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ESTABLISHING A METERING PLAN TO ACCOUNT FOR WATER USE AND LOSS

Potable Water

Establishing a Metering Plan to Account for Water Use and Loss

This document is the fifth in a series of best practices related to the delivery of potable water to the public. For titles of other best practices in this and other series, please refer to *www.infraguide.ca.*

National Guide to Sustainable Municipal Infrastructure

NRC · CNRC
Federation of Canadian Municipalities
Canada

Establishing a Metering Plan to Account for Water Use and Loss

Issue No. 1.0

Publication Date: September 2003

INTRODUCTION

InfraGuide – Innovations and Best Practices

Why Canada Needs InfraGuide

Canadian municipalities spend $12 to $15 billion annually on infrastructure but it never seems to be enough. Existing infrastructure is ageing while demand grows for more and better roads, and improved water and sewer systems responding both to higher standards of safety, health and environmental protection as well as population growth. The solution is to change the way we plan, design and manage infrastructure. Only by doing so can municipalities meet new demands within a fiscally responsible and environmentally sustainable framework, while preserving our quality of life.

This is what the National Guide to Sustainable Municipal Infrastructure (InfraGuide) seeks to accomplish.

In 2001, the federal government, through its Infrastructure Canada Program (IC) and the National Research Council (NRC), joined forces with the Federation of Canadian Municipalities (FCM) to create the National Guide to Sustainable Municipal Infrastructure (InfraGuide). InfraGuide is both a new, national network of people and a growing collection of published best practice documents for use by decision makers and technical personnel in the public and private sectors. Based on Canadian experience and research, the reports set out the best practices to support sustainable municipal infrastructure decisions and actions in six key areas: 1) municipal roads and sidewalks 2) potable water 3) storm and wastewater 4) decision making and investment planning 5) environmental protocols and 6) transit. The best practices are available on-line and in hard copy.

A Knowledge Network of Excellence

InfraGuide's creation is made possible through $12.5 million from Infrastructure Canada, in-kind contributions from various facets of the industry, technical resources, the collaborative effort of municipal practitioners, researchers and other experts, and a host of volunteers throughout the country. By gathering and synthesizing the best Canadian experience and knowledge, InfraGuide helps municipalities get the maximum return on every dollar they spend on infrastructure – while being mindful of the social and environmental implications of their decisions.

Volunteer technical committees and working groups — with the assistance of consultants and other stakeholders — are responsible for the research and publication of the best practices. This is a system of shared knowledge, shared responsibility and shared benefits. We urge you to become a part of the InfraGuide Network of Excellence. Whether you are a municipal plant operator, a planner or a municipal councillor, your input is critical to the quality of our work.

Please join us.

Contact InfraGuide toll-free at **1-866-330-3350** or visit our Web site for more information. We look forward to working with you.

The InfraGuide Best Practices Focus

Potable Water

In keeping with the adage "out of sight, out of mind", the water distribution system has been neglected in many municipalities. Potable water best practices address various approaches to enhance a municipality's or water utility's ability to manage drinking water delivery in a way that ensures public health and safety at best value and on a sustainable basis. The up-to-date technical approaches and practices set out on key priority issues will assist municipalities and utilities in both decision making and best-in-class engineering and operational techniques. Issues such as water accountability, water use and loss, deterioration and inspection of distribution systems, renewal planning and technologies for rehabilitation of potable water systems and water quality in the distribution systems are examined.

Decision Making and Investment Planning

Elected officials and senior municipal administrators need a framework for articulating the value of infrastructure planning and maintenance, while balancing social, environmental and economic factors. Decision-making and investment planning best practices transform complex and technical material into non-technical principles and guidelines for decision making, and facilitate the realization of adequate funding over the life cycle of the infrastructure. Examples include protocols for determining costs and benefits associated with desired levels of service; and strategic benchmarks, indicators or reference points for investment policy and planning decisions.

Environmental Protocols

Environmental protocols focus on the interaction of natural systems and their effects on human quality of life in relation to municipal infrastructure delivery. Environmental elements and systems include land (including flora), water, air (including noise and light) and soil. Example practices include how to factor in environmental considerations in establishing the desired level of municipal infrastructure service; and definition of local environmental conditions, challenges and opportunities with respect to municipal infrastructure.

Storm and Wastewater

Ageing buried infrastructure, diminishing financial resources, stricter legislation for effluents, increasing public awareness of environmental impacts due to wastewater and contaminated stormwater are challenges that municipalities have to deal with. Storm and wastewater best practices deal with buried linear infrastructure as well as end of pipe treatment and management issues. Examples include ways to control and reduce inflow and infiltration; how to secure relevant and consistent data sets; how to inspect and assess condition and performance of collections systems; treatment plant optimization; and management of biosolids.

Transit

Urbanization places pressure on an eroding, ageing infrastructure, and raises concerns about declining air and water quality. Transit systems contribute to reducing traffic gridlock and improving road safety. Transit best practices address the need to improve supply, influence demand and make operational improvements with the least environmental impact, while meeting social and business needs.

Municipal Roads and Sidewalks

Sound decision making and preventive maintenance are essential to managing municipal pavement infrastructure cost effectively. Municipal roads and sidewalks best practices address two priorities: front-end planning and decision making to identify and manage pavement infrastructures as a component of the infrastructure system; and a preventive approach to slow the deterioration of existing roadways. Example topics include timely preventative maintenance of municipal roads; construction and rehabilitation of utility boxes; and progressive improvement of asphalt and concrete pavement repair practices.

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ACKNOWLEDGEMENTS

The dedication of individuals who volunteered their time and expertise in the interest of the *National Guide to Sustainable Municipal Infrastructure (InfraGuide)* is acknowledged and much appreciated.

This best practice was developed by stakeholders from Canadian municipalities and specialists from across Canada, based on information from a scan of municipal best practices and an extensive literature review. The following members of the National Guide's Potable Water Technical Committee provided guidance and direction in the development of this best practice. They were assisted by the Guide Directorate staff, by Associated Engineering, and by Veritec Consulting Inc.

Carl Yates, Chair
Halifax Regional Water Commission,
Nova Scotia

Fred Busch
Mayor, District of Sicamous, British Colombia

Sukhi Cheema
Government of the Northwest Territories

Normand DeAgostinis
Ductile Iron Research Pipe Association,
Anjou, Quebec

Tim Dennis
City of Toronto, Ontario

Dave Green
Health Canada, Ottawa, Ontario

Gordon Lefort
IPEX Inc., Langley, British Colombia

André Proulx
Delcan Corporation, Ottawa, Ontario

Diane Sacher
City of Winnipeg, Manitoba

Piero Salvo
WSA Trenchless Consultants Inc., Ottawa, Ontario

Ernie Ting
Town of Markham, Ontario

Michael Tobalt
Technical Advisor, NRC

In addition, the Potable Water Technical Committee would like to thank the following individuals for their participation in working groups and peer review:

John Braam
County of Oxford, Ontario

Ken Brothers
Halifax Regional Water Commission, Nova Scotia

Fred Busch
Mayor, District of Sicamous, British Colombia

Michel Chevalier
City of Ottawa, Ontario

Eric Jackson
Water and Wastewater Consultant,
Vernon, British Columbia

Tony LoConsolo
Region of Peel, Ontario

Mike Morin
EPCOR Water Services inc., Edmonton, Alberta

David Stoddart
Neptune Technology Group (Canada) Ltd.

Acknowledgements

This and other best practices could not have been developed without the leadership and guidance of the Project Steering Committee and the Technical Steering Committee of the *National Guide to Sustainable Municipal Infrastructure*, whose memberships are as follows:

Project Steering Committee:

Mike Badham, Chair
City Councillor, Regina, Saskatchewan

Stuart Briese
Portage la Prairie, Manitoba

Bill Crowther
City of Toronto, Ontario

Jim D'Orazio
Greater Toronto Sewer and Watermain Contractors Association, Ontario

Derm Flynn
Mayor, Appleton, Newfoundland

David General
Cambridge Bay, Nunavut

Ralph Haas
University of Waterloo, Ontario

Barb Harris
Whitehorse, Yukon

Robert Hilton
Office of Infrastructure, Ottawa, Ontario

Joan Lougheed
City Councillor, Burlington, Ontario
Stakeholder Liaison Representative

René Morency
Régie des installations olympiques
Montréal, Quebec

Saeed Mirza
McGill University, Montréal, Quebec

Lee Nauss
City Councillor, Lunenburg, Nova Scotia

Ric Robertshaw
Region of Halton, Ontario

Dave Rudberg
City of Vancouver, British Columbia

Van Simonson
City of Saskatoon, Saskatchewan

Basil Stewart
Mayor, Summerside, Prince Edward Island

Serge Thériault
Department of Environment and Local Government, New Brunswick

Alec Waters
Alberta Transportation

Wally Wells
Dillon Consulting Ltd., Ontario

Technical Steering Committee:

Don Brynildsen
City of Vancouver, British Columbia

Al Cepas
City of Edmonton, Alberta

Andrew Cowan
City of Winnipeg, Manitoba

Tim Dennis
City of Toronto, Ontario

Kulvinder Dhillon
Province of Nova Scotia, Halifax, Nova Scotia

Wayne Green
City of Toronto, Ontario

John Hodgson
City of Edmonton, Alberta

Bob Lorimer
Lorimer & Associates, Whitehorse, Yukon

Betty Matthews-Malone
Haldimand County, Ontario

Umendra Mital
City of Surrey, British Columbia

Anne-Marie Parent
Councillor, City of Montréal, Quebec

Piero Salvo
WSA Trenchless Consultants Inc., Ontario

Mike Sheflin
Former CAO, Regional Municipality of Ottawa-Carleton, Ontario

Konrad Siu
City of Edmonton, Alberta

Carl Yates
Halifax Regional Water Commission, Nova Scotia

EXECUTIVE SUMMARY

This best practice serves as a roadmap for water utilities in planning, implementing, operating, and managing a metering plan to account for use and loss in the water distribution system. It incorporates all aspects of water distribution metering from the raw water source to the end user.

The need for an efficient use of water, like for all natural resources, is independent of its possible abundance in a given community, as it requires the utilization of human and energy resources at multiple stages to draw, treat and distribute an adequate supply. Hence a universal metering program has a goal going beyond water economy; it is a tool to promote public awareness and encourage consumers to be more accountable towards the environment.

