American Water Works Association

Dedicated to the World's Most Important Resource®

CONTROLLING NON-REVENUE WATER IN DRINKING WATER UTILITIES

COURSE 4

CUSTOMER METERING AND BILLING OPERATIONS FOR OPTMIZED REVENUE CAPTURE

COURSE 4 LEARNING OBJECTIVES

As a result of this course, you will be able to:

Describe	How recovering apparent losses enhances utility revenue
Explain	How utilities meter customer water consumption and bill for this service
List	Common water meters in use and types of meter reading systems
Detail	Good meter management practices – accuracy testing and meter replacement
Identify	Potential for billing errors and unauthorized consumption that siphon away revenue
Tabulate	Consumption and billing data reliably to track revenue capture and flag errors
Determine	Ways to improve metering & billing operations in your system

ACKNOWLEDGMENTS

Project Contractor

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Course 4
Customer Metering and Billing Operations for Optimized Revenue Capture

Course Agenda

Module Number	
1	Tracking Customer Water Consumption
2	Managing Customer Water Meters and Meter Reading
3	Efficient Billing Operations to Maintain the Revenue Stream
4	Course 4 Summary

MODULE 1

Tracking Customer Water Consumption

Module 1
Tracking Customer Water Consumption
Agenda

A. Apparent Losses and the Value of Water

B. Overview of Typical Metering & Billing Practices

C. Billing Errors and Missing Revenue

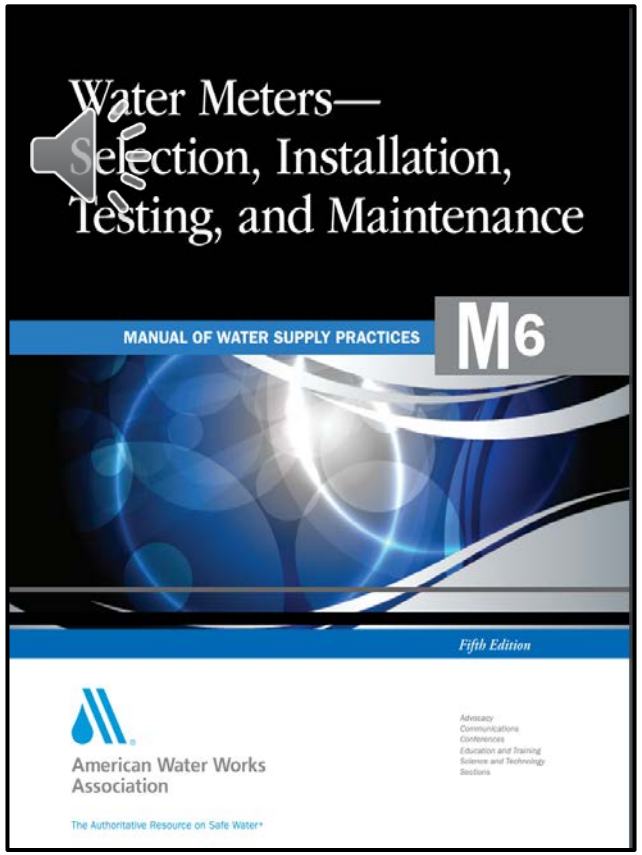
Learning Objectives

As a result of this module participants should be able to:

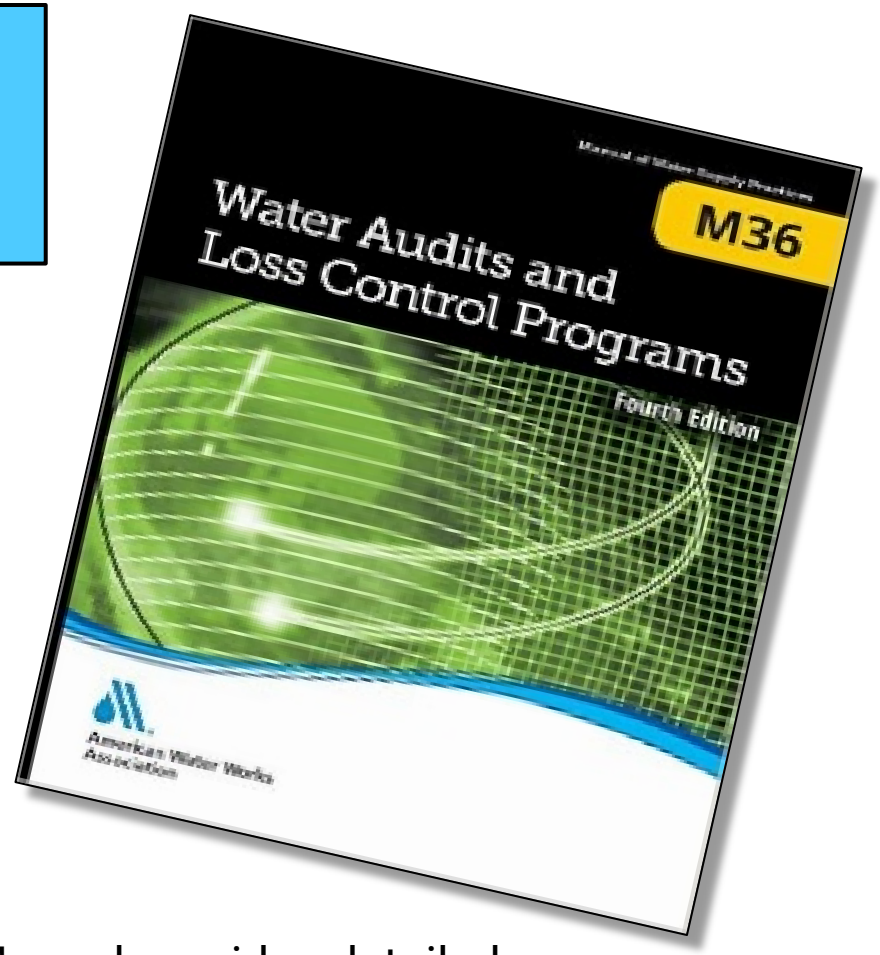
1. Recall the definition of Apparent Losses and recognize their impact on uncaptured revenue
2. Identify the typical metering and billing practices that water utilities employ
3. Illustrate the ways that metering and billing errors cost water utilities money

A. Apparent Losses and the Value of Water

AWWA manuals provide detailed guidance on metering, billing and apparent loss control

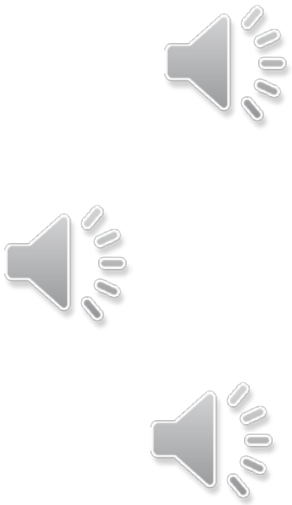


M6 Manual gives guidance on customer metering



M36 Manual provides detailed guidance on Apparent Loss control

A. Apparent Losses and the Value of Water



Apparent Losses	Systematic Data Handling Error
	Customer metering inaccuracies
	Unauthorized consumption

- Apparent Losses cause a portion of customer consumption to be understated, and revenue is not captured. Apparent Losses include:
  - Systematic data handling error (billing errors)
  - Customer metering inaccuracies
  - Unauthorized consumption
- Apparent losses are “paper” losses, not the physical loss of water

A. Apparent Losses and the Value of Water

The apparent loss volume and cost from the AWWA Water Audit

- Recall that the water audit calculates the annual volume of Apparent Losses
- The water audit also calculates the cost impact of Apparent Losses

	Volume MG/Yr	Value $/Yr
Apparent Losses	296.7	$1,210,051
Real Losses	1,537.2	$801,241
Unbilled Authorized Cons	75.8	$39,494
Non-Revenue Water	1,909.6	$2,050,786

AWWA Free Water Audit Software, Version 6.0
Dashboard worksheet excerpt

	WATER LOSSES				1,833.825	MG/Yr
	Apparent Losses					
	Default option selected for Systematic Data Handling Errors, with automatic data grading of 3					
SDHE	Systematic Data Handling Errors:	n	g	3	19.483	MG/Yr
CMI	Customer Metering Inaccuracies:	n	g	4	257.705	MG/Yr
UC	Unauthorized Consumption:	n	g	3	19.483	MG/Yr
	Default option selected for Unauthorized Consumption, with automatic data grading of 3					
	Apparent Losses:				296.671	MG/Yr
	Real Losses					
	Real Losses:				1,537.154	MG/Yr
	WATER LOSSES:				1,833.825	MG/Yr
	NON-REVENUE WATER					
	NON-REVENUE WATER:				1,909.592	MG/Yr

AWWA Free Water Audit Software, Version 6.0
Worksheet excerpt

A. Apparent Losses and the Value of Water – KNOWLEDGE CHECK

Place a check in the box to the left of the apparent loss sub-component that results from the condition shown below:

Water meter removed and replaced with a "straight pipe" or a "cheater pipe" in a meter pit

Check Indicator below	Apparent Loss Sub-component
	Customer Metering Inaccuracies
	Unauthorized Consumption
	Systematic Data Handling Error

A. Apparent Losses and the Value of Water – KNOWLEDGE CHECK

Which of the below four water audit components is *not* part of Apparent Losses?

a. Customer Metering Inaccuracies
b. Unauthorized Consumption
c. Billed Metered Authorized Consumption
d. Systematic Data Handling Error

A. Apparent Losses and the Value of Water

Water Utility Impacts

- Lost revenue when some customers are under-billed
- Damaged equipment from tampering: customer water meters, fire hydrants
- Customer consumption totals are under-stated, affecting:
  - Customer consumption reporting
  - Water conservation tracking
  - Planning studies

Damaged meter register from attempt to tamper with the meter

A. Apparent Losses and the Value of Water

CUSTOMER IMPACTS

- Frustration and complaints from billing errors
- Possibly more frequent water rate increases
  - ***When some customers under-pay for water (or don't pay at all), this means other customers bear the burden of funding the water utility – this is an "equity" or fairness problem***

A. Apparent Losses and the Value of Water

Putting a Value to Apparent Losses

- Apparent losses mean:
  - Some customers are under-billed
  - Some customers are not billed at all
  - Revenue is lost
- Revenue is valued at the ***Customer Retail Unit Charge (CRUC)***
  - May be a single (uniform) rate, or
  - A weighted average of different rates for various customer classes

Significant revenue loss can occur due to Apparent Losses!

