Water Efficiency

Water Plant Operator

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INTRODUCTION TO WATER EFFICIENCY

Rising costs, limited high quality drinking water supplies and environmental concerns are all important reasons for water efficiency.

Benefits of Water Efficiency

- Lower water costs due to lower use and fewer leaks.
- Lower energy costs for hot water.
- Delay the need for a municipality to build new treatment facilities, helping to control utility costs.

Water Costs Money

Increasing expenses are associated with a growing demand for municipal water. Costs include the construction and maintenance of infrastructure, pumping costs, treatment, and monitoring for both water and wastewater. All of these expenses will eventually be borne by taxpayers and/or water customers.

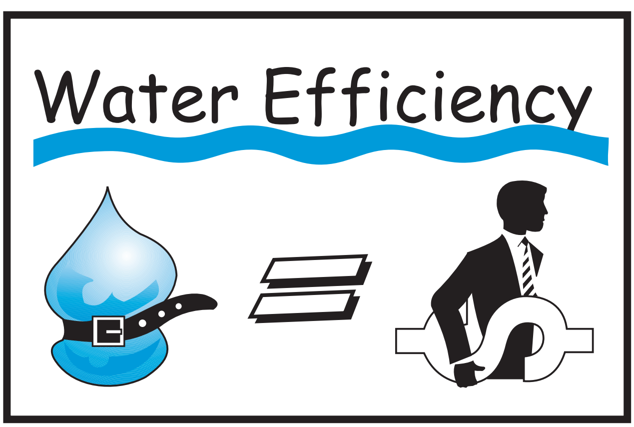
Environmental Impact of Water Use

The amount of water available for municipal use in Manitoba is diminishing, and available water sources have sometimes become contaminated as a result of natural or human activities. More efficient use of water will protect existing supplies for later years.

Water consumption puts pressure on the water body receiving treated wastewater. The effect of wastewater discharge depends on the amount and quality of the wastewater and the nature of the treatment. If a sewage treatment plant is overloaded, it will not adequately treat the wastewater.

Water Audit

A water audit will determine where water is used in your facility, and how much water use and leaks cost. Gathering this information is the first step toward implementing cost-effective solutions.



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BENEFITS OF A SYSTEM WATER AUDIT

A basic water audit will determine the efficiency of your water and wastewater systems. It gives decision makers facts they can use to prioritize spending on repairs and system renovations. Therefore, it is important to share the results of the audit with your CAO, council and community. Good budgeting decisions can only be made when they are based on facts. The most important sources of information and ideas are your employees, the people have the best working knowledge of the facility. Their experience and expertise regarding their building systems and use patterns are essential.

Various aspects of a water audit include:

- Facility audits
- Percent unaccounted-for-water determination
- Meter calibration
- Leak detection

A system water audit can be especially useful if you have:

- Expensive water or wastewater treatment
- Limited water availability
- Infrastructure use at or near capacity
- Discharge into a sensitive water body
- Low revenues from water
- Billing water meters over 15 years old, depending on local conditions and type of water meters
- System meters that are not calibrated annually
- Per capita consumption that has increased by over 10% in recent years

Benefits of reducing unaccounted-for-water include:

- Recovers production capacity that has been lost to leaks or unauthorized uses. The additional capacity may allow a utility to defer capital construction expenditures for new water supplies and water system expansion.
- Longer life of pumps and treatment equipment due to less use.
- Maintenance and operating costs can be reduced due to lower demand on equipment.
- Reduced liability (increasing due diligence) because of reduced possibility of:
  - contamination through a cross connection through the leak (hole) in the pipe
  - structural damage to nearby buildings or roads caused by washout or wetting of soil

UNACCOUNTED-FOR-WATER

What is Unaccounted-for-water?

Unaccounted-for-water is the difference between the amount of water a utility purchases or produces and the amount of water that it can account for in sales and other known uses for a given period. Both the age of the water system and the characteristics of the population served by the system can affect the amount of unaccounted-for-water. For example, a rural utility system with widely scattered customers is generally expected to have a higher percentage of unaccounted-for water due to the longer distances between customers. However, the quality of construction is such an important factor that a properly constructed older system may have less unaccounted-for-water than a newer system that was built with inferior materials or that was carelessly installed.