While there is a comprehensive list of reasons why utilities choose to meter, there are four underlying and fundamental drivers for universal metering: equity, water efficiency and environmental stewardship, economic management benefits and system management.

Not unlike the balance sheet used in general business accounting practices, utilities should complete a water balance to account for usage and loss in a distribution system. As with any accounting system, the information obtained or calculated is only as good as the information input. Hence, actual metered information will provide a more accurate evaluation of system performance and help utilities prioritize and manage water infrastructure programs more effectively.

The water meter provides the essential tool for both the utility and the consumer to measure and monitor consumption. According to Environment Canada[1], flat rate customers in Canada use 457 litres of water per capita per day compared to volume based customers who use only 269 litres per capita per day. As a result, universal metering has proven to reduce overall residential and industrial, commercial and institutional (ICI) water consumption by 15 to 30 percent.

In addition to a discussion of water accountability practices, this best practice provides a detailed technical overview of current metering and meter reading equipment. Guidelines on the sizing, selection, testing, and maintenance of meters, from raw water intake to the end user, form a major component of this best practice, and are provided with links to current industry standards.

While overall economic strategies will vary greatly across the country, this best practice provides key considerations to help individual utilities assess their priorities in developing these strategies. Establishing proper financing and rate structures to account for all fixed and variable costs is essential to ensure full cost recovery in the water system.

1. Environment Canada, July 2001 Report, *Municipal Water Pricing 1991-1999*, p. 10, http://www.ec.gc.ca/erad/

1. General

1.1 Introduction

This document details the best practice for establishing a metering plan to account for use and loss in the water distribution system. It was initiated following the development of InfraGuide's best practice, *Water Use and Loss in Water Distribution Systems*, which revealed that metering by the water utility is critical in accounting for water use and loss in the distribution system and warrants a separate best practice.

1.2 Scope

The objective is to provide utilities with a guide to the methods and technologies associated with the planning, installation, operation, and management phases of a metering plan.

This best practice incorporates all aspects of water distribution metering including source and production meters, distribution and district meters, and industrial, commercial, and institutional (ICI) and residential consumption meters. A discussion of water accountability practices provides utilities with answers to the questions: Why meter? Where should water be metered? How and where can water metering information be used? Guidelines on sizing and selecting meters, and choosing a meter reading technology for each part of the distribution system are provided along with recommendations for testing, calibration, and maintenance procedures. While overall economic strategies, such as rate structures and billing schedules, will vary greatly across the country, key considerations are provided to help assess the priorities of each utility in developing these strategies.

1.2.1 Links to Current Industry Best Practices on Water Metering

The American Water Works Association (AWWA), the American Water Works Association Research Foundation (AwwaRF), the International Water Association (IWA), and the Canadian Water and Wastewater Association (CWWA) are leading authorities in the water industry. Each organization provides valuable resources to water utilities and sets the standards from which this best practice was developed.

The objective is to provide utilities with a guide to the methods and technologies associated with the planning, installation, operation, and management phases of a metering plan.

1.3 Glossary

Backflow — The flowing back or reversal of the normal direction of water flow.

Backflow Prevention Device — A device that prevents backflow.

Best Practice — State of the art methodologies and technologies for municipal infrastructure planning, design, construction, management, assessment, maintenance and rehabilitation that consider local economic, environmental and social factors.

Couplings — Pipe fitting used to join two pipes together.

Data Logger — An electronic data storage device that records readings at predetermined intervals. Data is retrieved either through telemetry or direct connection with a computer.

District Metered Area (DMA) — A discrete area of a distribution system generally covering 25 km of watermain or 2,500 service connections with one or more metered inputs that is used to calculate and derive the levels of real losses.

Eddies — Areas of water swirling in a circular motion. Eddies are normally found in the turbulent area behind a blunt object placed in the flow path.

Full Cost Recovery — A practice which ensures that the total cost of providing any service is recovered.

GSM — Refers to the Global System for Mobile Communication. GSM is a registered trademark of the GSM Association.

ICI — Industrial, Commercial and Institutional.

In-situ — To be done in place. With reference to meter testing, it refers to testing the meter at the location of use as opposed to removing the meter and testing it on a test bench.

Non-Revenue Water — The difference between the system input volume and the billed authorized consumption.

Pressure Reducing Valve (PRV) — Valve used in a distribution system to decrease pressure from a higher pressure area to a lower pressure area.

Real Losses — Water that is produced and distributed but is physically lost from the distribution system up to the point of customer metering.

SCADA — Supervisory Control And Data Acquisition system.

System Input — Volume of water input to a transmission or distribution system.

Transducers — Device which produces an output signal in response to a different sort of input signal.

Turndown Ratio — The ratio between the minimum flow and maximum flow measurement capabilities of a water meter.

Water Audit / Balance — An evaluation calculation that quantifies volumes of water into the system, authorized consumption (billed and unbilled, metered and unmetered) and water losses (apparent and real).

2. Rationale

Full cost recovery is a common theme among utilities across Canada. To achieve full cost recovery, water utilities should adopt practices similar to manufacturing businesses, accounting for raw materials from start to finish. Water meters throughout the distribution system can be compared to weight scales, serving as a key component of the business accounting system.

An effective means of accounting for water use and loss is critical for the efficient operation and management of water supply and distribution systems. Accurate and timely water use measurement is the primary means used by water utilities to:

- create equitable charge-out rates for customers;
- reduce water use wastage;
- promote water efficiency;
- measure low and peak flow rates;
- minimize environmental impacts;
- minimize loads on wastewater facilities;
- measure use of water resource;
- generate revenue; and
- ensure future capital costs for the system are apportioned to users.

Metering is a generally accepted concept in achieving all or some of the above. It is also an important step in achieving full cost recovery and ensuring that potable water is appropriately valued and respected.

An effective means of accounting for water use and loss is critical for the efficient operation and management of water supply and distribution systems.

3. Understanding Metering in a Water Distribution System

As every day passes, we continue to hear how the supply of fresh potable water is a global concern. It is becoming ever more expensive to draw, treat, and distribute an adequate supply of potable water. As these costs continue to rise, managing our water supply and distribution infrastructure will be of utmost importance.

Metering how much water we draw, treat, distribute, and consume is now widely recognized in North America and around the world as a best management practice. This guide presents the merits, both technical and environmental, associated with universal metering. It also includes the current best practices associated with selecting, sizing, installing, reading, and maintaining water meters from the source to the end user.

3.1 Universal Metering

In its simplest definition, universal metering involves moving from a flat rate, or non-metered based, system of billing to a volume based metered user pay system. With a flat rate system, users who consume a high amount of water are billed the same amount as those who use only a little. With a metered system, consumers are billed for the metered volume of water they use.

The water meter provides the essential tool for both the utility and the consumer to measure and monitor consumption. According to Environment Canada, flat rate customers in Canada use 457 litres of water per capita per day compared to volume based customers who use only 269 litres per capita per day. Universal water metering has proven to reduce overall residential and ICI water consumption by 15 to 30 percent.

The water meter provides the essential tool for both the utility and the consumer to measure and monitor consumption.

While there is a comprehensive list of reasons why utilities choose to meter, there are four underlying and fundamental drivers for universal metering:

- equity;
- water efficiency and environmental stewardship;
- economic management benefits; and
- system management.

To achieve a long-term reduction in efficient and effective water use, universal metering should also be complemented with an appropriate pricing structure and a public education program to show consumers how to use water efficiently.

3.2 Why Meter?

3.2.1 Equity

Universal metering provides an equitable basis for charging individual users for the cost of water and the treatment of sewage. With a metered system, end users become directly accountable for their own water use and are charged an equitable price for the amount of water they consume. Under the principle of user pay, end users have an incentive to control their water use.

A properly designed user pay rate structure should encourage wise water use and ensure the utility recovers sufficient revenues to cover the full capital and operating cost of producing and distributing potable water. These rates should also take into account the cost of existing infrastructure depreciation.

The benefits of metering include water use segregation for system planning, performance monitoring, improved customer service, and improved distribution system operations.

Metered, user pay rate structures are the standard for most other commodities, such as electricity, natural gas, and fuel; this philosophy should be adopted by the water industry to implement a full cost recovery management plan for water treatment and distribution, and wastewater treatment and collection.

3.2.2 Water Efficiency and Environmental Stewardship

Water efficiency and universal metering programs go hand in hand. Often, the need for water use reduction is a primary driver of a universal metering program. Metered utility customers use less water and, therefore, universal metering can be used as a tool to sustain the existing source of supply, defer capital expansion of treatment facilities, or free up existing source supplies for new development.

Environmental benefits associated with a sustainable reduction in water use include the reduced use of chemicals for production, a reduced load for wastewater treatment plants, possible reductions in combined sewer overflows, energy savings, and sustainability of supply. Protecting our environment and source water supplies, whether ground or surface water, is an activity that provides due diligence for all utilities.

3.2.3 Economic Management Benefits of Metering

For many utilities, the decision to adopt universal metering is driven primarily by economics. Maximum day demand rates ultimately govern the sizing of water supply production facilities. By lowering the summer peak or the average annual demand, existing plant capacity can be used to support additional population growth, and the implementation schedule for plant expansion can be extended. In addition, an overall reduction in the water demand lowers operating costs for water and wastewater facilities.

3.2.4 System Management

System meters provide a powerful management tool that enhances a utility's ability to detect leaks in the distribution system, target specific areas in need of repair, and measure and identify the areas of real water loss.

Accurate water measurement is only one benefit associated with metering. Other benefits include water use segregation for system planning, performance monitoring, improved customer service, and improved distribution system operations.