A. Apparent Losses and the Value of Water

Putting a cost to Apparent Losses – Four Steps

1. Get the annual Apparent Loss volume (MG) from the water audit
2. Calculate the Customer Retail Unit Charge (CRUC)
   - Get the variable charge from the water rate structure, usually charged "per 1,000 gallons" or "per 100 cubic feet (ccf)" in the USA
3. Convert the CRUC to a "per million gallons" basis
4. Multiply CRUC by Apparent Losses to calculate the annual Apparent Loss cost, meaning cost of uncaptured revenue

A. Apparent Losses and the Value of Water

Cost of Apparent Losses: example calculation – single rate

- Small system with audited Apparent Losses of 2.98 MG
- Customer Retail Unit Charge (CRUC) = $5.81 / 1,000 gallons (**kgal)**
- Convert CRUC to a “per million gallons” basis

  CRUC = ($5.81 / kgal) x (1,000 kgal / MG) = **$5,810 / MG**
- Annual Apparent Loss cost = ($5,810 / MG)(2.98 MG) = **$17,314**
- Taken as $17,314 of potentially missed revenue for the year

A. Apparent Losses and the Value of Water

Cost of Apparent Losses: example weighted average calculation – multiple rates

Example Calculation:

- Cost of Apparent Losses: Multiple Rates
  - Residential Customers: $5,810/MG
  - Commercial Customers: $4,950/MG
- Get from billing records the annual billed consumption for:
  - Residential customers: 41.08 MG
  - Commercial and industrial customers: 3.15 MG
- Use a weighted average calculation as shown below:

$$\text{Weighted CRUC} = \frac{[(\$5{,}810/\text{MG}) \times (41.08\ \text{MG})] + [(\$4{,}950/\text{MG}) \times (3.15\ \text{MG})]}{41.08\ \text{MG} + 3.15\ \text{MG}} = \$5{,}748.75/\text{MG}$$

- The weighted CRUC of $5,748.75/MG is approximately equivalent to **$5.75 /kgal** which can be used to calculate the Apparent Loss cost

A. Apparent Losses and the Value of Water – KNOWLEDGE CHECK

The water audit for a small water utility quantified Apparent Losses of 4.0 MG

The utility has a single-rate Customer Retail Unit Charge of $6.50 per thousand gallons.

Calculate the value of missing annual revenue due to Apparent Losses in the system and select the answer from the below choices. *(Don't forget to convert the CRUC to dollars per million gallons)*

a. $26,000.00

b. $ 26.00

c. $ 2,600.00

d. $ 1,625.00

B. Overview of Typical Metering and Billing Practices

Generating data for the customer water bill:

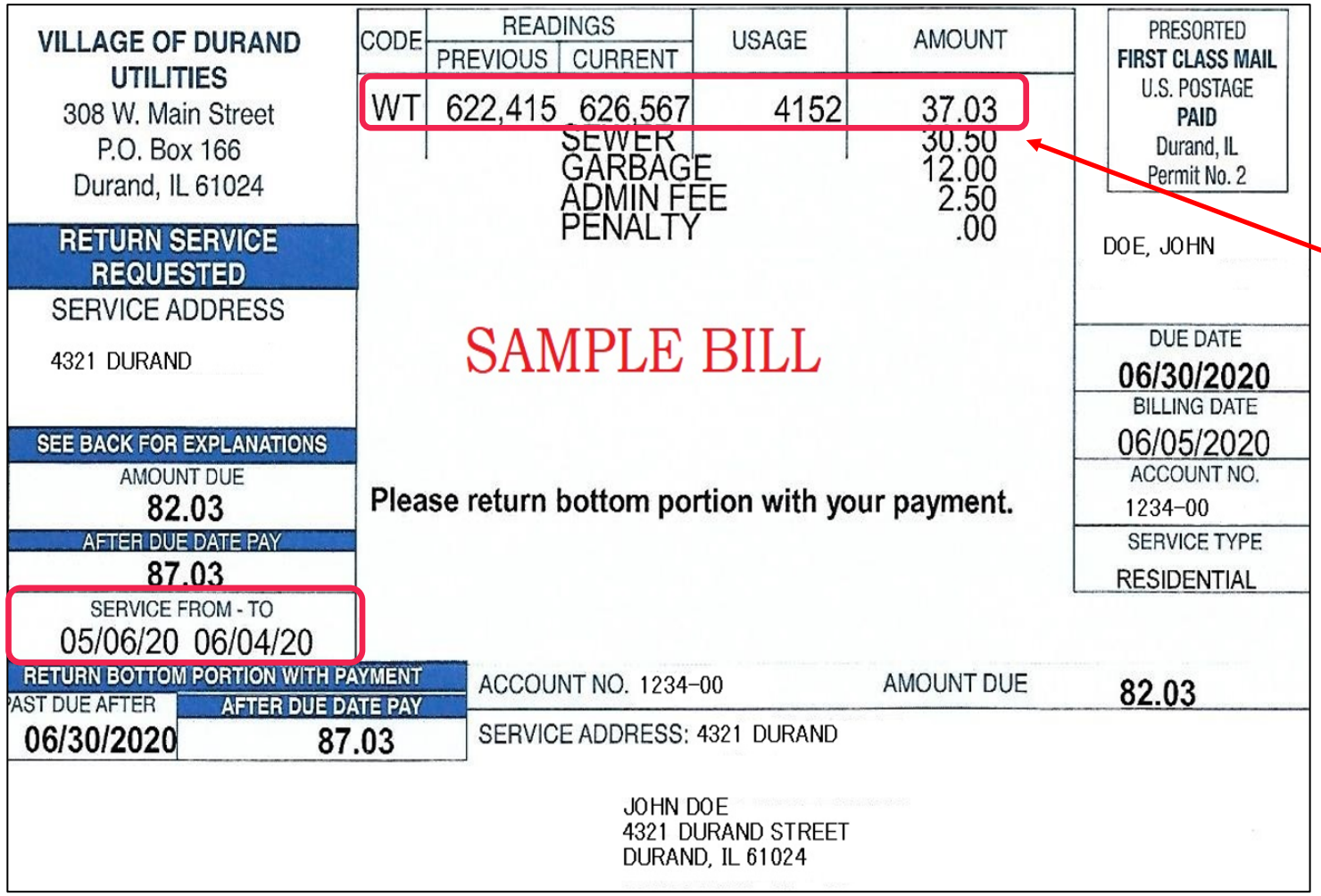
Meter registers water consumption

Water meter is read: manually or automatically

Water bill is generated and sent

B. Typical Metering and Billing Practices

Typical customer water bill for one month



VILLAGE OF DURAND UTILITIES
308 W. Main Street
P.O. Box 166
Durand, IL 61024

RETURN SERVICE REQUESTED
SERVICE ADDRESS
4321 DURAND

SEE BACK FOR EXPLANATIONS
AMOUNT DUE
82.03
AFTER DUE DATE PAY
87.03
SERVICE FROM - TO
05/06/20 06/04/20

CODE	READINGS PREVIOUS	READINGS CURRENT	USAGE	AMOUNT
WT	622,415	626,567	4152	37.03
				SEWER 30.50
				GARBAGE 12.00
				ADMIN FEE 2.50
				PENALTY .00

SAMPLE BILL

Please return bottom portion with your payment.

PRESORTED
FIRST CLASS MAIL
U.S. POSTAGE
PAID
Durand, IL
Permit No. 2

DOE, JOHN

DUE DATE
06/30/2020
BILLING DATE
06/05/2020
ACCOUNT NO.
1234-00
SERVICE TYPE
RESIDENTIAL

RETURN BOTTOM PORTION WITH PAYMENT
PAST DUE AFTER 06/30/2020
AFTER DUE DATE PAY 87.03

ACCOUNT NO. 1234-00 AMOUNT DUE 82.03
SERVICE ADDRESS: 4321 DURAND

JOHN DOE
4321 DURAND STREET
DURAND, IL 61024

Volumetric component: water usage billed

Water bill source:
Village of Durand, IL

Apparent Losses are based only on the volumetric charges!

B. Typical Metering and Billing Practices

Note: The Water Audit does not include the collections process

The end point for the water audit is the customer bill

Water shutoff notice source:
City of Nelsonville, OH

While collections are important to utility finances, they aren't taken into account in the water audit process

B. Typical Metering and Billing Practices – KNOWLEDGE CHECK

Which of the below steps is not part of the process typically used in generating the customer water bill?

a. Water meter registers consumption
b. Water meter reading is obtained
c. The customer calls the utility to request a bill be sent to them
d. Water bill is generated and sent to customer

B. Typical Metering and Billing Practices – KNOWLEDGE CHECK

True or False: data from the collections process is included as part of the water audit?

TRUE

FALSE

C. Billing Errors and Missing Revenue

How billing errors occur

Data Transfer Error

CUSTOMER METER READING

Manual meter reading – labor intensive, human error can occur

Automatic/Advanced meter reading – equipment failure can occur

Data Handling Error

Skewed estimates (when meter reading fails)

Improper billing adjustments

Poor account management

Outdated software protocols

C. Billing Errors and Missing Revenue

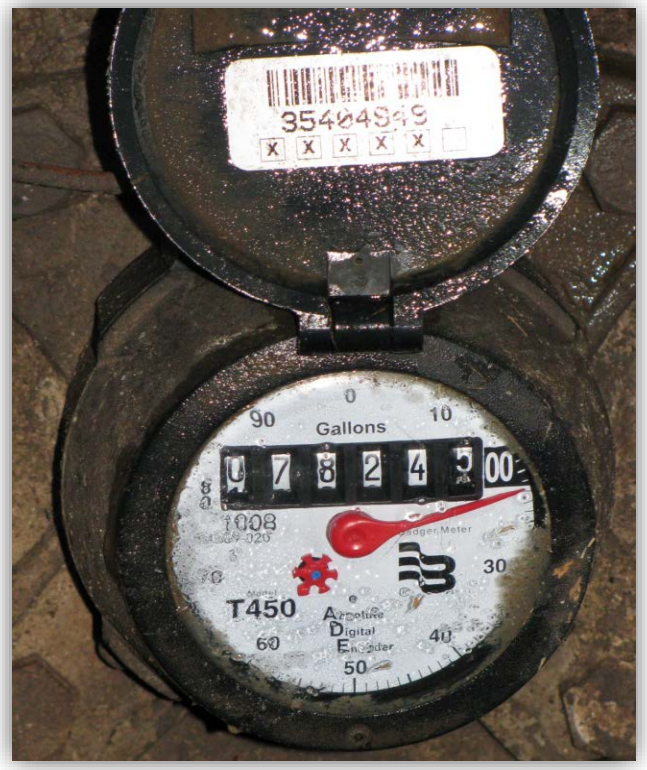
Data Transfer Error

Can you see what the current reading is on this meter?