To accurately determine the amount of unaccounted-for-water, a utility must know the amount of water used by all of its customers and the amount of water produced by all of its production facilities. This requires that the system be completely metered. At minimum, utilities should analyze data over a 12-month period, preferably coinciding with the utilities' fiscal year. Using data from several years, if available, will increase the accuracy of the audit. The same unit of measure should be used for all production and use data, if possible. This will reduce the possibility of a mathematical error.

Total water produced for any one-year period	(1)_______
Total water sold for the same one-year period	(2)_______
Subtotal (line 1 minus line 2)	(3)_______

Estimate the amount of water used for authorized but unmetered water uses during the same one-year periods:

Fire fighting and training	____________	
Skating rinks (indoor and outdoor)	____________	
Curling rinks (outdoor and outdoor)	____________	
Water main flushing	_______	
Landscaping in public areas	_______	
Schools	_______	
Swimming pools (indoor and outdoor)	_______	
Use in other public buildings	_______	
Water truck tank filling	_______	
Construction	_______	
Storage tank drainage	_______	
Use by unmetered buildings	_______	
Sewer plant uses	_______	
Bleeders	_______	
Errors in record keeping	_______	
Estimated water theft	_______	
Other	_______	
Subtotal	_______	(4)_______

Total unaccounted-for-water (line 3 minus line 4) (5)_______

$$\frac{\text{Total unaccounted-for-water (line 5) x 100}}{\text{Total water produced (line 1)}} = \text{Percent unaccounted-for-water (6)}\_\_\_\_\_\%$$

Form 1. UNACCOUNTED-FOR WATER CALCULATION

STEP 1

- Verify accuracy of water production or purchase records and production system metering equipment

Ensure that when production records are compared with metered uses, the same exact time period is used. Otherwise, sudden increases or decreases in water use, such as lawn watering or water used for bleeding may result in faulty data comparisons, and therefore inaccurate estimates of unaccounted-for water.

STEP 2

- Determine unaccounted-for-water volumes

Record total volume of water conveyed to treatment plant (if not on a water pipeline.)

Record total volume of water treated and sent to distribution (total the volume of water produced or supplied to the distribution system, as measured by all master meters at wells and treatment facilities or points of purchase from other utilities.)

Correct for any inaccuracies found during system meter calibrations. In most cases, system meters should be calibrated once a year.

STEP 3

- Identify the volume of unaccounted-for water lost from the distribution system. Water loss estimates must be carefully prepared since this data is an essential part of the benefit/cost analysis.

You may wish to monitor late night flow (i.e., between 1:00 and 5:00 a.m.) to determine approximate volume of leakage. If water softeners are recharging, however, or industry has a continuous water use, this may not be helpful, unless those uses can be discontinued for the monitoring night, or the water use can be approximated.

STEP 4

- Identify, on an ongoing basis, sections of the distribution system with the most breaks.