3.3 Financial Options for Metering

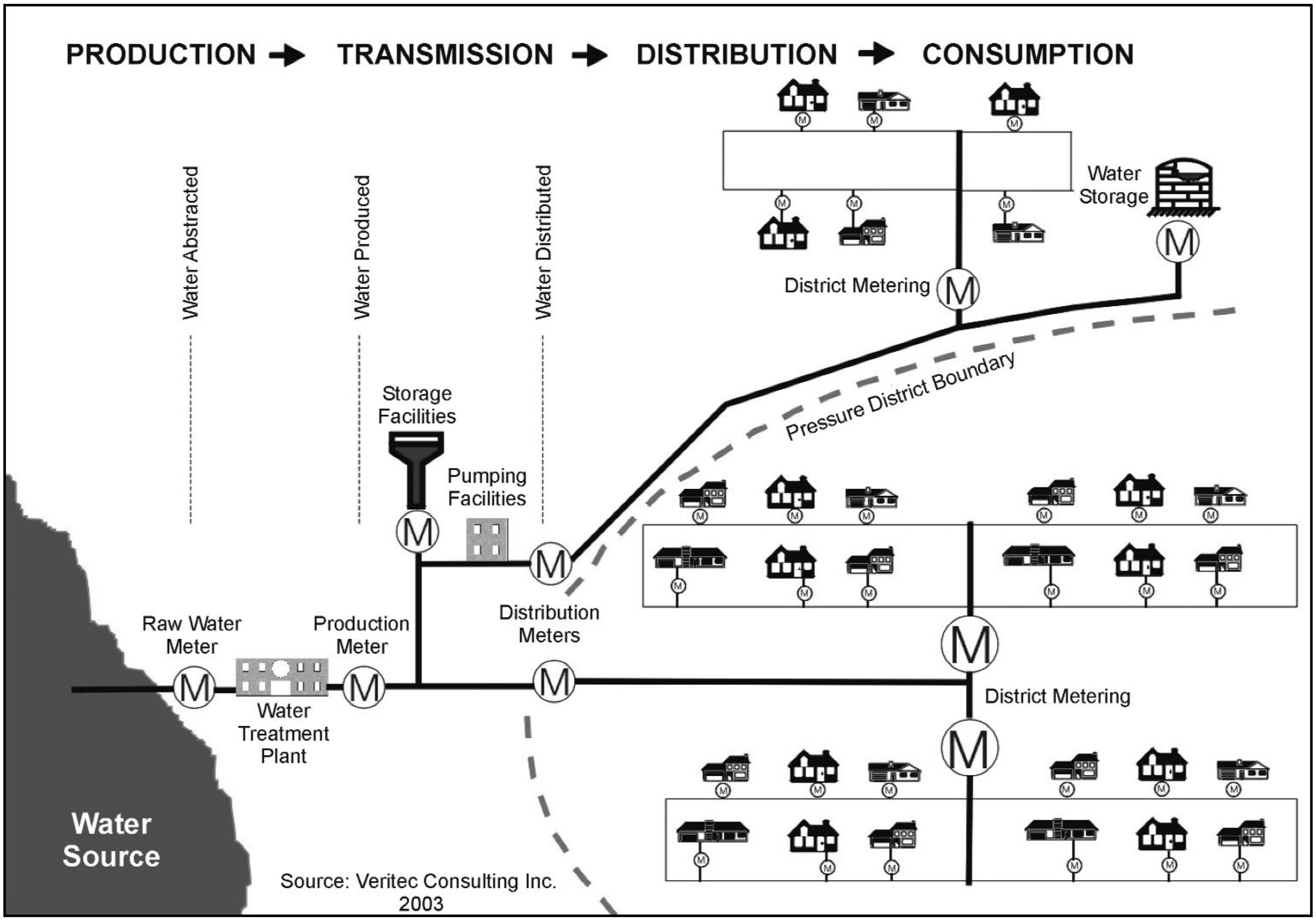
The most common funding practices include the following.

- *Universal metering reserve fund* — Part of the revenues collected from the flat rate structure is allocated to a specific universal metering fund.
- *User pay* — End users cover the supply and installation cost of the water meters, either up front or on utility bill financing.
- *Third party financing* — Many private companies offer supply and installation programs with appropriate financing options to amortize the universal metering program over several years.
- *Provincial and federal infrastructure programs* — Utilities may qualify for provincial and/or federal water infrastructure grants associated with the installation of water meters where it would reduce the need for more costly system expansions.
- *A combination of any of the above.*

The importance of proper financial planning and analysis before and following the implementation of a universal metering program cannot be overly stressed. A full cost recovery model should be followed by the utilities to ensure that all aspects of the water system are properly funded.

Figure 3-1 illustrates and provides the foundation for establishing a metering plan to account for water use and loss.

Figure 3-1: Metering in a water distribution system



3.4 Where Water Should Be Metered

A reliable metering plan to account for both water use and loss requires metering in all stages of water production, distribution, and consumption. It is recommended that water metering be carried out in the following areas:

- water withdrawal or raw water intake;
- production or treated water output;
- distribution;
- district metered area, and
- consumer or end users (large and small).

3.5 General Water Accountability Practices

Utilities should implement a comprehensive water audit, or water balance, to account for usage and to determine losses in a distribution system. As highlighted in the InfraGuide's Water Use and Loss in Water Distribution Systems best practice, a great deal of research has been done on the accounting process for water in a distribution system. The IWA Standard Water Balance provides the current best practice for water accountability.

Figure 3-1
Metering in a water distribution system

4. Strategies for Proper Metering and Appropriate Technologies

For the purposes of this guide, water meters are divided into two broad categories: supply meters and consumption meters. Supply meters are used to measure water delivered to all areas of the distribution system from the water source up to the consumption meter. Consumption meters, as the name implies, are used to measure water used for volumetric based customer billing.

4.1 Supply Meters

In general, supply meters are used in the following four applications.

A raw water meter measures the amount of water withdrawn from the water source, normally at the point of withdrawal. For surface water sources, it is normally installed at the high lift raw water pumping station; for groundwater systems at the well house. In systems with lengthy raw water transmission piping, a second raw water meter may be installed directly before the treatment facility to determine system loss in the raw water transmission piping.

A production water meter records the total amount of water produced and input into the distribution system. Production metering is best inserted just before water exits the treatment facility into the distribution system. Production metering is an essential operating parameter for treatment facility operation, and for distribution system operation and water accounting.

Source water meters act as both a raw water meter for water withdrawal and a production meter for treatment and system operation. Little or no water is used between the water withdrawal point and the production point. Source water meter installation is recommended at the exit of the treatment facility.

Distribution water meters are used to measure water movement within the distribution system. Obtaining and analyzing demand profiles in distribution systems can provide valuable information to improve operational factors, such as pumping and storage facility management. In addition, analyzing minimum night flows in district metered areas can prioritize water loss reduction efforts. Distribution metering should be installed at the following key points within a water system:

- *Municipal boundaries* — Any boundary between utilities, where water is imported or exported outside the jurisdiction should be metered.
- *Distribution facilities* — These include pumping stations, pressure reducing facilities, and storage facilities. System flow profiles, reservoir balancing, and real water loss calculations can be achieved with distribution system metering.
- *Pressure Management Areas (PMA)* — Similar to DMA's, boundaries between pressure areas or districts should be metered. This allows the utility to monitor input flows and demands, and identify areas within the entire system that may require more attention with respect to real water losses.
- *District Metered Areas (DMA)* — DMA's have been used in parts of the world for over 100 years, but have not traditionally been used in North America. The DMA approach is recognized as the best practice for distribution system leakage investigation and water loss control. With a DMA, a small portion of the water distribution system can be isolated with supply coming from a single or multiple feeds. Flows are recorded in a manner that allows the minimum night flow to be calculated to determine changes in input volumes that may indicate leakage.

Supply meters are used to measure water delivered to all areas of the distribution system from the water source up to the consumption meter. Consumption meters, as the name implies, are used to measure water used for volumetric based customer billing.

4. Strategies for Proper Metering and Appropriate Technologies

4.1 Supply Meters

Flow trends can provide valuable data for hydraulic analysis and system operational planning.

4.1.1 Types of Supply Meters

Several types of meters are used in a water supply system. Most provide a combination of volumetric and flow measurement. Both types of measurements should be included to register total amounts of water and to record flow rate trends. Flow trends can provide valuable data for hydraulic analysis and system operational planning. As well, the ability to obtain demand profiles is essential in district metering applications. The following meters are appropriate for all raw, production, source, and distribution meter applications.

Differential Pressure Flow Meters
Differential pressure meters include venturi style, V-cone and orifice plate designs. The principle of the differential pressure flow meter is to create a flow restriction where water velocity is increased at the restriction. Pressure readings are taken both upstream and at the restriction. The differential pressure reading between both points is directly proportional to the square of the flow.

Magnetic Flow Meters
Magnetic flow meters (mag meters) use the Faraday principle. A magnetic field is generated around the pipe where flowing water induces an electric current that is directly proportional to the velocity of the water.

Turbine and Propeller Flow Meters
These meters have rotor blades placed directly in the path of flowing water. When water strikes the blades, they rotate at a rate that is proportional to the flow velocity. Turbine meters have a rotor mounted on two central bearings. Propeller meters have a tapered propeller face that normally does not cover the entire pipe cross-section.

Ultrasonic Flow Meter
The ultrasonic flow meter is a non-intrusive device that uses a pair of transducers placed appropriately on the pipe such that an ultrasonic pulse is sent in the direction of flow, followed by a return pulse in the opposite direction. The principle is that the pulse along the flow will be faster than the return pulse. The time difference between the pulses is a function of the velocity of the water.

Vortex Flow Meter
The vortex flow meter utilizes a non-streamlined body placed directly in the middle of the pipe axis. This body splits the flow into two streams and creates eddies directly downstream of the meter. Eddies created by the low-pressure area behind the shedding element alternately rotate with the spacing between them being directly proportional to the velocity of the water.

Insertion Flow Meter
Several types of insertion flow meters use the same principles as the full bore flow meters. They include the pitot rod (differential pressure), turbine, magnetic (single and multi-point), paddle, and vortex insertion meters. Insertion meters measure the velocity of flow at a single point within the pipe and are installed through tap connections with an isolating valve.

4.1.2 Right Sizing and Selection of Supply Meters

In the selection of an appropriate flow meter, the old saying, "the right tool for the job" should apply. Each meter application is different with respect to pipe size, flow range, pumpage, pressure, location, and cost. All of these factors, including available budget should be considered when selecting the appropriate metering technology. Determining the following information beforehand will help in the meter selection process:

- upstream and downstream pressure requirements at the metering location;
- piping arrangement and size both upstream and downstream of the metering location;
- the minimum and maximum flow range expected, with fire flow considerations;
- minimum flow velocity considerations;
- level of meter accuracy required;
- available space for installation and maintenance;
- electrical availability at the metering location;
- the type of meter reading and signal generating device, if any; and
- the use and importance of recorded data in the day-to-day system operation.

Table 4-1 provides the advantages and disadvantages for each type of meter based on accuracy, flow range capability, pressure loss, installation requirements, and maintenance.