C. Billing Errors and Missing Revenue

Data Transfer Error

Customer Meter multiplier miscoding: meter reading gives an erroneous value that calculates to only one-tenth of the actual water consumption



Meter Register reading: 078245.23

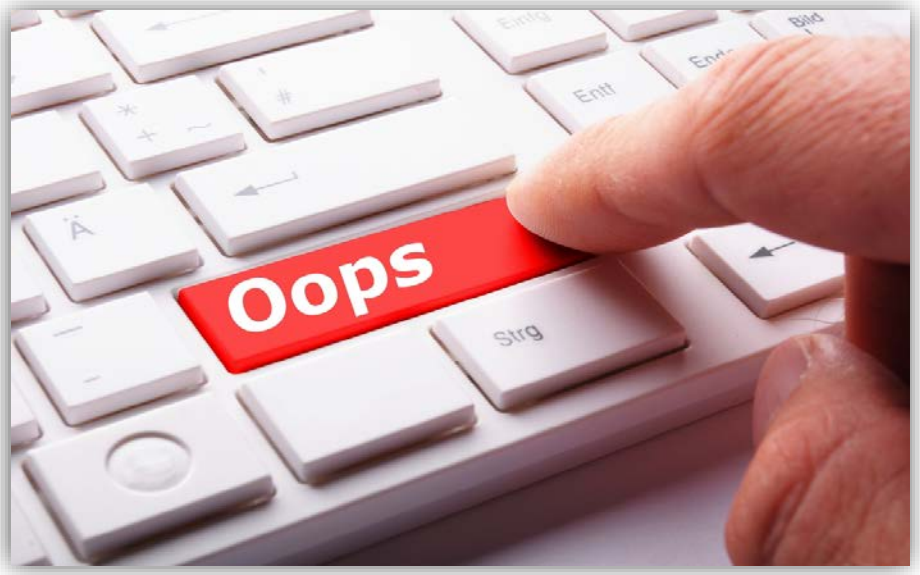
Handheld reader reading: 07824

Photos source: Johnson Controls

C. Billing Errors and Missing Revenue

Data Handling Error

Zero Consumption Accounts – no water consumption for two or more billing cycles



Graphic source: www.cogniview.com

This usage pattern may occur for a valid reason – such as an unoccupied building

But it might occur from meter malfunction, billing error, or meter tampering (unauthorized consumption)

C. Billing Errors and Missing Revenue: KNOWLEDGE CHECK

Which of the below represents a data transfer error?

a. A 25-year old mechanical meter under-registers flow by 10%

b. Water is taken without permission from a fire hydrant by a landscaping contractor

c. An errant billing adjustment is made in the billing system

d. A meter reader sees a snake in a customer meter pit and decides not to read the meter, instead recording a meter reading that he guesstimated

C. Billing Errors and Missing Revenue – KNOWLEDGE CHECK

True or False:

Zero consumption accounts always mean that someone is stealing water.

TRUE

FALSE

Module 1 Summary

Apparent Losses have three components and can cause significant under-billings and loss of revenue.

Customer consumption is usually measured by water meters and is a key part of the water bill.

Billing errors are often a hidden source of Apparent Loss but can result in considerable uncaptured revenue.

Now on to Module 2 which discusses customer water meters and meter management

MODULE 2

Managing Customer Water Meters and Meter Reading

Module 2

Managing Customer Water Meters and Meter Reading

Agenda

A. Water Meter Technology

B. Meter Reading Technology

C. Water Meter Upkeep: Accuracy Testing & Replacement

Learning Objectives

As a result of this module participants should be able to:

1. Identify traditional and newer types of meters
2. Define the primary features of meter reading technology
3. Recognize the need to keep meters operating accurately by testing and replacement

A. Water Meter Technology

Water meters entered use in the early 1900s and are in common use in the United States (but not in all countries)

Metering Customer Consumption is beneficial because:

- It is the link between the volume of water consumed and the value of the water
- It can identify water waste by measuring inordinately high flows
- It provides data on the water using habits of the customer population needed for planning and operational purposes

Photo source: Badger Meter

A. Water Meter Technology

Many types and brands of water meters exist in a wide range of sizes

Accurate meter performance depends on:

- Proper meter type selection and installation
- Proper sizing of the meter
- Periodic maintenance, accuracy testing, and repair or replacement of the meter

Positive displacement meter

Compound Meter with two registers

A. Water Meter Technology: KNOWLEDGE CHECK

Which of the below is not one of the benefits of customer metering?

a. It can limit waste by measuring inordinately high flows

b. It makes for additional maintenance work for the water utility

c. It is the link between the volume of water consumed and the value of the water

d. It provides data on the water using habits of the customer population needed for planning and operational purposes

A. Water Meter Technology

Primary Meter Types – **Meters for Residential Service**

Positive Displacement Meter

- Nutating disc meter: the most common meter in the USA!
- Sizes: 5/8”, ¾”, 1”, 1-1/2”, 2”
- Very good performance if water quality is good
- Remains accurate for high cumulative volume, approximately 1 million gallons for 5/8” meters

Positive displacement, nutating disc meter
Source: Johnson Controls

A. Water Meter Technology

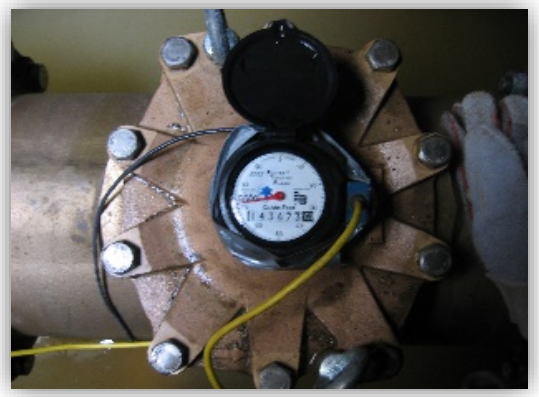
Primary Meter Types – **Traditional Meters for Commercial & Industrial Service**

Turbine Meters

- Designed for steady moderate to high flows
- Have a high low flow threshold under which flow is not registered
- Newer horizontal turbine or “floating ball” technology is accurate at low flowrates

Compound Meters

- Two meters in one: positive displacement for low flow & turbine meter for high flow
- Accurate at high and low flows
- More expensive & maintenance intensive
- Watch out for the “cross-over” range



Many older turbine meters in sizes 3-inch, 4-inch, and 6-inch are likely to be over-sized and missing low flows

A. Water Meter Technology

Primary Meter Types – **Newer Meters for customer consumption metering**

Magnetic Meters

- Accurate over a wide range of flows
- Requires power, now have long-life batteries

Source: Endress & Hauser

Ultrasonic Meters

- Accurate over a wide range of flows
- Requires power, now have long-life batteries

Source: Master Meter

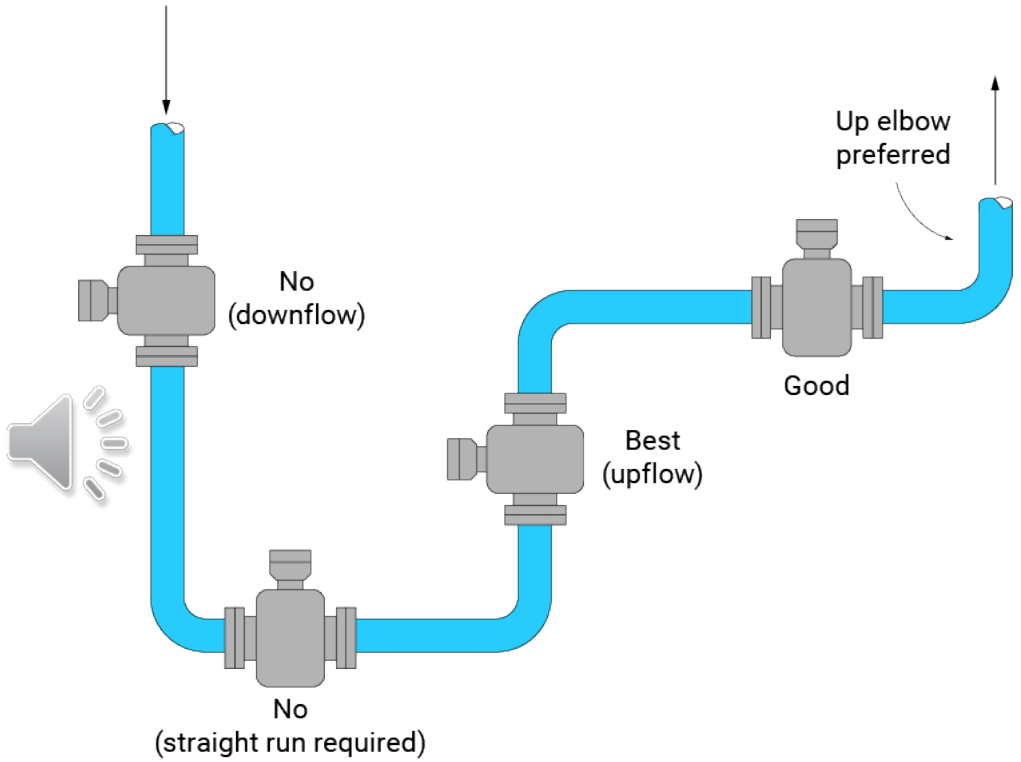
Single-jet Meters

- Accurate over a wide range of flows
- Works well with sediment in the water

Source: Sensus

A. Water Meter Technology

Primary Meter Types – **Magnetic Meters**



Electro-magnetic Meters

- Require a full pipe of water
- Use caution when installing on pipelines discharging water to an open tank or reservoir
- Meter installation alignment:
  - Horizontal: acceptable
  - Vertical: acceptable if flow is moving up, poor if flow is moving downward.
- Unobstructed pipe needed: at least five diameters upstream and two diameters downstream

- Best to have grounding for mag meters, especially larger meters
- Mag meters can be impaired by stray current or by placing a magnet near the meter

A. Water Meter Technology

Primary Meter Types – **Batteries for Magnetic and Ultrasonic Meters**

NO POWER – NO FLOW MEASUREMENT

- Mag and Ultrasonic Meters need power, either by battery or hard wire
- Battery life is an important consideration

Magnetic Meters – Expected Battery Life		
Bore	Integral	Remote
5/8", ¾"	20 years	
1.5" – 3"	10 years	7 years
4" – 8"	7 years	5 years
10" – 24"	4 years	3 years
> 24"	2 years	2 years

Quoted battery life from one manufacturer

A. Water Meter Technology – KNOWLEDGE CHECK

True or False: traditional turbine meters have superior accuracy at low flowrates?

