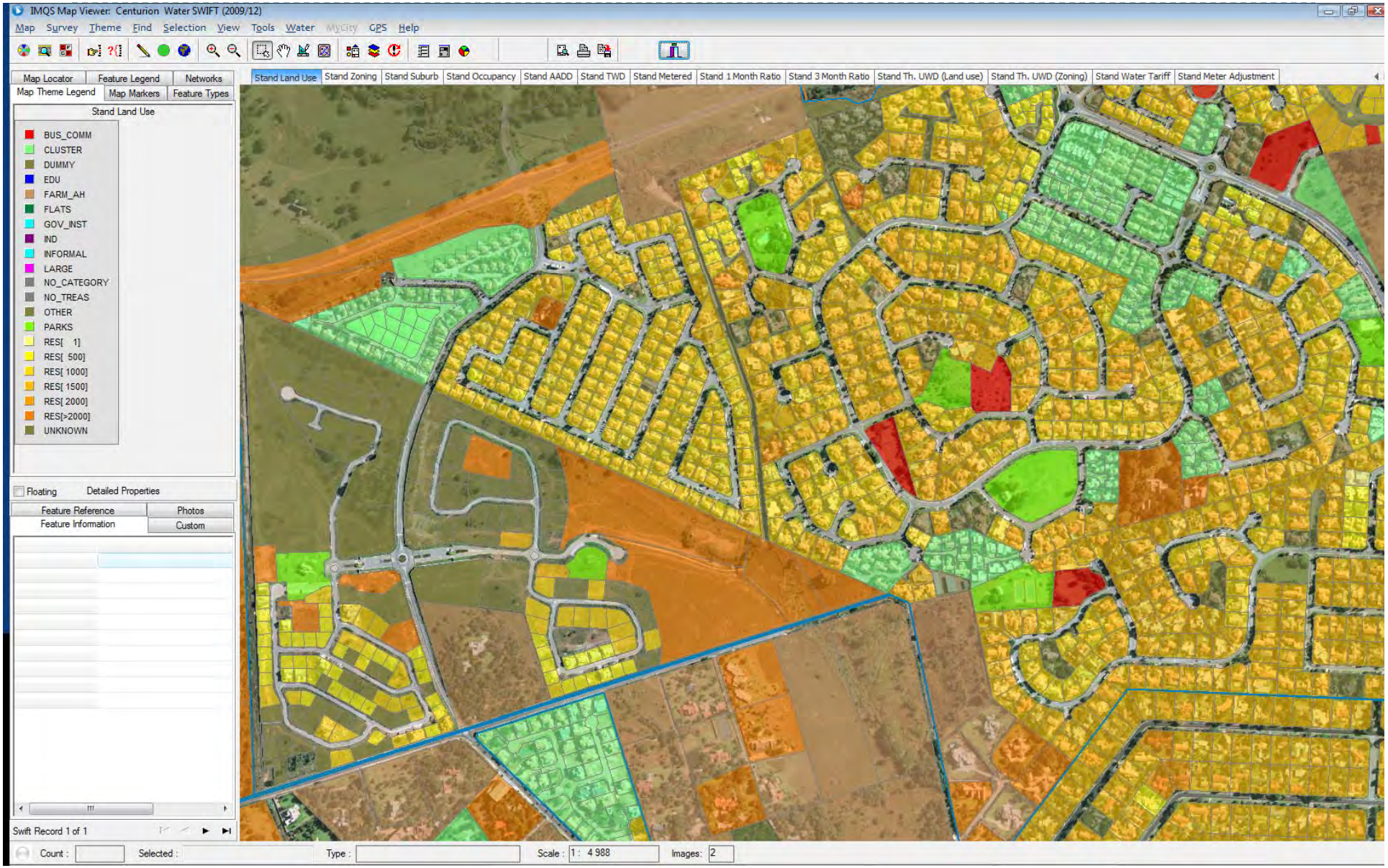

50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
% of sales
12
24
36
48
60
72
> 72
Age (Months)