Table 4-1
Supply Meter Types Advantages and Disadvantages

Table 4-1: Supply Meter Types Advantages and Disadvantages

Meter Type	Advantages	Disadvantages
Venturi	Long life, primary element >30 yrs Transducer >10 yrs Low maintenance	Difficult to service primary element Installation costs may be high Requires more space to install Lower turndown ratio
Orifice plate	Low cost flow meter Easy to install and service Long life, primary element >30 yrs Transducer >10 yrs	High pressure loss Flow range may be too low More sensitive to pipe arrangement
Magnetic	Little or no pressure loss or flow obstruction Large range of sizes High flow turndown range (bi-directional) Not affected by minor flow disturbances	Requires electrical conductivity in water (not usually a problem in drinking water) Higher accuracy models become expensive
Propeller/Turbine	Large range of sizes Excellent accuracy – short term Broad range of flow Easy installation	High maintenance cost and frequent calibration required Can be expensive in large pipes Wear affected by water quality Very sensitive to flow disturbances
Ultrasonic	Non-intrusive with no friction loss No flow interruption during maintenance Very high range of flow (100:1) Low installation cost Cost effective for larger pipes	Very sensitive to physical fluid characteristics Very sensitive to flow profile changes Very sensitive to flow disturbances Affected by pipe wall condition and internal scaling Expensive in smaller pipe application
Vortex	Low head loss Very high turndown ratio Simple installation and maintenance Very good accuracy	Sensitive to flow profile disturbances Limited range of pipe sizes Slightly more expensive than other types of meters of same size
Insertion	Inexpensive in larger pipe applications No flow interruption during maintenance No measurable head loss Installation is simple and inexpensive	Very sensitive to flow profile and location of measurement Requires frequent calibration More sensitive to pipe arrangement

4.1.3 Supply Meter Installation

Once the meter type and size have been selected, it is important to follow proper meter installation requirements. The following recommendations apply to meter installation:

- Ensure a sufficient length of straight piping is provided both upstream and downstream of the meter.
- Do not place meters near bends, valves, or other fittings that can create a flow disturbance. Limit the number of couplings used in the upstream and downstream straight pipe run to the meter.
- Where an acceptable length of straight piping is not possible, use a flow straightener to reduce and limit the amount of flow disturbance. Pressure loss may be a factor with flow straighteners.
- Ensure that an appropriate piping arrangement is provided to ensure that in-situ meter accuracy testing can be completed.
- Ensure the installation provides sufficient room for proper maintenance of the meter and that proper safety precautions have been taken.
- Flow meter signal transmission and calibration to data capture or SCADA system should be verified.
- Wherever possible, an appropriate bypass assembly with isolating valve should be considered to ensure a continued supply during meter maintenance or replacement.

Most meter manufacturers provide standard installation drawings recommended for their products.

4.1.4 Supply Meter Reading Technologies

There are many meter recording, reading, and associated technologies in the marketplace today. To determine the best and most cost-effective solution, each water utility should determine how the data would be used in daily reporting and system operation. Larger systems often require continuous meter information, whereas very small systems may only require daily visual readings of the meter's volumetric odometer. A meter reading log is recommended at all sites.

The following options are presented to describe the various meter reading and recording technologies available. Each technology should be evaluated on an operational and cost-benefit basis to determine what is best suited for the water utility.

On-Site Data Logging
There are many data loggers available that are compatible and capable of recording the flow meter signal at the metering site. The main advantage of the data logger is that flow data is recorded electronically and can be downloaded to a host computer. Flow profiles can be graphed, flow anomalies studied, and volumetric totals compared between the logged data and the meter's odometer (if available) to ensure proper signal recording.

Telemetry Data Logging
Telemetry data logging uses the same approach as on-site logging; however, an automated data transfer is completed between the host computer and the data logger. There are several ways to complete the data transfer: standard land phone line and modems, cellular modems or GSM technology. In each case, the data transfer can be programmed to be automatic and can be initiated by the user at any time. This technology allows the utility to be one step closer to a continuous monitoring system.

SCADA
SCADA is an approach that is being adopted by water systems of all sizes. There are many operational advantages to having continuous data from strategic locations within the distribution system. A SCADA system captures operating information for the operator to analyze at a central, or remote location. These systems also provide automatic and manual control opportunities of pumps, PRVs, flow valves, reservoirs and other equipment.

AMR Meter Reading
AMR stands for automatic meter reading, which means the meter's volumetric total is read and transferred automatically. This includes phone read and radio read (RF) technologies. AMR technologies are described

To determine the best and most cost-effective solution, each water utility should determine how the data would be used in daily reporting and system operation.

The proper maintenance of any metering device is essential to ensure it operates at its specified accuracy.

in detail in section 4.2.4. AMR technology can be used on municipal boundary meters for billing purposes in systems that incorporate AMR technology in their meter billing systems.

A high level of meter reading and recording should be the goal of each utility. This helps achieve the highest standards in water measurement and allows knowledgeable system operators to enhance system operations.

4.1.5 Testing and Maintenance of Supply Meters

All too often, flow meters are installed and forgotten when it comes to routine maintenance and calibration. The proper maintenance of any metering device is essential to ensure it operates at its specified accuracy, and is of even greater importance for source and production meters.

Most meter manufacturers have a recommended maintenance and testing section in the operation manual for their meters. However, the following practices are also recommended.

Supply or Distribution Meters

- All supply system meters should be tested for accuracy at least once a year and calibrated as necessary.
- All meters should be tested in-situ. This allows the accuracy test to verify if any installation or meter placement issues exist that may be creating inaccuracies.
- A qualified service technician should test all meters with a calibrated secondary metering device. A meter calibration program consists of verifying meter signal transmission and comparison between local and remote integrators.
- Meter testing results should be well documented and stored, for future reference and performance gauging of the measuring element. Examining trends in meter accuracy records may help identify and justify more frequent testing. It will also help identify when maintenance is required or when it is time to replace the metering device.
- Any recorded error should be logged and corrective action taken to adjust the recorded volumes. It is recommended to calibrate or replace the inaccurate meter. A correction factor may be applied to adjust for meter inaccuracies determined from calibration tests.

District Metered Area

With respect to DMA meters that use a temporary type of metering system, such as an insertion meter, the following procedure should be completed.

- Ensure site conditions have not changed by completing a velocity profile of the monitoring site each time the meter is used in the temporary location. If the meter is left for extended periods, velocity profiling should be completed every six months.
- Ensure the insertion meter is calibrated at an appropriate testing facility on a yearly basis to verify accuracy and identify any maintenance requirements.
- Ensure the signal transmission from the meter to the recording device is accurate.
- Any inaccuracies noted during routine maintenance should be logged and recorded for each temporary meter, and correction factors should be established for any data recorded.

In-Situ Testing

The most widely used and acceptable practices for in-situ testing of source, production, and distribution meters include the following.

Ultrasonic Flow Meter

An ultrasonic flow meter is installed directly upstream or downstream of the meter to be tested. Flow and volumes are compared between both meters. This test has several advantages: it is non-intrusive, easy to install and complete, it allows a meter to be tested under normal operating flows, and the test can be conducted over a long period of time. The disadvantages of this technique include the requirements for a proper piping arrangement, correct installation of the ultrasonic meter for accurate results, and obtaining on-site readings.

Insertion Flow Meter
The insertion flow meter is installed directly upstream or downstream of the meter to be tested. Insertion meters normally require a 50 mm (2 in.) full-bore tap with a full bore isolation valve for installation. There are several advantages: it is easy to install and complete, the meter can be tested under normal operating flows, and the test can be completed over a long period of time. Disadvantages include the need for a proper piping arrangement, and an accurate flow velocity profile test for the insertion meter positioning. The insertion meter should also be checked frequently for accuracy at an appropriate facility.

Portable Meter Test Rig
Another method to test meters in situ can be done by re-measuring flow from the in-situ meter downstream of the meter through a bank of calibrated test meters, installed on a portable test rig or trailer. Water to the distribution system is normally diverted though a meter bypass assembly to maintain the system supply. A set volume of water at predetermined low, medium, and high flow rates is discharged from the test rig. The set volume at each flow rate is compared to the recorded volume of the meter to be tested, and the average meter accuracy is determined. Advantages of this test are ease of installation, and accurate comparisons with the in-situ meter at the set test flow rates. The disadvantages include the water lost from the test rig discharge, the short duration of the test, and that the meter is tested at a predetermined flow rate and not at the normal operating flow rates.

The test methods listed above are only appropriate if suitable piping arrangements to install the test meters are available. The most appropriate testing methodology will depend on size of the meter to be tested.

4.2 Consumption Meters

Consumption meters are the most important meters within a water distribution system. They are the “weight scales” of the utility and provide customers with accurate water use information. Consumption meters provide for an equitable user pay system based on water consumed.

Selecting, sizing, reading, and maintaining consumption meters are the four most important components to properly manage a water system, including appropriate billing and the reduction of losses in a distribution system. Generally, there are two types of consumption meters: large and small. They are often treated differently with respect to the four components listed above.

Large Consumption Meter
The definition of a large meter may vary among utilities. For the purpose of this guide, a large meter is defined as any meter that has a line size of 38 mm (1 ½ in.) or greater. These meters are generally used in the ICI sector. In systems with over 20,000 accounts, it is not uncommon to have 20 percent of the ICI accounts constitute 80 percent of the water usage. In smaller systems, one ICI account can constitute over 50 percent of the entire water usage. Therefore, proper selection and maintenance of these meters is essential.

Small Consumption Meter
Small meters are defined as all meters equal to or less than 25 mm (1 in.) in line size. These meters are generally used in residential housing or small commercial accounts. It should be noted that in some water systems, small meters are often installed and forgotten with respect to routine maintenance and testing. Although the water used by residential accounts are relatively low when compared to ICI accounts, routine maintenance and periodic testing is still recommended as their overall water consumption is substantial.

4.2.1 Types of Consumption Meters

Consumption meters are generally required to record volumetric totals for billing purposes and overall water system management. Therefore, volumetric meters are used as opposed to flow meters. The following is a description of each type of consumption meter currently available.

Selecting, sizing, reading, and maintaining consumption meters are the four most important components to properly manage a water system.

In most cases, meters are sized and selected based on the size of the service line.

Positive Displacement
A volumetric meter that captures definite volumes of water in a chamber containing a piston or disk. The chamber water exits the meter and the piston or disk rotates to be filled again. The number of rotations of the measuring chambers is converted to the volumetric register.