True

False

A. Water Meter Technology: KNOWLEDGE CHECK

Which of the most common meter in use?

a. Turbine meter

b. Magnetic meter

c. Positive displacement/nutating disc meter

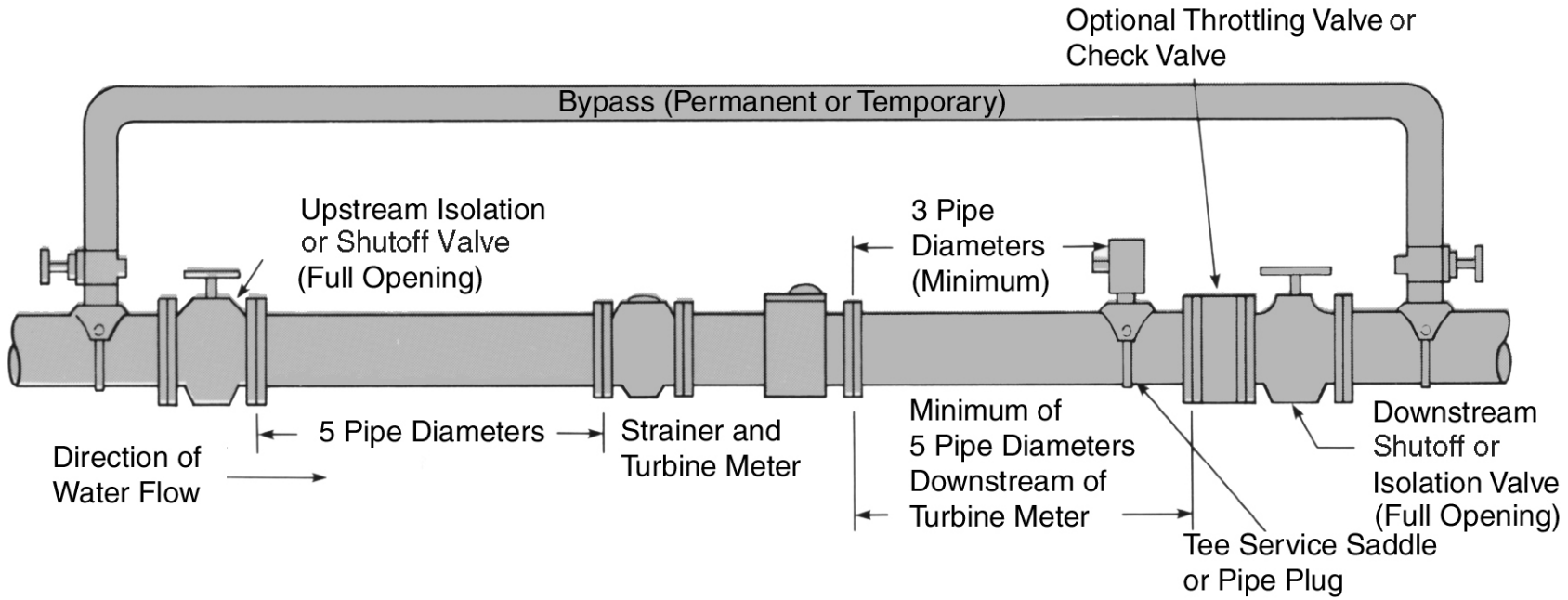
d. Single-jet meter

A. Water Meter Technology

Meter Installation Considerations

PROPER INSTALLATION CONFIGURATION

- Ensure sufficient space, layout, and features for the desired meter set



Source: AWWA M6 Manual

A. Water Meter Technology

Meter Installation Considerations

Traditional mechanical meters are best installed upright and in the horizontal alignment

A bank of water meters improperly installed at an angle instead of upright and horizontal

Poor installation: water meter installed upside down.

Turbine meter installed vertically

A. Water Meter Technology – KNOWLEDGE CHECK

True or False: it is good practice to leave adequate unobstructed pipe spacing both upstream and downstream of most large customer meters.

True

False

B. Meter Reading Technology

UNITS OF MEASUREMENT BY WATER METERS IN THE USA*

- Gallons or cubic feet (1 cubic foot = 7.48 gallons)
- Meter registration: one rotation of the sweep hand may be equivalent to 10 gallons or to 1,000 gallons (or 1 to 100 $ft.^3$).
- Important to know the “resolution” for large meters (2-inch and larger).
- Some meter register numbers may use a “multiplier” value to convert the reading from the meter to the proper volume measurement (***it’s extremely important to include the proper multiplier in the Customer Billing System***)

*water meters in Canada and almost all other countries register in metric units

B. Meter Reading Technology

DIRECT READING (MECHANICAL) METERS*

- Uses mechanical energy from water flowing through a measuring chamber to turn a shaft which is magnetically coupled to an “odometer-style” register display through a series of reducing gears
- Older direct-read meter registers provide a visual display and may not be able to communicate with an electronic meter reading device.

Direct read “odometer” style meter register with sweep hand

Source: Water Research Foundation Report *Advanced Metering Infrastructure: Best Practices for Water Utilities*

B. Meter Reading Technology

ELECTRONIC PULSE REGISTERS (DIGITAL ENCODERS)

- Can generate low current pulses that can be accumulated by a Meter Interface Unit (MIU).
- They may be characterized as either passive or active
- These represent the current generation of meter registers designed to connect to automatic meter reading systems

Digital Encoder register

Source: Water Research Foundation Report *Advanced Metering Infrastructure: Best Practices for Water Utilities*

B. Meter Reading Technology

Meter Reading Methods

Manual Meter Reading
Walking and visually recording meter readings
One reading per billing period

Automatic Meter Reading (AMR)
Electronic reading
One reading per billing period

Advanced Metering Infrastructure (AMI)
Electronic reading
Readings on demand, up to one per hour

Manual meter reading with handheld unit

AMR mobile reading

B. Meter Reading Technology

Manual Meter Reading

Traditional visual manual meter reading

Problems from poor access to meters, visual mis-reads, or illegible hand-writing

Walk-by touch-pad and outdoor meter register are common features of a partially automated meter reading system

More accurate reads but still labor-intensive

B. Meter Reading Technology

Automatic Meter Reading (AMR)

Mobile Read AMR

- Vehicle drives by properties to get within radio transmission range to obtain readings upon polling
- Requires labor to drive but reads many meters quickly and accurately
- Still, it only obtains one reading per cycle

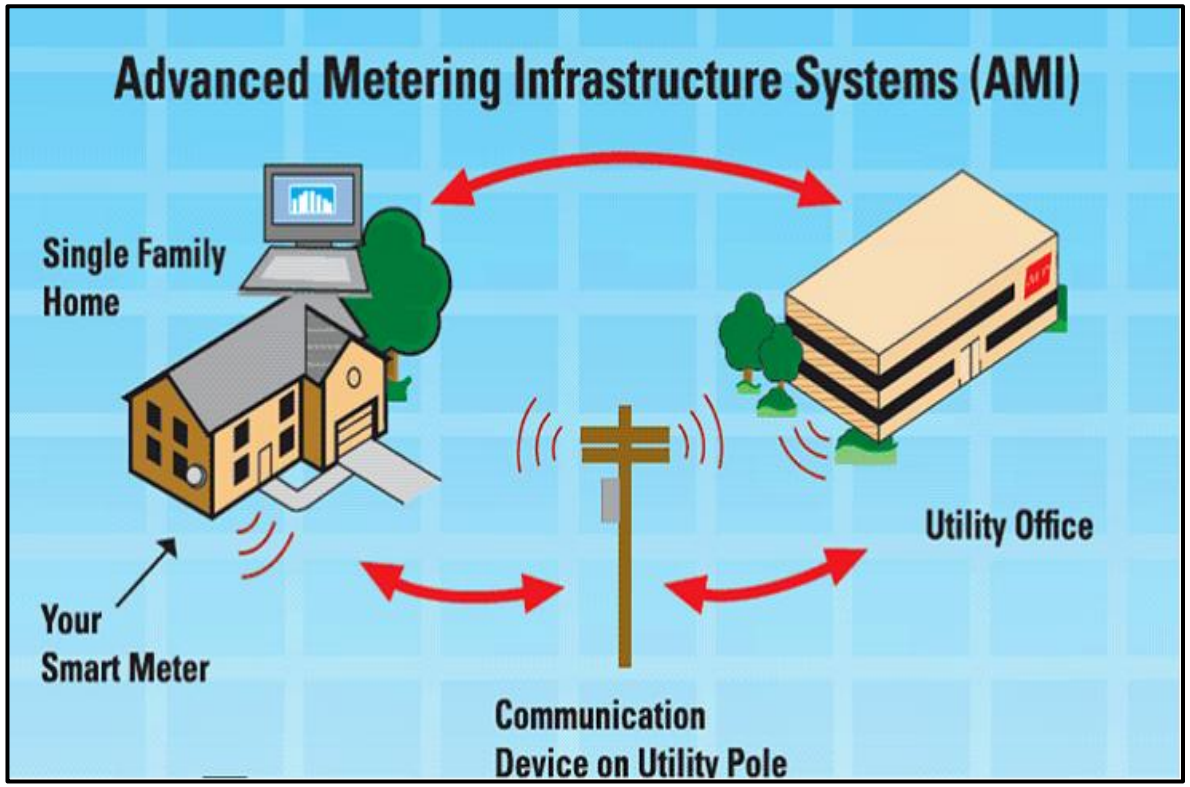
Mobile Read AMR
Source: Don Schlenger & Associates

B. Meter Reading Technology

Advanced Metering Infrastructure (AMI)

Features

- Fixed communication network
- Two-way transmission; to and from customer
- Granular reading data (hourly or on-demand)
- Limits the need to visit properties (few “truck rolls”)
- Higher upfront costs from network
- Companies host the data, no need for heavy information technology investment



B. Meter Reading Technology – KNOWLEDGE CHECK

True or False: a meter that registers down to units of every 10 gallons has a higher resolution than a meter that registers down to 100 gallons.

True

False

B. Meter Reading Technology: KNOWLEDGE CHECK

Which of the below meter reading methods can provide meter readings "on demand" from the office?

a. Manual meter reading

b. Automatic Meter Reading (AMR)

c. Advanced Metering Infrastructure (AMI)

C. Water Meter Upkeep: Accuracy Testing & Replacement

How accurate are my customer water meters?

The best way to know is to test a portion of your meters for accuracy each year!