12
24
33
36
48
60
72

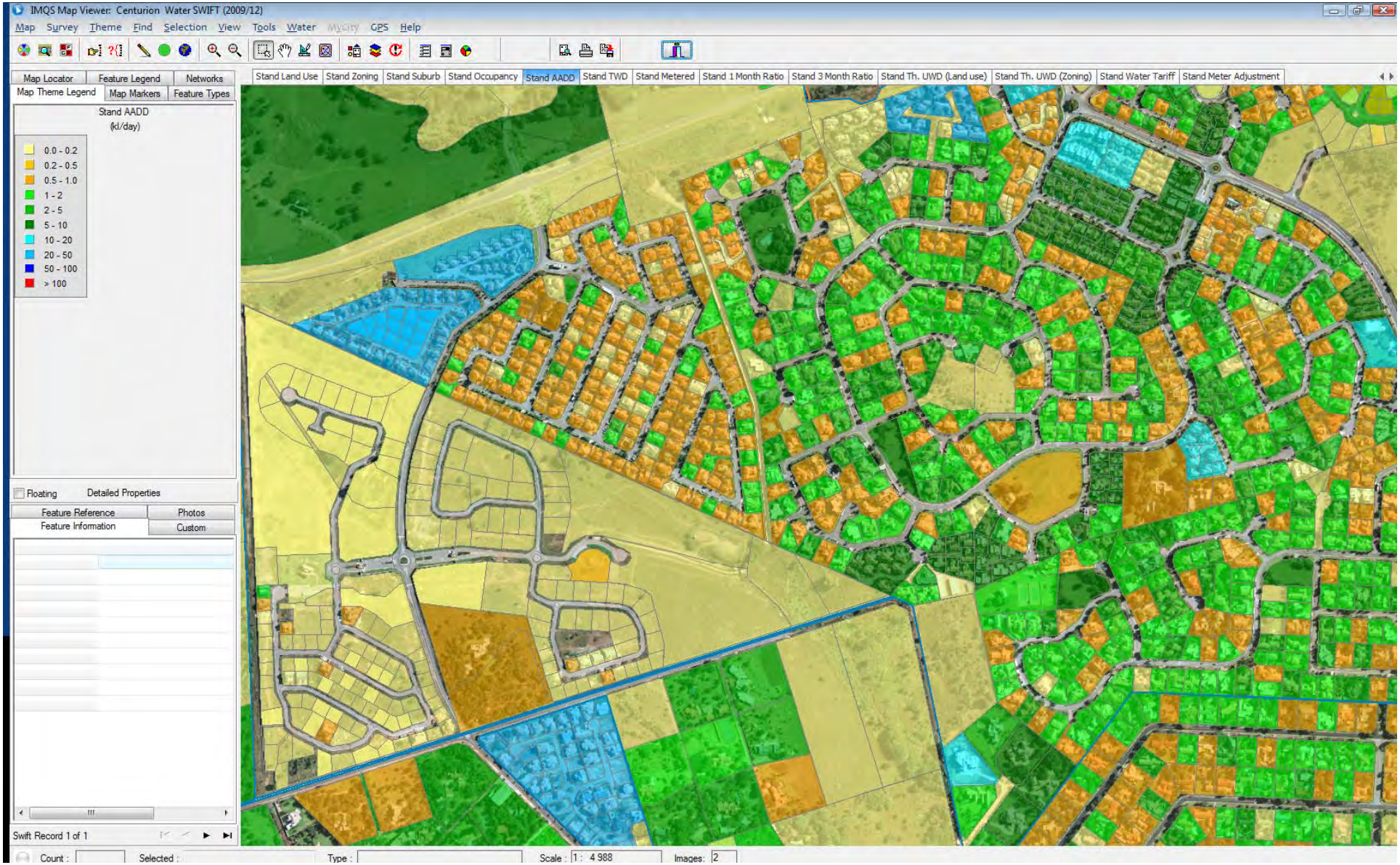
- Water demand statistics



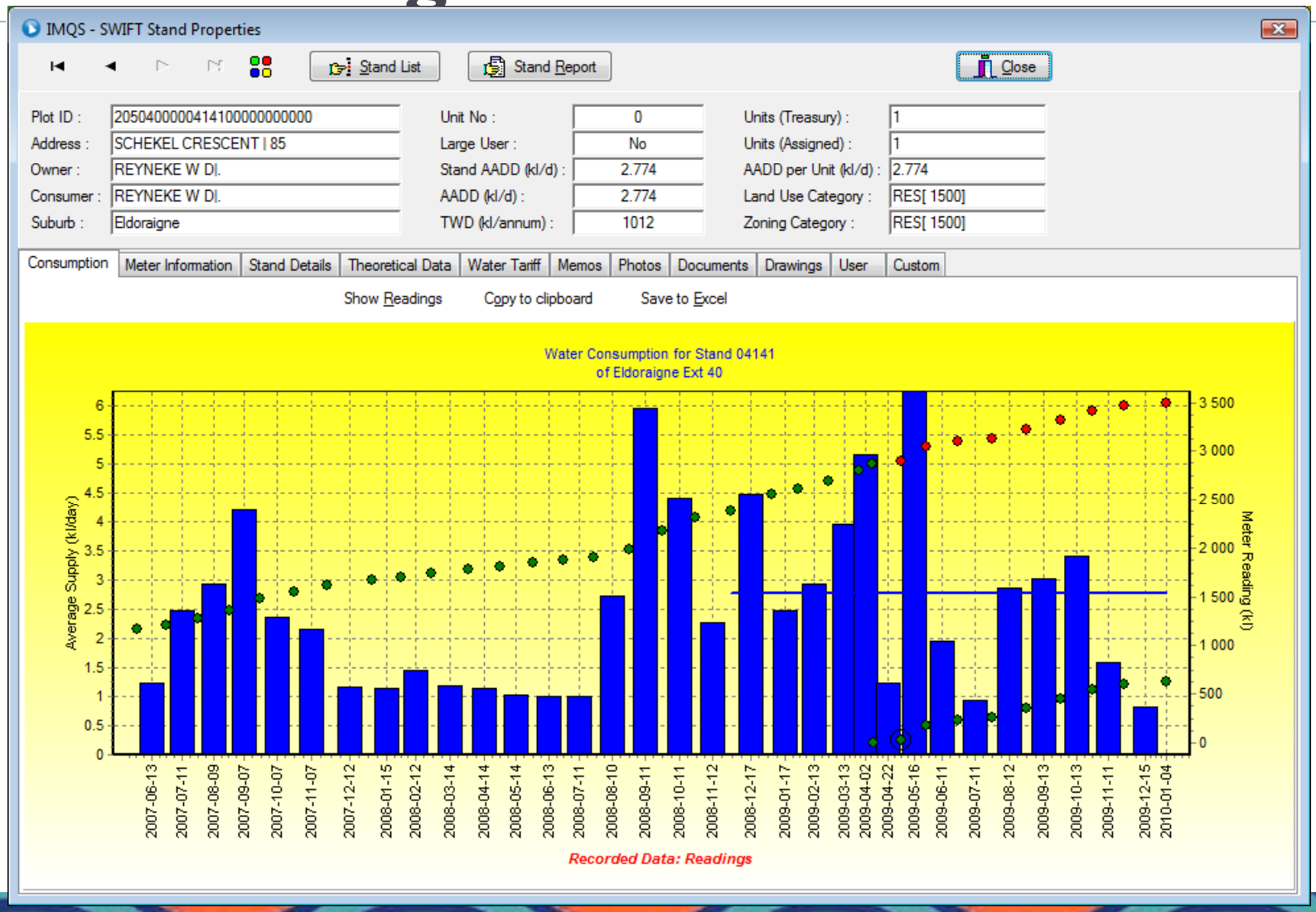
Themed Maps: Landuse



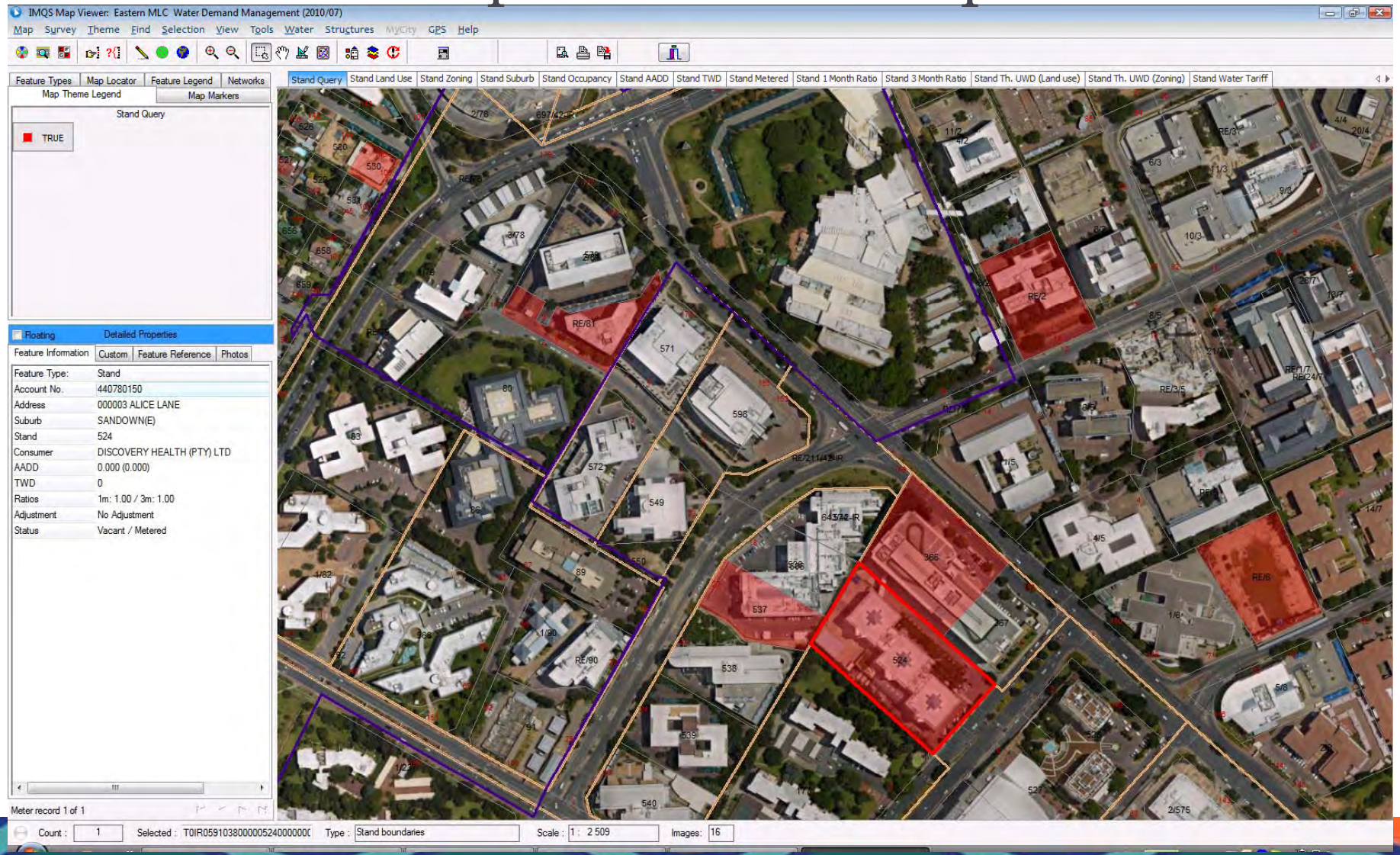
Themed Maps: Consumption



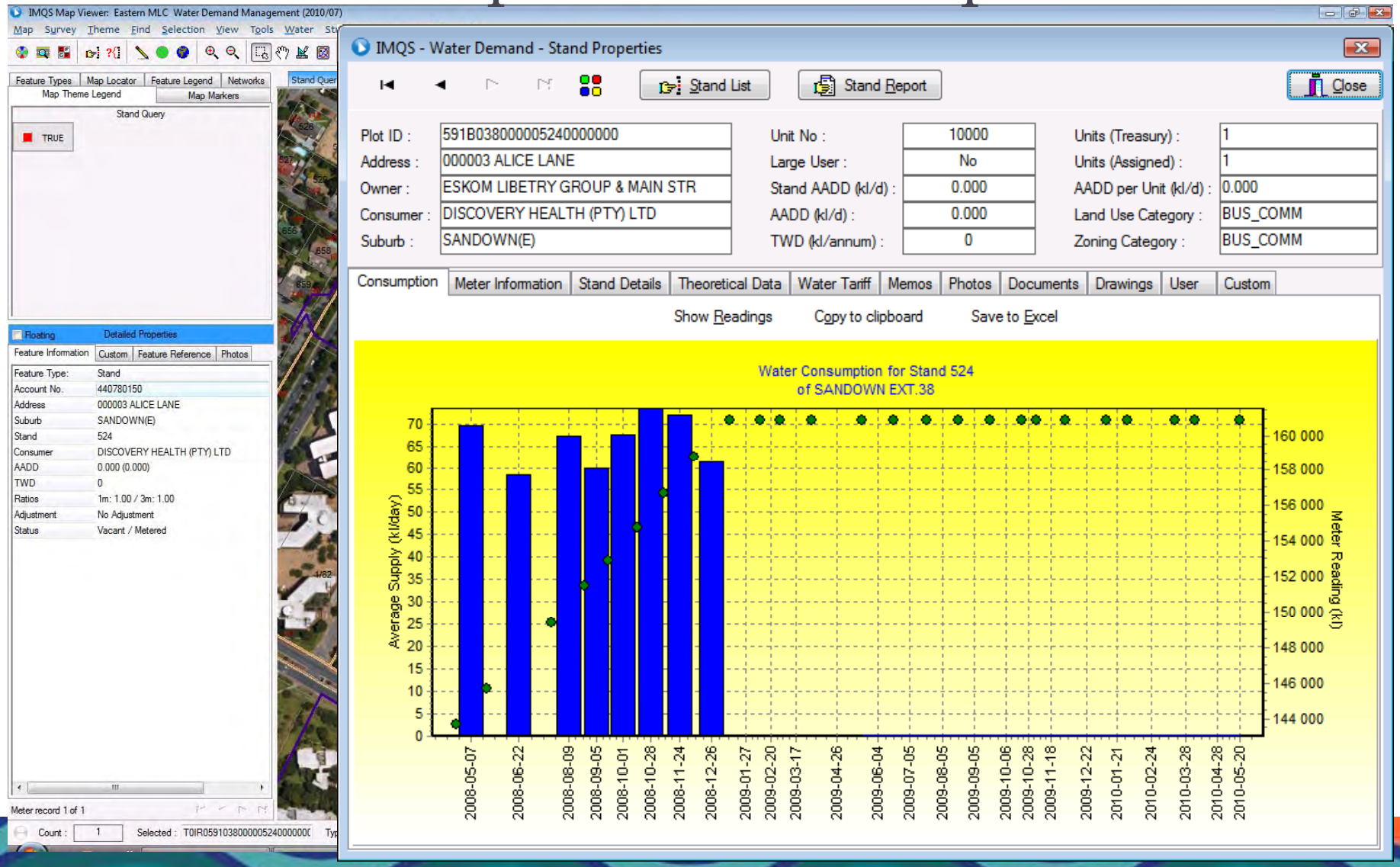
Meter reading verification



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)

Percentage Actual Readings in last 12 months

Value	Number meters		AADD	
	(Count)	(%)	(kl/day)	(%)
90-100	27 759	62	42 164	52
80-90	5 854	13	10 638	13
70-80	4 796	11	9 181	11
60-70	2 315	5	4 950	6
50-60	1 298	3	2 962	4
40-50	942	2	2 385	3
30-40	708	2	2 695	3
20-30	464	1	2 478	3
10-20	457	1	2 057	3
0-10	291	1	1 154	1
None	207	0	1 083	1
Total	45 091		81 747	

Last reading type summary

Value	Number meters		AADD	
	(Count)	(%)	(kl/day)	(%)
Estimated	5 998	13	19 596	24
Actual	39 093	87	62 151	76
Total	45 091		81 747	

Days since last actual reading

Value	Number meters		AADD	
	(Count)	(%)	(kl/day)	(%)
None	207	0	1 083	1
90-365	1 041	2	4 793	6
60-90	846	2	2 117	3
30-60	3 759	8	8 744	11
<30	39 238	87	65 010	80
Total	45 091		81 747	