Turbine and Propeller
These types of meters have rotor blades placed directly in the path of flowing water. When water strikes the blades, they rotate at a rate that is proportional to the flow velocity. Turbine meters have a rotor that generally fits the entire cross section of the pipe and is mounted on two central bearings. Propeller meters have a tapered propeller face that normally does not cover the entire pipe cross section. The rotor is mounted on one set of bearings located on the downstream side of the rotor.

Compound
Compound meters have both a positive displacement meter and a turbine meter within the same meter body. They are used in applications where a large variance between minimum flow and maximum flow occurs on a routine basis. Small flows are directed through the positive displacement-measuring element. When the flow rate reaches the maximum allowable flow for the positive displacement meter side, the resulting pressure drop allows a swing valve assembly to open and direct flow into the turbine side as well as the positive displacement side of the compound meter.

Magnetic
Magnetic meters use the Faraday principle. A magnetic field is generated around the pipe where flowing water induces an electric current that is directly proportional to the velocity of the water.

Velocity
The velocity water meter is a variant of the turbine meter. It operates like the paddlewheel on the back of a riverboat with the water traveling perpendicular to the rotational axis of the impeller. There are two types of velocity meters currently available: the single jet and the multi-jet.

Solid State
The solid-state meter has no moving parts. Water enters the fluidic oscillator through a nozzle that forms an accelerated jet. When the jet enters the flow chamber, it is initially drawn to one of the two diffuser walls. The jet travels along the wall and then exits the flow chamber. At this point, a small portion of the flow is caught in the feedback channel and returned to the base of the incoming jet. This causes the jet to flip to the other side of the chamber, where it travels along the other diffuser wall, and a small amount of water is returned via the other feedback channel to repeat the process. This oscillation between the diffuser walls continues while flow is present, and its frequency is proportional to the rate of flow through the chamber.

4.2.2 Right Sizing and Selection of Consumption Meters

The right sizing and selection of consumption meters is one of the most important and often overlooked steps in the metering process. In most cases, meters are sized and selected based on the size of the service line. Before establishing the recommendations for appropriate right sizing and selection of meters, three fundamental practices should be addressed.

- The utility (and not the premise owner) should own the water meter.
- The selection and sizing of the water meter should be determined by the utility. For larger meter selection and sizing, consultation with the property owner is suggested.
- There should be a consumption meter on each service connection.

In general, service lines and building plumbing are designed and sized to provide minimum head loss under maximum flow demand conditions. The current "customer" may have very different water consumption patterns that effect the appropriate meter size selection.

There are two steps involved with right sizing meters: establish the expected minimum and maximum flow range, and continue monitoring the demand pattern to ensure the meter size is still valid.

Meter selection should be based upon expected consumption profiles of the customer. Meter size may be much smaller than the service line size. The following points should be considered when sizing consumption meters:

- Consider the types and number of water using fixtures. Plumbing fixtures may or may not be efficient low flow units. A large number of fixtures can result in many staff using fixtures coincidentally and, therefore, a greater instantaneous demand rate.
- Water using processes may require water at a constant flow rate or only during short intervals. Water demand rates may vary, and processes may be controlled manually, by timers, or by demand.
- Landscape irrigation may be controlled manually or automatically. Automatic systems may employ timers or more complex systems that use the level of moisture in the soil (and local weather forecasts) to schedule irrigation periods.
- Consider the number of building occupants and hours of operation. Sites may have a number of staff that is on site simply to "check in" at certain times of the day.
- Consider peak flows. Staff may or may not take breaks (i.e., use washrooms), at coincidental times. This could either cause a big, short-term demand or spread the demand out over a longer period.
- Buildings with flush valve toilets should be fitted with a minimum 25 mm (1 in.) meter to prevent flow restrictions and impaired flush valve operation.
- When the site is subject to a significant range of demand flow, a compound meter is recommended.

Selecting the proper size and type of meter should be based upon the calculation of the foregoing, minimum and maximum flow rates, and selection from the meter manufacturers' sizing charts. This type of evaluation should also be performed during a change in customer (move or use change) and during meter maintenance change-out programs. Refer to Appendix B for a meter sizing guide table.

4.2.3 Consumption Meter Installation

Once a consumption meter of the right size has been selected, proper installation to ensure long life, optimum accuracy, and ease of maintenance is the next critical step. Installation of consumption meters can be categorized based on size.

Small Meters

In general, small meters are installed in residential dwellings. Where weather conditions permit, they should be installed at the property boundary outside the house in a meter pit. Meter pits allow for easy access to the meter, reduces tampering and records any leakage on the customers' supply piping. However, for most Canadian utilities this is not cost effective or possible due to the cold climate. Therefore, most small meters are installed inside the building immediately after the main shut-off valve.

The AWWA M6 manual provides an excellent reference detailing small meter installation for both inside and outside installations. The following points should be considered when looking at the installation of small consumption meters.

- Position the meter in a horizontal plane for optimum meter performance.
- Locate the meter so it is readily accessible for reading, servicing, and testing.

Once a consumption meter of the right size has been selected, proper installation to ensure long life, optimum accuracy, and ease of maintenance is the next critical step.

- It is recommended that electrical grounding to metallic water service pipes not be permitted. However, if it is permitted in certain jurisdictions, it should be completed before the meter inlet; and a grounding strap should be used during installation and maintenance to prevent accidental shock to meter service personnel.
- Protect the meter from freezing and other conditions that could damage the installation.
- Provide a high-quality inlet shut-off valve to allow for meter maintenance.
- Provide a shut-off valve on the outlet side of the meter to prevent water draining back when the meter is removed.
- Provide for minimum loss of pressure.
- Consider public safety, and design the installation to prevent accidents.
- There should a curb stop connection installed at the property line for every metered connection.
- Provide appropriate support when connecting the meter to a plastic service line to prevent excessive pipe deflection and material stress.
- Install adequate tampering safeguards to ensure that tampering of the meter or the register does not occur.
- Follow provincial plumbing codes at all times with respect to any requirements for backflow prevention and appropriate materials for installation.
- Provide meter installers with the proper training and tools to complete the work in a competent manner. Local guidelines may apply in certain provinces with respect to the level of training and certification required for meter installation.
- Provide public education programs and information to residents before the implementation of a universal metering program.

Large Meters

Larger meters should preferably be installed in a chamber at the property boundary. However, most large meters are installed inside the premise, due to cost considerations associated with the Canadian climate.

AWWA is the main source guide for proper installation of large meters. The meter manufacturer's specifications on installation should also be referenced for meter types not covered in the AWWA M6 manual.

Most of the general requirements listed above for smaller meters also apply for large meters. In addition, the following practices are recommended.

- If meters are to be installed inside the premise, ensure that access to the meter is always available for routine inspection and servicing.
- Provide an appropriate bypass assembly with the appropriate valves to ensure the premise is not left without water during periods of meter servicing or change-out.
- Ensure that the installation allows for future meter accuracy testing with an appropriate location for discharge of water during testing.
- Fire protection piping, complete with appropriate backflow prevention, should be located upstream of the meter.
- A strainer should be installed upstream of the meter for turbine, propeller, and compound meters to stop any larger debris from damaging it.
- Appropriate straight lengths of pipe, both upstream and downstream of the meter, should be provided according to the manufacturer's specifications to ensure maximum meter accuracy. Straight pipe length equivalent to 10 pipe diameters upstream and 5 downstream are typically referenced.

Appendix A contains detailed meter installation drawings for all sizes of water meters. These drawings have been provided to assist in setting standards for proper meter installations.

4.2.4 Consumption Meter Reading Technologies

Appropriate reading methods can minimize reading costs and provide timely data to the utility. This requires an understanding of each available reading technology and a cost-benefit analysis to determine the most suitable reading method. The following is a short description of the reading technologies currently available.

Direct Read
The water meter is read directly from the register on the meter. A meter reader records the odometer reading manually through visual inspection.

Remote Pulser Read
The water meter reading is still recorded manually, by a meter reader. However, an outside odometer is provided so the reading can be obtained without entering the premise.

Automatic Remote Read
The meter is read at an outside remote device, but is recorded automatically using a hand-held interface. A probe is either attached or touched to the outside remote device, and the meter reading is captured and stored in the hand-held computer. There are three types of automatic remote reading technologies: a prong connection (similar to an electrical socket connection), a touch connection where the tip of the probe touches the outside remote device (touchpad), and a proximity read where the probe needs only to be in close proximity of the outside remote device.

Telephone Read
The water meter register is connected to an interface unit that has access to a telephone landline. The meter is read automatically through the phone line connection. The process can be fully automated. There are two types of telephone reading systems: inbound and outbound connections.

Radio Frequency Read
The meter is connected to a transponder unit that transmits the meter reading via a radio frequency (RF) signal. The transponder is activated automatically by an outside transmitter/receiver. There are three types of RF reading approaches currently available: the walk-by where a meter reader walks down the street and collects the RF meter reading signals, the drive-by where the meter reader drives down the street and collects the RF meter reading signals in a properly equipped vehicle, and the fixed area network, which involves installing an infrastructure system that will collect the meter readings and transmit them to a central location via a network of receiving and transmitting stations. The fixed area network will fully automate the meter reading process.

Meter reading technologies are constantly evolving and new technologies are currently being considered and tested. Technologies such as cellular or GSM, power line and satellite reads may soon be introduced into the marketplace.

Table 4-2 highlights the advantages and disadvantages to each reading technology described above.

Meter reading technologies are constantly evolving and new technologies are currently being considered and tested.

4. **Strategies for Proper Metering and Appropriate Technologies**

4.2 Consumption Meters

Table 4-2
Consumption Meter Reading Technologies Advantages and Disadvantages

Table 4-2: Consumption Meter Reading Technologies Advantages and Disadvantages

Reading Technology	Advantages	Disadvantages
Direct read	■ Lower meter supply cost ■ Lower installation cost	■ Low read success rate ■ Need access to meter ■ Higher labour costs
Remote pulser read	■ No access to meter needed ■ Acceptable read success rate	■ Higher supply and installation costs ■ Higher maintenance of remote reader ■ Manual meter reading still required ■ Requires periodic verification between remote and actual meter register volume
Automatic remote read	■ No access to meter needed ■ High read success rate ■ Encoded signal thus captured read is from the meter register ■ Less labour required – more reads per day due to automated reading ■ Not affected by minor flow disturbances	■ Higher supply and installation costs ■ Higher maintenance or remote reader
Telephone read	■ No meter readers required ■ Can program unit to profile water use ■ Excellent read success rate	■ Requires access to land phone line ■ Higher supply costs
Radio read	■ Excellent read success rate ■ Can be fully automated with fixed area network ■ Lower labour costs	■ Higher supply and installation costs ■ Battery replacement and disposal issues ■ Large infrastructure set-up costs for fixed area network

There are several cost considerations related to the selection of a meter reading technology; meter type, installation, and reading costs. Moving from direct read to radio technology enables the utility to have more frequent and more accurate water meter readings; however, the initial cost of meter supply and installation may not provide an acceptable payback with respect to meter reading savings.