C. Water Meter Upkeep: Accuracy Testing & Replacement

Accuracy Check for the Residential Population

Calculate the average monthly consumption of **residential** meters

Example: Pennsylvania water utility

–residential daily consumption = 259,600 gallons/day (PA DEP Primary Facility Report)

– 259,600 gal/day x 366 day/year = 95,013,600 gallons

– 95,013,600 gallons / 2,736 connections / 12 months/year = **2,894 gallons per residential connection per month**

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF SAFE DRINKING WATER
PLANNING AND CONSERVATION DIVISION

Primary Facility Report for [redacted]

REPORT FOR CALENDAR YEAR JAN 1 TO DEC 31, 2016

AVERAGE DAILY WATER USE

Type	Metered Connections		Unmetered Connections	
	Number	Water Use (GPD)	Number	Water Use (GPD)
Domestic	2,736	259,600	0	0
Commercial	181	36,300	0	0
Industrial	6	67,350	0	0
Institutional	29	34,370	0	0
Bulk Sales to other PWS	0	0	0	0
Oil and Gas	0	0	0	0
Other	15	256,338	0	0
Unaccounted For Water				1,029,749
Total	2,967	653,958	0	1,029,749

Explain 'Other' Connections: Fire Protection 2private/13 private Other would include Backwash water,Plant use, High Service pumps, and some Tank Overflow.

Annual Water Supply Primary Facility Report
PA Dept. of Environmental Protection

C. Water Meter Upkeep: Accuracy Testing & Replacement

What is typical residential consumption?

An important Water Research Foundation study found:

USA average of 4,208 gal/connection/month

For small, rural water utilities a better range may be:

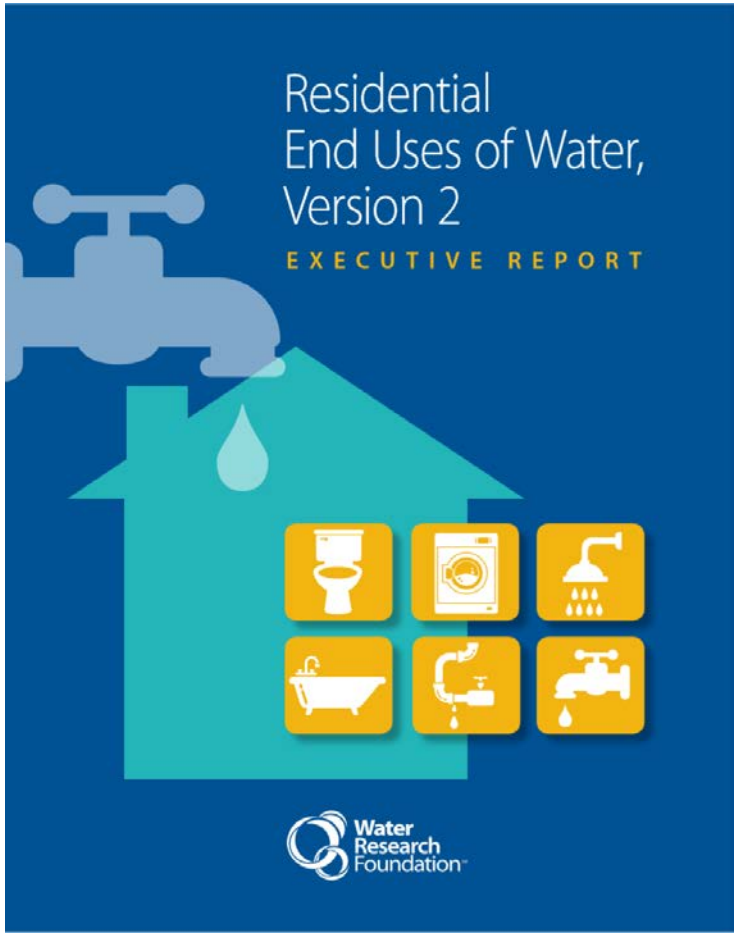
3,500 – 3,800 gal/connection/month

Larger, suburban or urban systems may be:

4,000 – 5,000 gal/connection/month

When average residential consumption is notably below 3,500 gallons, perhaps customer meters may be under-registering

However, there are other factors to consider……



Source: Water Research Foundation

C. Water Meter Upkeep: Accuracy Testing & Replacement

Accuracy Check for the Residential Population

Average residential consumption – other factors

Customer meters may have good accuracy and average residential consumption may be less than 3,500 gal/conn/month if:

- Many seasonal-use buildings exist, water is not used every day
- Many homes in the community house only one or two persons
- The water utility operates a water conservation program that is successful in reducing consumption

Seasonal home on a lake in a small PA community

***Conclusion**: the example PA utility with average residential consumption of 2,893 gal/conn/month may be incurring reduced meter accuracy that should be investigated*

A. Water Meter Upkeep: KNOWLEDGE CHECK

Which of the below ranges of average monthly residential water consumption is taken as a reasonable range for small, rural water utilities?

a. 4,000 – 4,208 gallons per connection

b. 3,500 – 3,800 gallons per connection

c. 5,000 – 6,000 gallons per connection

d. 1,000 – 1,500 gallons per connection

C. Water Meter Upkeep: Accuracy Testing & Replacement

Meter Accuracy Testing is the best way to gauge the accuracy of customer meters

- *Best to test a small number of meters each year*
- *It is not necessary (or feasible) to test all of your meters*
- *Can use your own equipment or send meters to a meter testing company*

Testing a 5/8-inch meter on a small meter test bench

C. Water Meter Upkeep: Accuracy Testing & Replacement

Two Primary Test Methods exist:

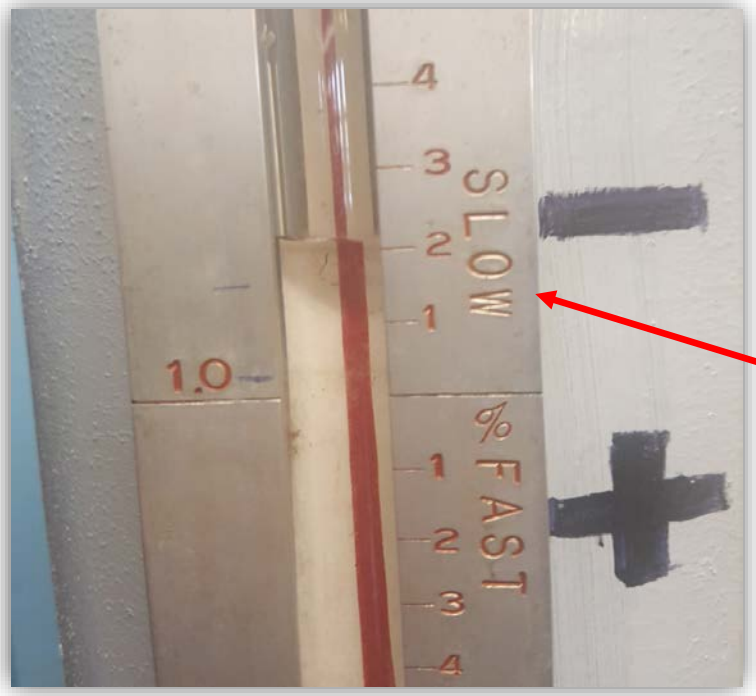
1. Test bench – mount meter on the bench and run water through the meter into a tank of know volume

2. Flow comparison with portable test meter: pass flow through the meter and a second meter in series

Meter test bench used for testing residential meters of 5/8-inch size
Source: Waterfm.com

C. Water Meter Upkeep: Accuracy Testing & Replacement

Test Bench Meter Testing

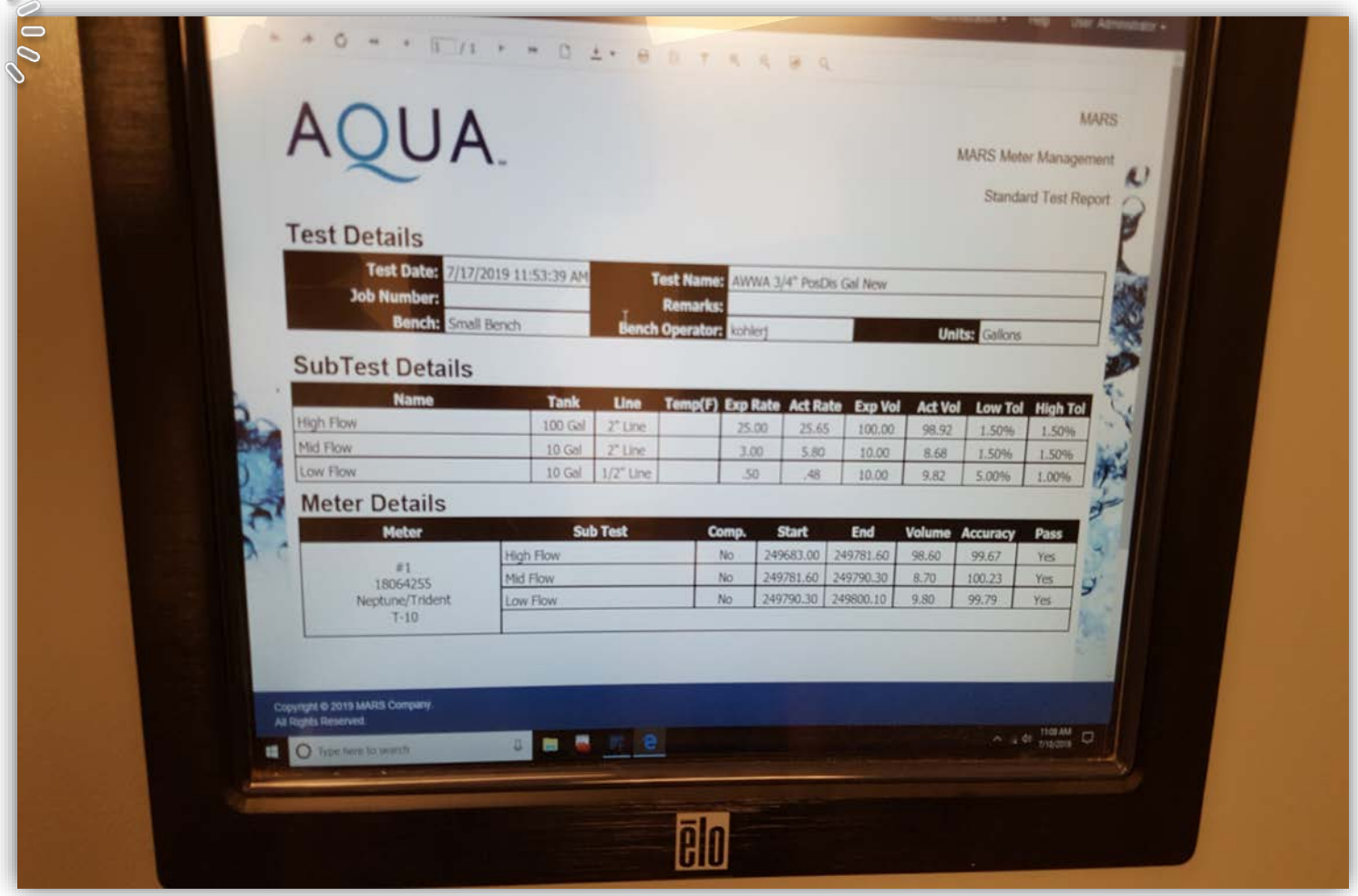


The “sight-glass” gives a visual accuracy reading

Water flowing into tank during a meter test

C. Water Meter Upkeep: Accuracy Testing & Replacement

Test Bench Meter Testing



Display from modern test bench showing meter test results

Testing Quality Control

- Accuracy testing is a ***precision*** activity
- Only skilled and trained personnel should do testing
- Test meters at three flowrates, per AWWA Manual M6:
  - Low flowrate
  - Intermediate or medium flowrate
  - High flowrate
- Follow written procedures
- ***When in-service meters are retrieved for testing, always conduct the low-flow test first !***