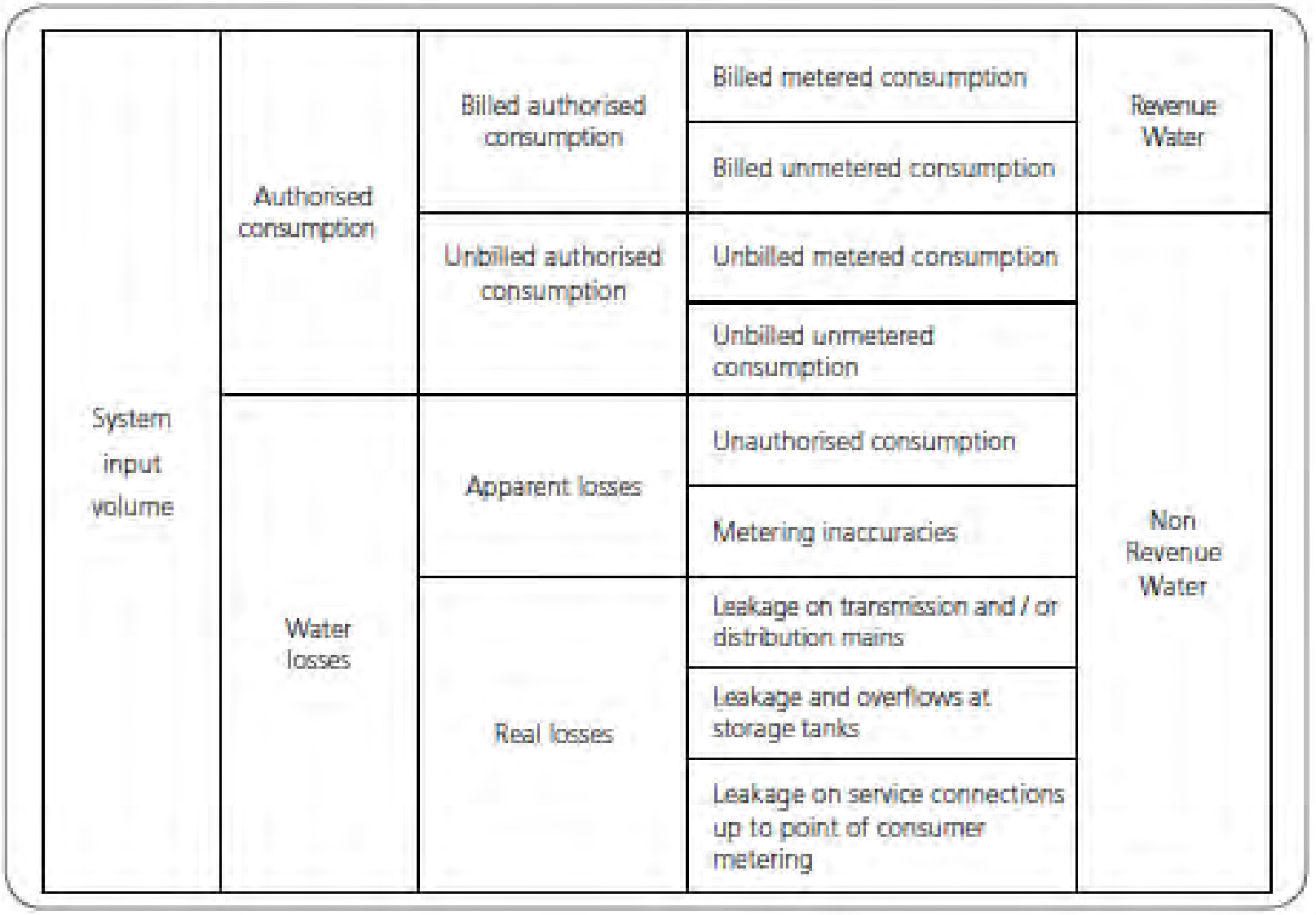
Asset management

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

Water management

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

Municipal water balance



System input volume	Authorised consumption	Billed authorised consumption	Billed metered consumption	Revenue Water
			Billed unmetered consumption	
		Unbilled authorised consumption	Unbilled metered consumption	Non Revenue Water
			Unbilled unmetered consumption	
	Water losses	Apparent losses	Unauthorised consumption	
			Metering inaccuracies	
		Real losses	Leakage on transmission and / or distribution mains	
			Leakage and overflows at storage tanks	
			Leakage on service connections up to point of consumer metering	

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