A detailed cost-benefit analysis should be completed to determine an appropriate meter reading strategy. A combination of technologies may be the most effective solution for some utilities. Currently, the automatic remote read option has been the most cost effective solution for most water utilities.

4.2.5 Testing and Maintenance of Consumption Meters

Accurate water meters are essential for customer equity and water system management. It is recommended that water meters be tested and maintained regularly to accurately measure volumetric water consumption. As meters age, they generally read low.

Water meter accuracy is affected by the following factors and therefore they should all be considered when evaluating a testing and maintenance program:

Volume
The registered volume of the meter as an indicator for testing frequency is an important factor. Meters using large water volumes account for large revenues. Testing these meters more frequently is recommended.

Age
The age of a meter is an important factor with respect to testing frequency. Large meters should be tested at a minimum every five years, with more frequent testing as the size increases. Small meters can often be left for longer periods before requiring testing or replacement.

Water Quality
Water quality can have a significant effect on the performance and lifespan of water meters. Utilities with harsher water conditions should consider increasing the frequency of meter maintenance programs.

Performance
The collection, recording, and periodic review of meter calibration performance test results will provide valuable meter performance data. This will help the utility determine the adequacy of the existing meter maintenance or replacement frequency.

Retail Cost of Water
The meter maintenance and testing frequency will be influenced by the equity concerns of the customer base, the retail cost of water and the cost of testing. Each water utility should assess the testing requirements, costs, and benefits of improved water registration and revenue collection when deciding on a meter-testing program.

The AWWA M6 manual entitled *Water Meters — Selection, Installation, Testing, and Maintenance*, recommends that an active meter testing and maintenance program be initiated to ensure fair and equitable metering to the customers. The manual provides all the necessary information to establish a pro-active water meter testing and maintenance program. Additional suggestions are provided below to enhance testing and maintenance programs.

New Water Meters
While the AWWA M6 manual recommends that all new meters be tested, it is not always a viable option. The manufacturer normally does this and warrants meter performance to AWWA new meter accuracy specifications.

It is recommended that batch testing of new water meters be considered on a statistically valid sample size to ensure quality and to set the accuracy benchmark for future testing to gauge meter performance.

It is recommended that water meters be tested and maintained regularly to accurately measure volumetric water consumption.

AWWA recommends that meters in service should be tested, on average, as follows:

Meter Size	Test Frequency
15 mm to 25 mm (5/8 in. to 1 in.)	Every 10 years
25 mm to 100 mm (1 in. to 4 in.)	Every 5 years
100 mm (4 in.) and larger	Every year

Small Meter Maintenance

The testing, maintenance and replacement frequency for small meters is often completed based on one of three different parameters. All of these parameters are acceptable and may vary from one utility to another based on the various factors listed earlier in this section. This guide presents all three factors in order that each utility can determine the most appropriate parameter for their situation.

Volume Base Testing, Maintenance and Replacement

Small water meters are warranted from most manufacturers not only on age but also on total volume registered. The reasoning behind volume base testing is that the more a meter is used the more it wears and often the registered volume governs the meter warranty. Therefore recording and analyzing water meter registered volume is essential. In order to determine the appropriate volumes for testing and replacement, statistical sampling on water meters should be conducted in order to establish a volume vs. accuracy curve. The result will identify the most appropriate total registered volumes for meter testing and replacement.

Time Base Testing, Maintenance and Replacement

AWWA standards recommend a testing interval of 10 years be used for small meters as a starting point. In order to determine the most cost-effective testing and replacement interval, testing of a representative sample of residential water meters should be considered to establish an accuracy vs. time curve. The representative sample should be statistically valid so accuracy results can be applied to the entire meter population. Based on these results, a detailed protocol based on age of meter can be established for the testing and replacement frequency best suited for the utility.

Random Statistical Sampling

The reasoning behind random sample testing is based on ensuring the continued performance of the utility's smaller water meters. Any deterioration of accuracy can result in inequity to customers and should be identified as soon as possible. The random selection of the sample will ensure the meters are tested and performing in accordance with the manufacturer's warranty at all stages. Documentation records for meters not performing to this standard can support the utility's position for warranty claims to the meter manufacturer. The random sampling will also establish the criteria, based on both age and registered volumes, to cost effectively justify meter replacement schedules.

To test small meters, two methods are most commonly used to determine meter accuracy. They are:

Calibrated Meter Test Bench

Residential meters are removed and placed on a meter test bench. Normally, several meters are tested together. The accuracy of the meter is measured against a known volume of water in an accompanying tank.

Mobile Meter Tester

The residential meter is tested in-situ against a calibrated meter. The accuracy is determined by straight comparison of the volume registered on the meter with that registered on the calibrated test meter.

Large Meter Maintenance

It is advisable to provide for more frequent tests of large meters on the basis that an error in their registration has a greater effect on customer equity, utility credibility and on revenue issues. Older meters and those registering the largest volume should be given priority, since they generally read low. Mechanical drive meters require more frequent maintenance and show increased wear tendency compared to magnetic drive meters.

When testing large meters, it is desirable to test them in-situ. In doing so, any problems with the meter setting installation that could affect accuracy are identified quickly. This is especially important in the installation of turbine meters where improper meter settings have caused meters to be in error. This process allows for the identification of theft, unauthorized use, and authorized un-metered water.

Even with proper installation, water meters may be inaccurate when subjected to flow rates outside their designed range. Overall accuracy is improved if the majority of the flow volume occurs within the design flow range. Flow rates that occur above or below the range result in low accuracy levels.

The following large meter testing provisions are recommended:

- Review the consumption history to determine if the meter is over or under-sized.
- If a sizing issue is suspected, complete a building inspection to determine expected usage or complete a detailed profile on the existing meter.
- If the meter is not the right size, change the meter to the proper size.
- If the meter is properly sized, continue with routine maintenance and testing.
- Test the meter using an insertion meter or portable test rig.
- Test the meter's accuracy at leak flow (minimum flow), low flow, intermediate flow, and high flow. Complete a weighted accuracy reading based on the average recorded volume.
- If the test result determines the meter is outside acceptable accuracy limits, replace or refurbish the meter.
- If the meter is refurbished, complete another accuracy test to ensure the servicing work has corrected the meter error within acceptable accuracy limits.
- Ensure all test results and servicing are properly logged and recorded for future reference and for tracking purposes.

Each water utility should establish accuracy limits with respect to the relevant customer equity issues. The level of proactive meter maintenance and frequency of testing should be based on water system economics and the minimum best practices highlighted in this guide.

Even with proper installation, water meters may be inaccurate when subjected to flow rates outside their designed range.

5. Applications and Limitations

5.1 Fire Line Servicing and Metering

Section 4 of this guide did not specifically address the issue of fire line servicing and metering. Metering of combined fire and customer service lines is recommended. The selection of the appropriate meter and associated equipment may require professional advice. Flow detection valves should be considered to determine if consumption usage on the fire line is present.

The use of portable fire hydrant meters for the supply of potable water should only be permitted in special and temporary circumstances. Fire hydrant meters should be used in conjunction with appropriate backflow prevention devices based upon the risk assessment of the site.

5.2 Pricing and Rate Structures

Setting a rate structure to ensure full cost recovery and adequate revenues is essential for any universally metered system. In preparing a rate structure, there are two types of costs to consider: fixed and variable costs. There are also several types of rate structures available:

Fixed Rate
Users pay an equal amount for each unit of water consumed.

Increasing Block
Users pay an equal amount for each unit of water consumed up to a maximum, at which point a new higher unit rate is applied for each additional unit of water consumed. Several increasing blocks can be imposed.

Declining Block
Users pay an equal amount for each unit of water consumed up to a maximum, at which point a new lower unit rate is applied for each additional unit of water consumed. Several decreasing blocks can be imposed.

Seasonal Pricing
In this variation of the fixed rate, users pay an equal amount for each unit of water consumed; however, the unit rate will vary based on the season. The rate is normally higher in the summer months to try and curb peak demands due to dry weather irrigation and recreational use.

Fixed Cost Plus Rate
The user is charged a minimum amount regardless of consumption to cover specific fixed costs for operating the system and then charged a rate per unit of water consumed based on one of the structures listed above.

There are several variations to the rate structures listed above; however, they are the most common ones used. Each water utility should conduct a rate structure study to determine the most appropriate scenario for their system.

5.3 Reading and Billing

There are several factors to consider when deciding on a reading and billing scenario for a universally metered system. Which department will be responsible for the reading and billing? Should the reading and billing be completed in-house or outsourced? What reading and billing frequency should be adopted? What type of reading and billing system to use?

To answer these questions, each utility needs to establish the costs associated with the reading and billing process. This will help identify the most cost-effective method for the utility. Usually, the finance department is responsible for the billing, reading, and collection activities.

5. Applications and Limitations

5.3 Reading and Billing

Customer consumption volumes and demand rates are important to the other utility department operators. These include plant/production, system operators, engineering and planning, and for annual water audits.

The reading and billing information should advise users of their consumption volume in a timely fashion. Noting consumption changes and highlighting red flags in the reading and billing process will help identify possible meter inaccuracy and potential usage issues, such as leakage, and enhance customer understanding and relations.

The utility should also bill frequently enough to ensure a proper cash flow for system operation. It is recommended that residential and small commercial users be billed quarterly or more frequently if economically viable. Large users should be billed on a monthly or more frequent basis.

6. Evaluation

In order that utilities can gauge and evaluate themselves with respect to the recommendations presented in this guide, the following highlights considerations for the implementation of a metering plan to account for water use and loss.

Water Source
Water extracted from any source should be metered. If advanced treatment is used, treated water production should also be metered. A proper meter testing and maintenance program should also be established for these meters.