C. Water Meter Upkeep: Accuracy Testing & Replacement

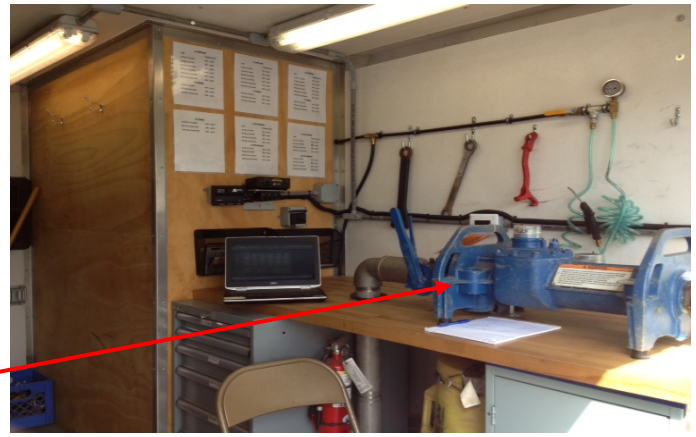
Comparative Meter Testing

- Often used for large commercial or industrial meters with a test port & bypass
- Water supply flows through the bypass during the test to keep customer supplied
- Flowrate from the subject meter and test meter are compared

Water being discharged to waste during large meter testing operation in Louisville, KY. (Utilities should follow applicable state and local requirements for the safe discharge of drinking water to surfaces.)

Hoses connecting test port on meter to calibrated meter in the truck

Calibrated test meter mounted in truck



B. Water Meter Upkeep: KNOWLEDGE CHECK

Select the two primary methods for customer meter accuracy testing from the below box:

a. Reservoir drop test

b. Bench Testing

c. Meter register calibration

d. Flow Comparison Testing

C. Water Meter Upkeep: Accuracy Testing & Replacement

Identifying which meters to test

- Target specific meters/conditions:
  - High water bill complaints from customers
  - Meters serving high water using customers
  - Test a sample of meters retired from service
  - High through-put meters (longevity)
  - Samples of newly purchased meters
  - Suspect meters
- Target a routine number of randomly selected active meters of a given type

JOHN J. MCINTYRE SONS, INC. SCALES

AN ISO / IEC 17025 ACCREDITED COMPANY

Certificate of Calibration

CUSTOMER: AQUA AMERICA
700 W SPROUL RD
SPRINGFIELD, PA 19064

MANUFACTURER: WEIGH-TRONIX
MODEL: 1310
SERIAL NO: 03901927
CAPACITY: 25000 lb
COUNT BY: 1 lb
LOC/DEPT: LARGE TANK

CALIBRATION & CERTIFICATION REPORT

WEIGHT APPLIED	PRE-SERVICE READINGS	ERROR	FINAL CALIBRATION
200 lb	200 lb	---	200 lb
400 lb	400 lb	---	400 lb
600 lb	600 lb	---	600 lb
800 lb	800 lb	---	800 lb
1000 lb	1000 lb	---	1000 lb

TEST WEIGHTS USED ARE TRACEABLE TO THE FOLLOWING NIST NUMBERS:

16777 (06/02/16)
16981 (07/15/16)
2275655 (01/22/16)
864090 (12/21/15)
866880 (12/23/15)
867987 (12/18/15)
872681 (01/27/16)
876960 (02/19/16)
882638 (03/29/16)
893810 (06/06/16)
901657 (07/21/16)

REMARKS: BUILD UP TEST TO 10,000LB

CALIBRATION DATE: 10/04/2016
CALIBRATION DUE DATE: 10/2017
CAL PROCEDURE: 57
TECHNICIAN:

REVISED: 07/01/2006 SUPERCEDES: 12/23/2002
CF - AQUA AMERICA
TEST PERFORMED ACCORDING TO NIST HB 44 TABLE 6, CLASS F and CLASS 1 TOLERANCE
Best Measurement Uncertainty are based on approximately 95% confidence interval using a coverage of k=2.
Test report shall not be reproduced, except in full, without the written consent of John J. McIntyre Sons, Inc.

514-516 KNORR STREET, PHILADELPHIA, PA 19111-4699 (215) 745-3304 FAX (215) 745-8762

SALES, SERVICE, RENTALS SINCE 1925

Certificate of calibration of scale used to weigh the water in a gravimetric tank in a meter test bench

C. Water Meter Upkeep: Accuracy Testing & Replacement

Accuracy test result data

Meter ID Number	Size (in.)	Meter Type	Date of Installation	Manufacturer	Test Date	Mean Registration at Various Flow Rates (designated as percentage of registration) Low	Medium	High
XYZ001	3	Turbine	June 1997	Sensus	Apr 2021	89	93.0	100
X00ZAA	3	Turbine	June 1999	Sensus	Apr 2021	70	95.2	98
NB123	4	Turbine	April 1991	Neptune	Apr 2021	95	99.0	102
NB456	6	Compound	July 2006	Neptune	Oct 2020	98	96.5	102
AA002	6	Magnetic	March 2011	Elster	Oct 2020	98	99.0	103
					Sum of mean registrations	450	482.7	505
					Mean registration for five meters tested	90	96.54	101

Source: AWWA M36 Publication

MANAGING TEST DATA

- Carefully document test result data; spreadsheets are great for this
- Organize the data
- Aggregate the data
- Apply the results
- Strive for statistical significance

C. Water Meter Upkeep: Accuracy Testing & Replacement

Meter Repair and Replacement

- Meter life ends when unacceptable accuracy exists, or it has completely failed (stopped or frozen meter)
- Meter deterioration occurs due to many factors
  - –Durability
  - –Mechanical wear
  - –Volume of cumulative consumption
  - –Aggressive water quality/corrosion buildup
- Projected Meter Life
  - –Historically, quoted in terms of years of service (20 years for 5/8-inch meters, less for larger meters)
  - –Current thinking: 5/8-inch meter life depends on cumulative consumption (***like automobile odometer reading***)

Failed water meter

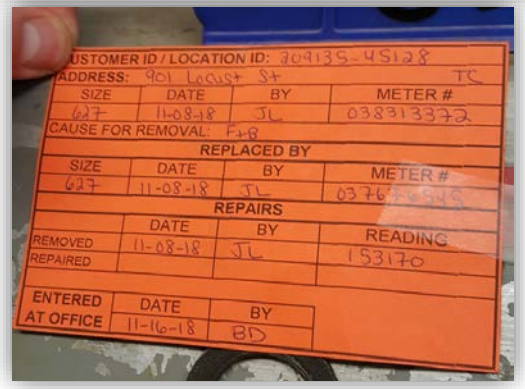
Automobile odometer
Source: Geotab

C. Water Meter Upkeep: Accuracy Testing & Replacement

WATER METER REPAIR OR REPLACEMENT

- Small mechanical meters: repair is in decline because it is no longer cost-effective for most utilities
  - –Replacement is the more cost-effective option
- Solid state meter repair must be done by manufacturer
- Repairing large mechanical meters can be cost-effective
  - –The ***Unitized Measuring Element (UME)*** of some large turbine meters can be routinely inter-changed
- Be sure to budget for meter upkeep at proper intervals

Inter-changeable Unitized Measuring Element (UME) for a large turbine meter



Residential meter repair program in a medium-sized water utility

C. Water Meter Upkeep – KNOWLEDGE CHECK

True or False: repairing customer meters is always more cost-effective than replacing them.

True

False

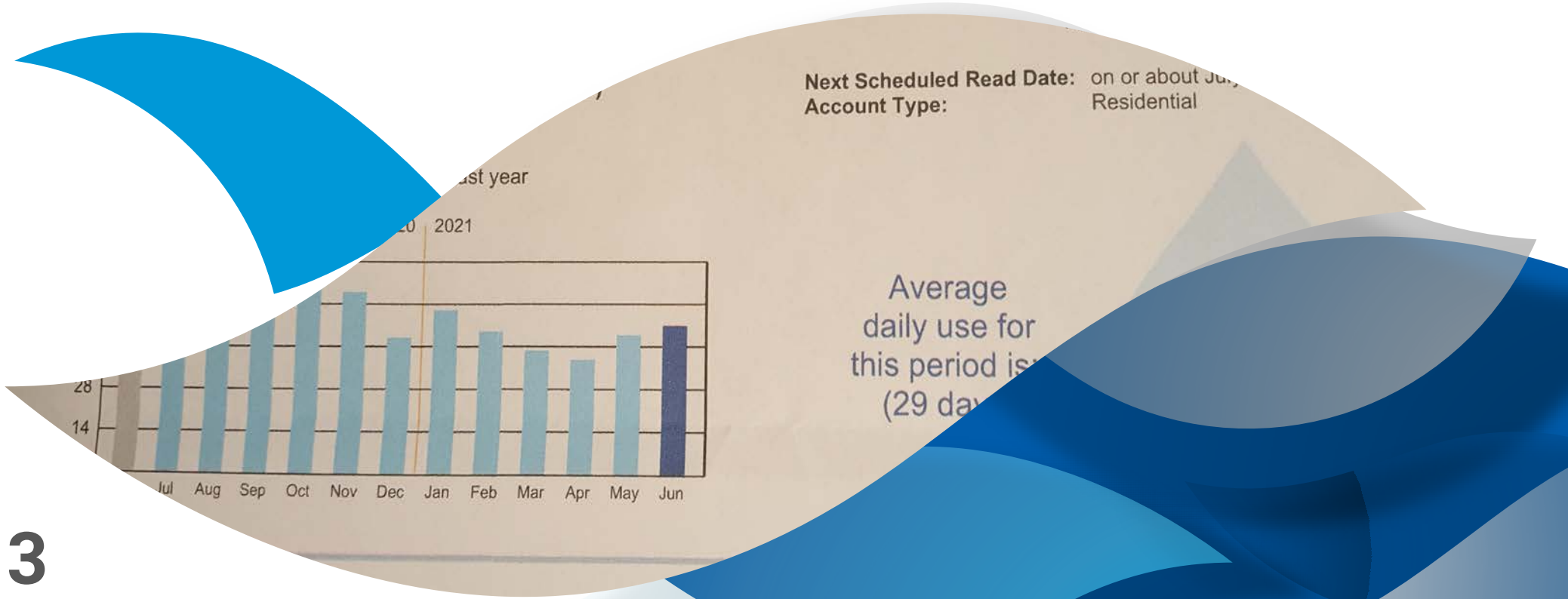
Module 2 Summary

Water utilities employ various types of water meters to measure customer consumption used in billing.