Distribution Meters
An evaluation of the merits associated with the use of distribution meters should be completed. If distribution meters are justified, an evaluation of the proper meter selection and installation should be completed. With the distribution meters in place, a pro-active meter testing and maintenance program should be established.

Consumption Meters
Large Meters — Large volume users, such as ICI accounts should be metered. Proper sizing, selection and installation of large meters should be evaluated. A pro-active meter-testing program should be implemented to provide appropriate equity amongst the customer base. An appropriate reading and billing program should be established to ensure full cost recovery and proper cash flow for the utility.

Small Meters — An evaluation should be completed to justify universal metering. If justified, small meter selection and installation guidelines should be established. An appropriate small meter maintenance program should be considered and a reading and billing program ensuring full cost recovery and appropriate customer service levels should be implemented.

If distribution meters are justified, an evaluation of the proper meter selection and installation should be completed.

Appendix A:
Standard Meter Installation Drawings

Please note that the following resources can be contacted to obtain a complete set of the standard meter installations drawings for each particular utility. For this best practice document, only the standard drawings from the City of Ottawa are presented for illustrative purposes.

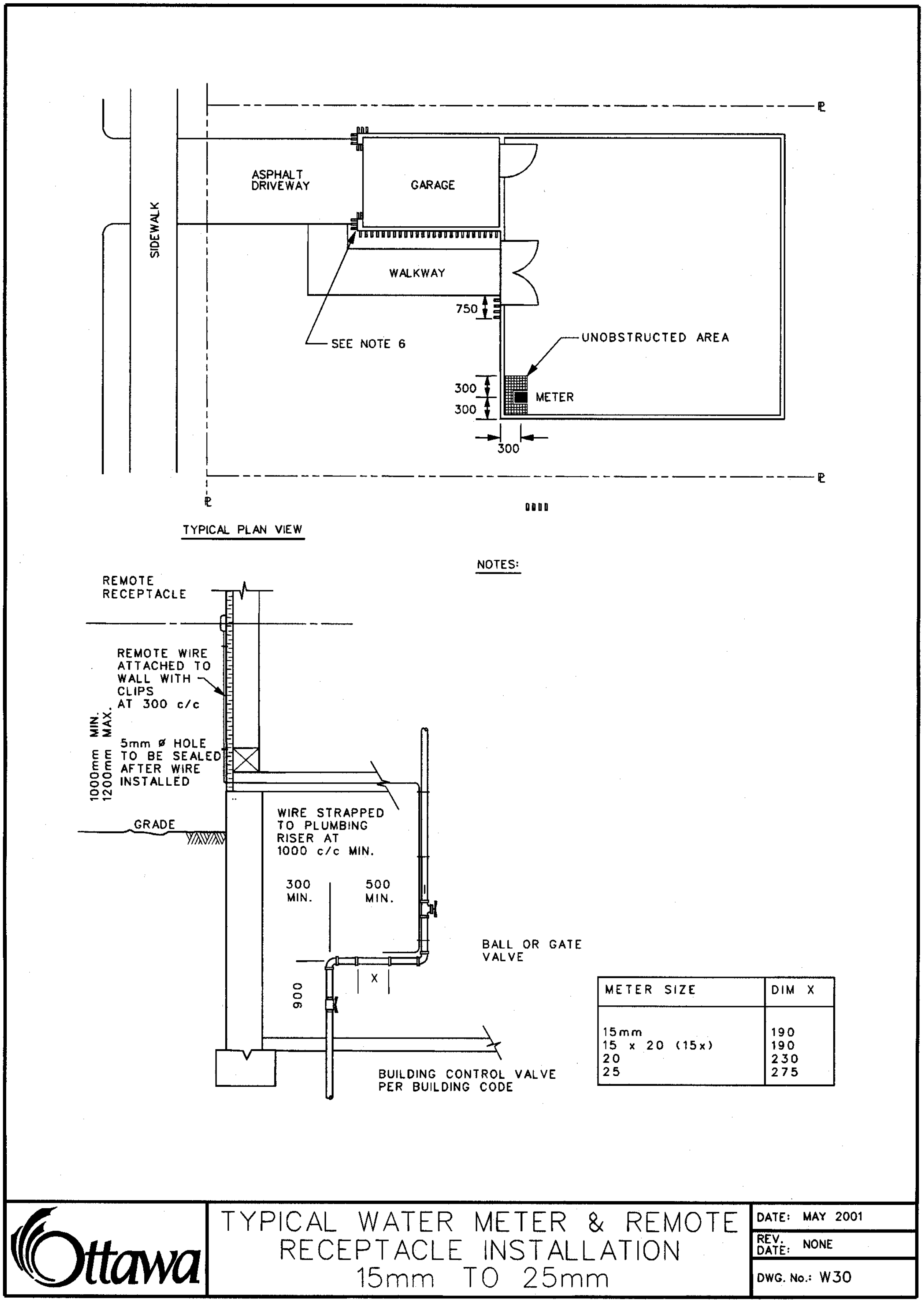
Contacts:

A. (Tony) LoConsolo, C.E.T.
Manager, Financial Services Meter Operations
Regional Municipality of Peel –
Finance Department
2 Copper Rd.
Brampton, Ontario – L6T 4W5
Tel: (905) 791-5997, Ext. 3229
Fax: (905) 450-8286
E-mail: *loconsolot@region.peel.on.ca*

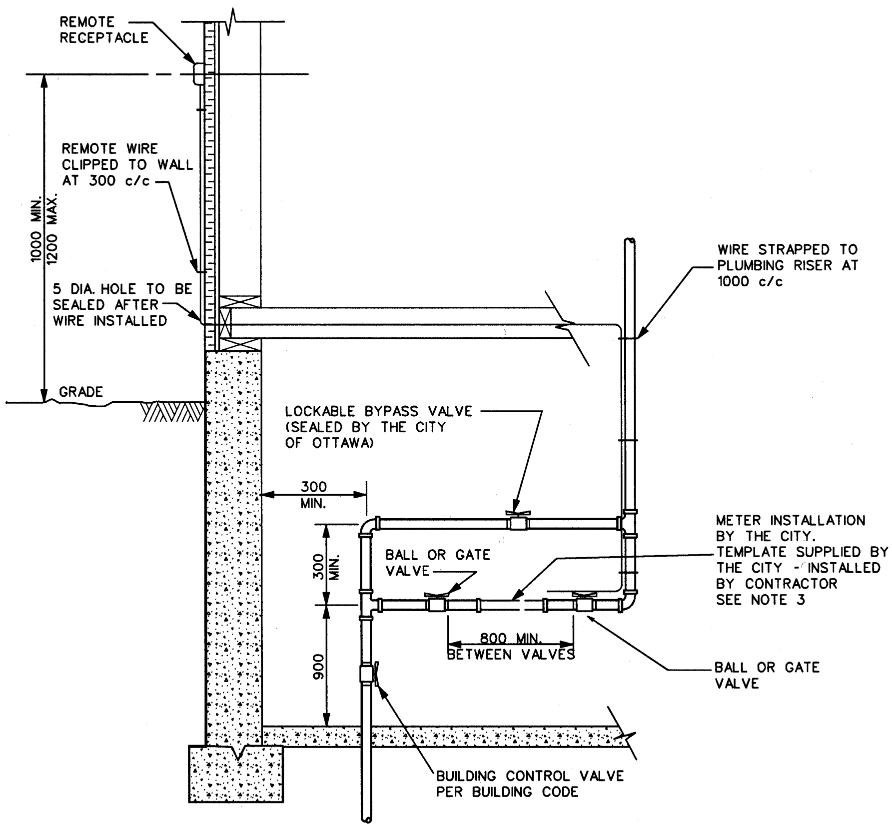
Mike Morin, R.E.T.
Distribution Specialist
EPCOR Water Services –
Network Services Section
10065 Jasper Avenue
Edmonton, Alberta – T5J 3B1
Tel: (780) 412-7630
Fax: (780) 412-3460
E-mail: *mmorin@epcor.ca*

Michel Chevalier, P.Eng., MBA
Manager, Customer Services and
Operational Support
City of Ottawa – Utility Services Branch
951 Clyde Avenue
Ottawa, Ontario – K1Z 5A6
Tel: (613) 580-2424 Ext. 22335
Fax: (613) 728-4183
E-mail: *MichelChevalier@ottawa.ca*

A. Standard Meter Installation Drawings



METER SIZE	DIM X
15mm	190
15 x 20 (15x)	190
20	230
25	275

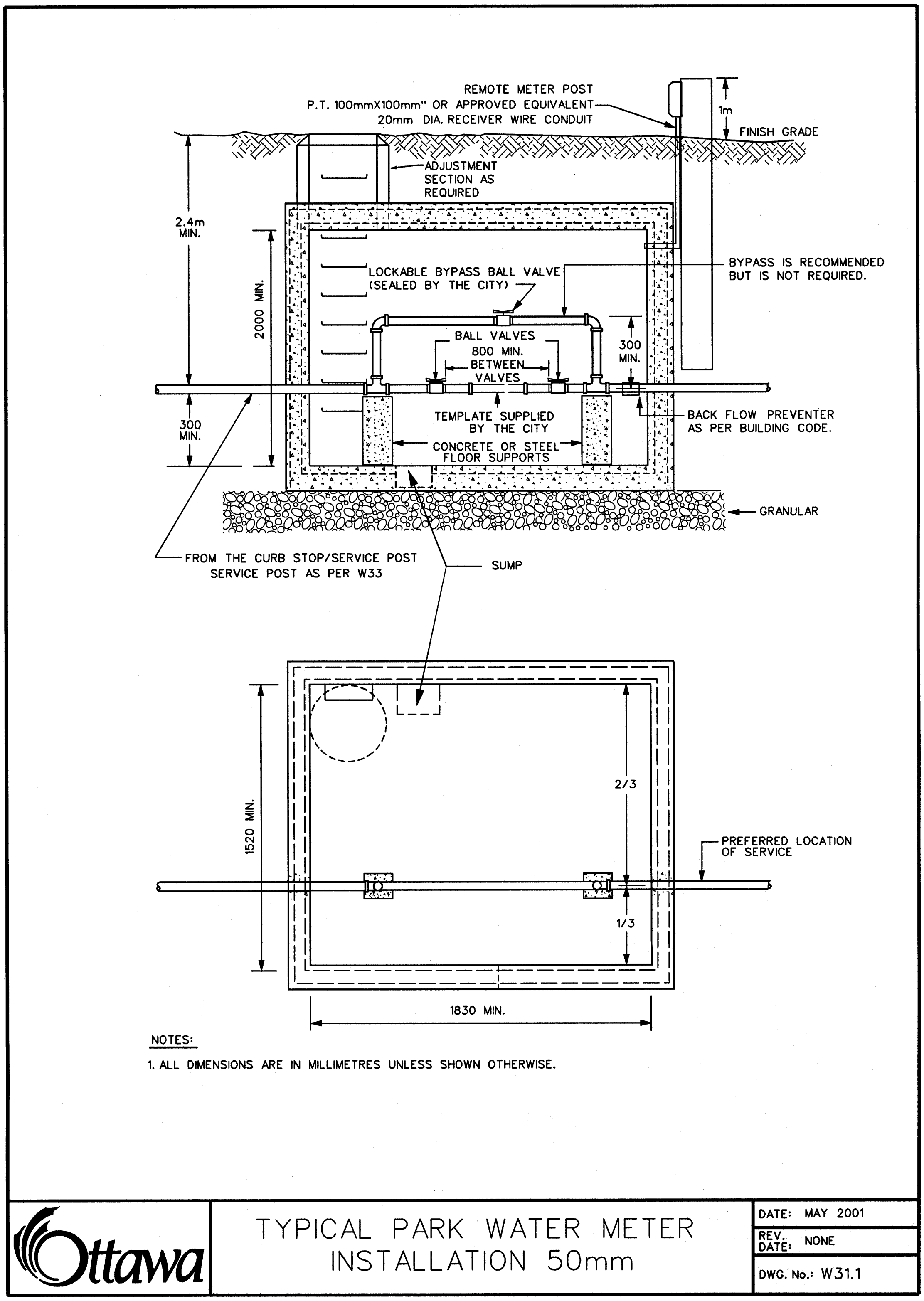


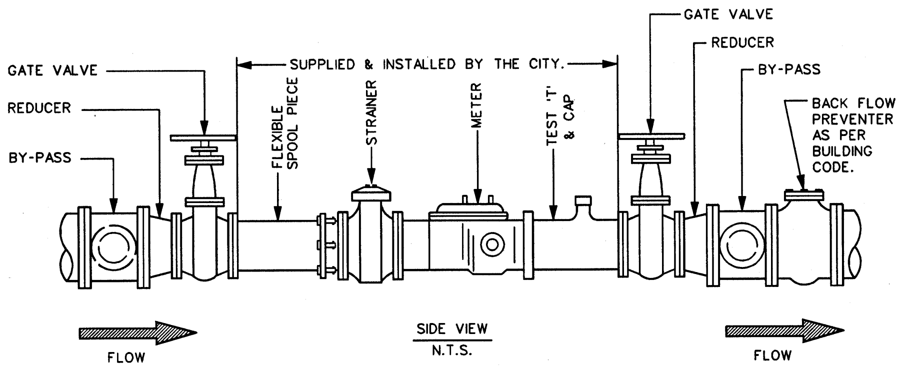
NOTES:

1- ALL DIMENSIONS IN MILLIMETERS UNLESS OTHERWISE NOTED.
2- METER SIZE & TYPE AS DETERMINED BY THE CITY - CITY TO SUPPLY TEMPLATE TO PLUMBING CONTRACTOR.
3- CONTRACTOR SHALL BE RESPONSIBLE FOR ALL PIPING & VALVES AND PROVIDE FLANGED ENDS TO MATCH CITY TEMPLATE.
4- METER MUST BE INSTALLED HORIZONTALLY.
5- ALL VALVES SHALL BE VISIBLE & ACCESSIBLE. BYPASS VALVE SHALL BE LOCKABLE BALL VALVE (OR SIMILAR)
6- ALL INSTALLATIONS SHALL HAVE REMOTE RECEPTACLE LOCATION APPROVED BY THE CITY.
7- THE DIAMETER OF THE BYPASS SHALL BE A MINIMUM OF HALF THE DIAMETER OF THE MAIN LINE.
8- A FREE AND UNOBSTRUCTED PASSAGEWAY MUST BE PROVIDED & MAINTAINED WITH NO PARTITION OR STORED MATERIAL WITHIN 500mm OF THE METER.
9- ALL MATERIALS TO BE IN ACCORDANCE WITH MW-19.15.

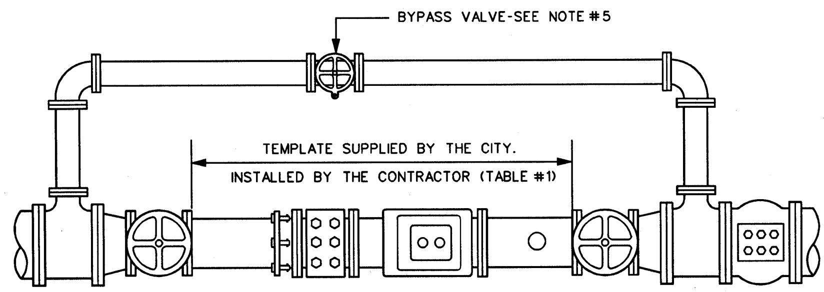
Ottawa	TYPICAL WATER METER & REMOTE RECEPTACLE INSTALLATION 40mm & 50mm	DATE: MAY 2001
		REV. DATE: NONE
		DWG. No.: W31

A. Standard Meter Installation Drawings





SIDE VIEW
N.T.S.



TOP VIEW
N.T.S.

TABLE #1

METER SIZE	TEMPLATE LENGTH
75	1300
100	1500
150	1800

NOTES:

1- ALL DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE INDICATED ON DRAWING.
2- METER SIZE & TYPE AS DETERMINED BY CITY - CITY TO SUPPLY TEMPLATE TO CONTRACTOR.
3- CONTRACTOR SHALL BE RESPONSIBLE FOR ALL PIPING & VALVES AND PROVIDE FLANGED ENDS TO MATCH CITY TEMPLATE.
4- METER MUST BE INSTALLED HORIZONTALLY.
5- ALL VALVES SHALL BE VISIBLE & ACCESSIBLE. BY-PASS VALVES SHALL BE LOCKABLE BALL VALVES. (OR EQUIVALENT).
6- ALL INSTALLATIONS SHALL HAVE A REMOTE RECEPTACLE-LOCATION APPROVED BY THE CITY.
7- THE BY-PASS LINE SHALL NOT BE LESS THAN 50mm DIA. OR HALF THE DIAMETER OF THE MAIN LINE, WHICHEVER IS GREATER.
8- GATE VALVES SHALL NOT BE SUBSTITUTED WITH BUTTERFLY VALVES. FULL PIPE FLOW IS NECESSARY FOR ACCURATE METER REGISTRATION.
9- A FREE AND UNOBSTRUCTED PASSAGEWAY MUST BE PROVIDED AND MAINTAINED WITH NO PARTITION OR STORED MATERIAL WITHIN 1000mm OF THE METER.
10- ALL MATERIALS TO BE IN ACCORDANCE WITH MW-19.15.

Ottawa	TYPICAL WATER METER INSTALLATION 75mm & LARGER	DATE: MAY 2001 REV. DATE: NONE DWG. No.: W32

Appendix B:
Consumption Meter Sizing Guide Table

Table B-1: Sample Water Meter Sizing Guide

Meter			Type of Use
Size	**Type**	**Flow Range**	
15 mm (5/8 in.)	PD	1 to 55 Lpm	Single family, duplex, small business (up to 10 staff)
20 mm (3/4 in.)	PD	2 to 110 Lpm	Large residences, homes w/ irrigation systems or swimming pools, apartment bldg w/o Laundromat (up to 6 units), barber shop, filling station w/o car wash, churches, small institutional
25 mm (1 in.)	PD	3 to 185 Lpm	Residences w/ pool and irrigation system, small to medium apartment building (6–17 units), small school (up to 200 students), institutional (up to 50 staff), churches w/ social activities, small motels (up to 10 units), large individual commercials, beauty parlor, group of commercials (up to 10 units)
38 mm (1.5 in.)	PD	5 to 375 Lpm	Apartment bldg (18–40 units), senior citizen apt bldg (up to 50 units), schools (up to 400 students), medium-sized hotels (up to 30 units), motels (up to 40 units), large filling stations w/o automatic car wash, small processing plants, small shopping centres, medium Laundromats or cleaners, restaurants, small hospitals (up to 100 beds), medical bldgs
50 mm (2 in.)	PD	7 to 600 Lpm	Medium apartment bldg (41–120 units), row houses condominium (41–80 units), schools w/ small irrigation (up to 2000 students), medium-sized hospitals or shopping centres, medium hotels or motels, large filling station w/ garage
50 mm (2 in.)	Compound	1 to 600 Lpm	Schools w/ irrigation (2000–5000 students), medium hospitals, community centres, nursing homes, city halls
50 mm (2 in.)	Turbine	15 to 600 Lpm	Can replace 50 mm (2 in.) PD meter, strainer recommended
75–100 mm (3–4 in.)	Compound	2 to 1600 Lpm	Condo complex or apartment bldg (120–350 units), large hotel or motel, hospital, office tower, schools (over 2500 students), large shopping centres, government bldg
75–100 mm (3–4 in.)	Turbine	40 to 1850 Lpm	Condo complex or apartment bldg (over 150 units), large Laundromats, large institutional, industrial plant, processing plant, hospital linen service, industrial cleaner

Note: PD = Positive displacement.
Lpm = Litres per minute.

Please note that this table is only a guide and should not be taken as correct for every situation. Proper sizing and profiling procedures as highlighted in Section 4.2.2 of this best practice should dictate the proper meter size.

References

American Water Works Association (AWWA), M36 Manual, *"Water Audits and Leak Detection"*, Second Edition, 1999.

AWWA, M6 Manual, "Water Meters – *Selection, Installation, Testing, and Maintenance"*, Fourth Edition, 1999.

Environment Canada, July 2001 Report, *Municipal Water Pricing 1991–1999*, p. 10, *http://www.ec.gc.ca/erad/*.

International Water Association, *"Performance Indicators for Water Supply Services"* Manual of Best Practice, IWA, 2000.

Thornton, Julian, *"Water Loss Control Manual"*, McGraw-Hill, 2002.

Notes