Consumption registered by the water meter can be reliably read by several different meter reading technologies.

Water meters are important utility assets that must be maintained to ensure reliable billing and revenue capture.

The final step in the process is customer billing, which we discuss next in Module 3



MODULE 3

Efficient Billing Operations to Maintain the Revenue Stream

Module 3

Efficient Billing Operations to Maintain the Revenue Stream

Agenda

A. Billing Policy and Practice

B. Reporting and Analyzing Billing Data

C. Guarding against Unauthorized Consumption

Learning Objectives

As a result of this module participants should be able to:

1. Define the way utility policy alone can result in apparent losses
2. Identify the ways regular customer consumption reports can reveal potential sources of apparent losses
3. Recognize that water may be obtain without paying for the service

A. Billing Policy and Practice

Good Billing Policy – Terms & Definition

- **Metering** – AWWA supports metering all cust me g for the volume of water consumed.
- **Billing** – invoicing customers and trackin and charges in an account. Best if all wate
- **Charging** – requiring payment to be m a ges ften vary with class of customer, may have d en te may b discounted, or – sometimes – may b w d re charge.

A. Billing Policy and Practice

Policies that allow “Free” or “Courtesy” Accounts are problematic:

- Sometimes water is provided for free to certain buildings, including:
  - Municipal buildings: offices, water & wastewater plants, community swimming pools, garages, others
  - Fire Department buildings, churches, others
- Problem: no revenue is returned to the water utility
- Problem: public perception may suffer due to perceived inequity

Source: Time.com

A. Billing Policy and Practice

Problems with “Free” or “Courtesy” Accounts

- Sometimes, these facilities are not metered, a problem since:
  - water usage is not tracked
  - high water use from plumbing leaks goes undetected
  - Other wasteful or exorbitant water uses are not revealed, and may be tacitly encouraged

A. Billing Policy and Practice

Problems with “Free” or “Courtesy” Accounts

A good policy to consider for all water users:

- Don’t classify any accounts as “Free” or “Courtesy”
- Install water meters, routinely read the meters, bill based upon measured water usage, tally the consumption and billed charges
- Discounts for certain customers are acceptable, but everyone should pay something, including municipal buildings owned by the municipality.
- “Free” water sends a bad message to the public

A. Billing Policy and Procedures

Terms of Service for the Provision of Water Supply

- Create clear policies for provision of water service, metering, billing, and collections
- Establish strong policies and put them in writing
- Customer rights and responsibilities should be explained, including:
  - The metering and billing process
  - Customer responsibility to pay
  - Penalties for tampering or non-payment

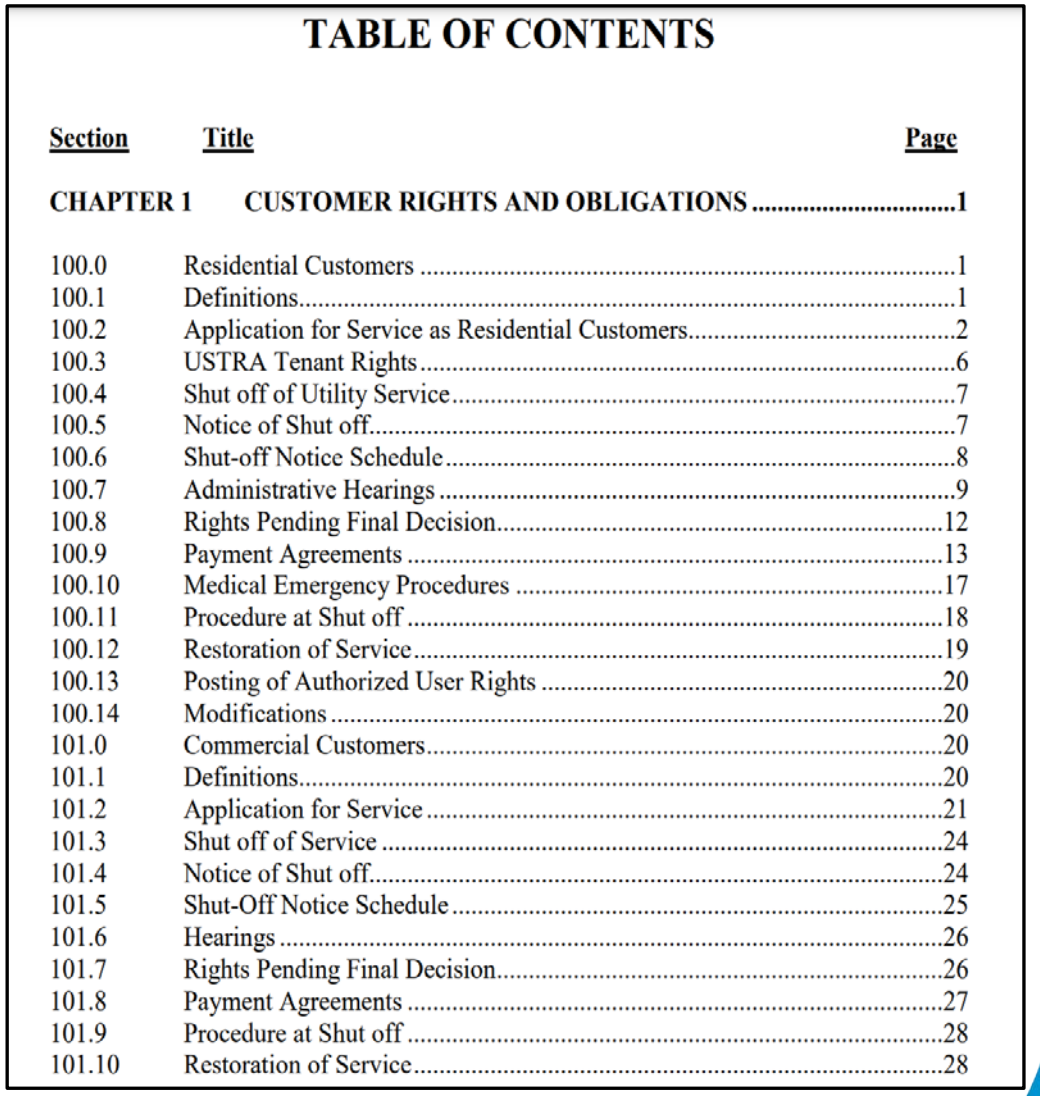


TABLE OF CONTENTS

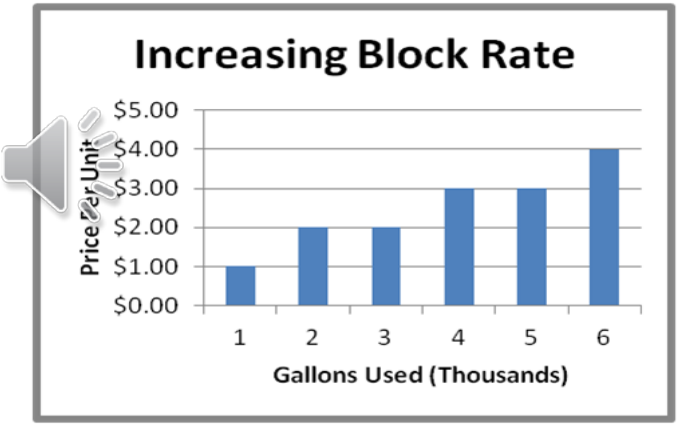
A. Billing Policy and Procedures – KNOWLEDGE CHECK

Which of the two below activities entail assessing a rate to the customer that applies to their specific customer status?

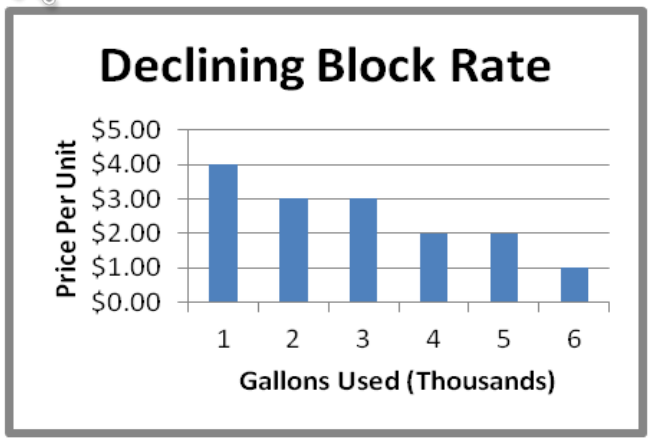
Billing

Charging

B. Reporting and Analyzing Billing Data: Good Internal Reporting Practices



Water rates are higher for higher consumption
Source: US EPA



Water rates are lower for higher consumption
Source: US EPA

1. Important to have good records on customer meter reading and billing data for utility management use
2. Having a computerized system is best
3. Keep your water rates up-to-date
4. Compile standard reports each billing cycle
5. Analyze the reports and data to stay on top of billing trends and to flag problems

B. Reporting and Analyzing Billing Data: Good Internal Reporting Practices

Detailed Billing Reports

- Lists data on individual customers – billed usage and charges
- Other detailed reports can list separately accounts flagged for missed meter reads, failed (stopped) meters, tampering, or other alerts

Billing Cycle: May 2020 Billing

EXAMPLE REPORT

Account Number	Name	Read Date	Previous Read	Current Read	Usage	Bill Amount	Bill Date
100-0	William Abbott Jr.	04/27/2020 12:00 PM	331789	333987	2198.0000	97.12	05/01/2020
						Water 42.12	
						Sewer 55.00	
101-0	John F. Dorman	04/26/2020 12:00 PM	555463	559270	3807.0000	106.93	05/01/2020
						Water 51.93	
						Sewer 55.00	
102-0	Willie J. Williams	04/26/2020 12:00 PM	387650	393296	5646.0000	118.15	05/01/2020
						Water 63.15	
						Sewer 55.00	
103-0	Tenant	04/27/2020 12:00 PM	286182	287898	1716.0000	94.18	05/01/2020
						Water 39.18	
						Sewer 55.00	

B. Reporting and Analyzing Billing Data: Good Internal Reporting Practices

Summary Billing Reports

- Lists totals for each billing cycle
- Can breakdown by meter size, customer class, other criteria

EXAMPLE REPORT

DATE OF REPORT 08/27/19 BILLING REGISTER SERVICE TOTALS BILL DATE 08/31/19 TIME: 10:25:56

SERV	DESC	NBR	USAGE	CHARGE	CREDIT	TAX	30 DEL	60 DEL	90 DEL	PENALTY	TOTAL DUE
101	MTR WTR DOMESTI	5967	67721	260860.32	2371.64-			1148.49	723.89	234.77	262967.47
102	MTR WTR COMMERC	259	14715	50602.42	141.00-					3.46	50605.88
103	MTR WTR INDUSTR	34	13373	48236.43	10.86-					2.39	48238.82
104	MTR WTR PUBLIC	19	7392	25437.92							25437.92
106	WTR - FREE	0	10								.00
271	BASE CHARGE	6144	6165.00	174090.90	2549.81-			539.06	972.67	247.14	175849.77
272	BASE CHARGE COM	291	291.00	22665.33	211.31-			3.98		10.10	22679.41
273	BASE CHARGE IND	33	33.00	4644.29	26.55-					2.77	4647.06
274	BASE CHARGE PUB	20	20.00	4503.15							4503.15
600	TURN-ON FEE	0					175.00		105.00		280.00

***** ONE OR MORE ACCOUNTS HAVE EXCEPTIONS. PLEASE REVIEW WARNING MESSAGES *****

USAGE:	TOTALS	103211	591040.76	5311.17-		175.00	1691.53	1801.56	500.63	589898.31
UNITS:		6510								

B. Reporting and Analyzing Billing Data: Good Internal Reporting Practices

Discovering metering & billing problems by reviewing billing data

EXAMPLE DETAILED REPORT

Acct No.	Meter Size	Meter Type	User Type	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total Consumption	REASON FOR CIRCLING SUSPECT DATA
1204	5/8"	PD	Residential	7	7	7	0	0	0	0	0	0	0	0	0	21	Zero consumption: might be unauthorized consumption, meter failure, or temporarily vacant property
1205	5/8"	PD	Residential	7	7	7	6	7	8	7	9	7	6	6	5	82	
1206	5/8"	PD	Residential	6	6	7	7	18	19	9	9	8	7	6	6	108	Two months with high consumption – may have been a plumbing leak that was eventually resolved.
1401	1"	PD	Residential	3	3	3	3	3	4	4	4	3	3	3	3	39	Very low consumption for a 1-inch meter. This meter is likely too large, especially for a single-family residential building
1402	1"	PD	Multi-unit Residential	22	23	27	29	33	37	42	45	39	34	27	25	383	
1403	1"	PD	Multi-unit Residential	77	95	95	95	95	95	95	95	95	-150	73	71	831	The same consumption value for 8 consecutive months suggests that an estimate was used. Negative number in Oct is a "catch-up" reading but negative consumption volumes can cause accountability issues.
1601	2"	PD	Commercial	27	33	37	39	42	45	51	54	46	40	37	33	484	
1602	2"	Magnetic	Commercial	32	38	44	52	55	61	14	2	2	2	2	2	306	Very low consumption for a 2-inch meter and an abrupt drop starting in August: likely a meter or meter reading equipment failure
1703	3"	Turbine	University	11	12	12	12	13	9	5	7	14	14	13	12	134	Very low consumption for a 3-inch meter; this meter is likely over-sized and the wrong type of meter
PD – Positive Displacement																	

B. Reporting and Analyzing Billing Data: Good Internal Reporting Practices - KNOWLEDGE CHECK

What is the primary reason to have good internal reporting practices in place in your water utility?

a. They can be sent to every customer to show them all of the data that you accumulate on them

b. They are used to analyze metering and billing data to stay on top of billing trends and to flag problems or errors

c. They are a good excuse for charging higher rates for water service

B. Reporting and Analyzing Billing Data: Good Internal Reporting Practices – KNOWLEDGE CHECK

Which of the two types of reports that we discussed provides a listing of individual customer accounts?

Detailed

Summary

C. Guarding Against Unauthorized Consumption

Illegally opened fire hydrant

Tampered customer meter with nail inserted into register to slow meter function

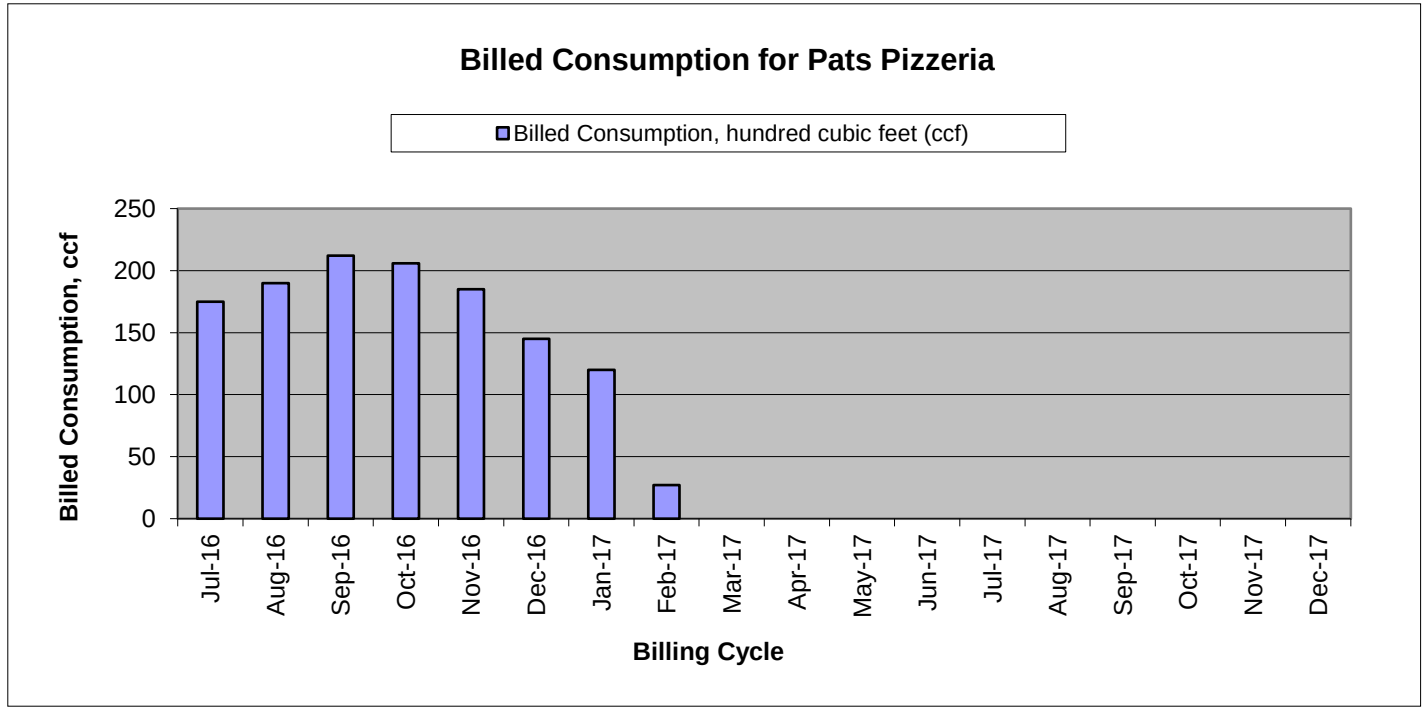
Unauthorized Consumption occurs in many ways

- Fire Hydrant misuse
- Tampering with Meters
- Tampering with Meter Reading Equipment
- Illegal connections
- Opening unmetered bypass piping around large water meter installations
- Illegal restoration of shutoff service connections (payment delinquency)
- Any other way a creative person wants to employ

C. Guarding Against Unauthorized Consumption

Tracking Unauthorized Consumption: uncovering when water is taken without payment

- Visual: “caught in the act” – this is hit or miss
- Billing records – unusually low or zero water usage
- Tamper alerts from AMR or AMI systems



Billing trend for pizza shop showing many months of zero consumption

C. Guarding Against Unauthorized Consumption

Containing Unauthorized Consumption – a three-pronged approach

Policy – having clear, written regulations that define allowable water uses and uses that are not permitted

Detection – having the ability to detect unauthorized consumption if it occurs

Enforcement – assigning penalties and having means to prevent unauthorized consumption from continuing

Fire Hydrant Usage

<u>Good Policy</u>

Bulk Water Station for selling water to fill tanks on trucks rather than from hydrants

<u>Questionable Policy</u>

Fire hydrant spray caps

Source: New York Daily News

C. Guarding Against Unauthorized Consumption – KNOWLEDGE CHECK

True or False: AMR and AMI systems feature alerts that automatically detect and flag tampering of meters and meter reading equipment?

True

False

C. Guarding Against Unauthorized Consumption: KNOWLEDGE CHECK

Which of the below items is not one of the steps water utilities should take to guard against unauthorized consumption?

a. Policy

b. Detection

c. Fire hydrant spray caps

d. Enforcement

Module 3 Summary

Reviewing your billing policy and procedures is perhaps the most important thing you can do to control apparent losses from billing error.

Compiling your billing data in regular reports and analyzing the data can point you to sources of apparent loss.

Unauthorized consumption can occur to some extent in any system, and you should be on the alert to this possibility and the ways to contain it.

Onward to the final part of Course 4

Course 4 Summary

Water utilities measure customer consumption and use it as a basis for billing; accurate metering and billing should produce a reliable revenue stream for your utility.

Water metering and meter reading technologies are continuously advancing and offer water utilities many advantages in keeping apparent losses to a minimum.

Strong policy and procedures are essential to an efficient billing process and addressing unauthorized consumption.

Water utilities will protect their revenue base if they monitor apparent losses and keep them to a minimum.

Course 4

Final Assessment Questions

(See accompanying list)

DISINFECTION BASICS – ELXX, 2nd Ed

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Course 5 Preview

Sustaining the Non-revenue Water Management Program

This course covers the best ways to sustain a successful water loss control program, including:

- Knowing that losses will keep growing if you don’t have a water loss control program in effect.
- How to plan and budget for continuing loss control efforts
- How to monitor your progress and improve the program over time

Thank you for completing Course 4

AWWA eLearning

Customer Metering and Billing Operations for Optimized Revenue Capture