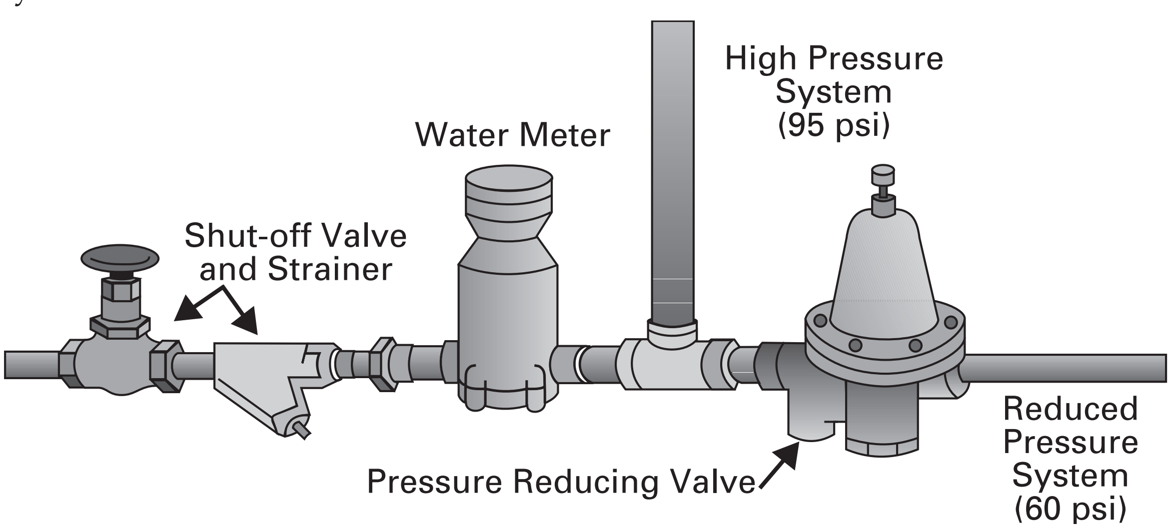
Tack a city street map on your wall. Every time there is a water main break, mark with a coloured pin (colour to indicate year of the break). This will help you identify your weakest areas at a glance.

STEP 5

- Meter examination to identify defective meters

Meter repair and replacement is often the single most cost-effective action that a utility can take to reduce the volume of unaccounted-for-water and therefore increase revenues to the facility.

If the average service age of meters is over seven years, spot checks of five percent of residential meters should be done regularly (yearly, randomly choosing meters each year) to ensure meter accuracy. If meters are incorrect, meters should be recalibrated or replaced. Meters can also be monitored for malfunction by checking for unusually high or low water use by customers. The average volume the meters are out should be corrected for in the metered numbers in your calculations for overall unaccounted-for-water.



AUDIT ANALYSIS

Determine how much of the identified water loss is recoverable. Then, using the cost of water to your community (water treatment, pumping costs, etc.), estimate the dollar value of that water. This money is simply seeping out of your system. Compare the cost of finding and repairing the leaks to the cost to the utility of the lost water and other associated costs, such as emergency leak repair.

You may also want to predict the probable future effects of not dealing with problem areas identified during the audit. For example, the worsening of leaks if system pressure is increased or higher future costs associated with emergency leak repairs, etc. may show immediate detection and repair to be more financially viable.

While utilities should strive to reduce unaccounted-for-water to a minimum, some loss is unavoidable. Losses of five (5) percent or less are considered excellent. This may be a cost effective goal if water is very scarce, water or wastewater treatment is very expensive, or system upgrades would be deferred. Ten (I0) to 15 percent is considered marginal for most municipal systems and is the point where serious efforts to determine the causes need to begin so that the situation does not get out of hand. Unaccounted-for-water rates above 15 percent for municipal systems and slightly higher (15%-18%) for widespread rural systems indicate the need for immediate actions.

Prioritize repairs, after deciding on criteria. Criteria may include:

- The amount of water lost in each problem area of the distribution system and the relative technical ease with which each zone may be repaired or upgraded.

- The amount of funds immediately available for leak repair. This is especially important in communities with an inadequate water

INDIVIDUAL METER RECORD	
METER LOCATION:	
DATE METER IN SERVICE:	
METER NUMBER.	
METER READING:	
LAST DATE TESTED:	
METER SIZE: 3/4" 1" 1 1/2" 2" 3" 4" 6" 8" 10" 12"	
BRAND OF METER:	
TYPE OF METER: TURBINE CLASS I _______ POSITIVE DISPLACEMENT/MULTI-JET _______ TURBINE CLASS II _______ COMPOUND _______	
REMARKS:	
PREPARED BY:	
DATE:	

Form 2. INDIVIDUAL METER RECORD

system budgeting process – where no matter how great the loss of finished water, the funds to fix the problem simply are not available because they have not been budgeted and rates are too low to generate needed additional revenue.

- The feasibility of detecting and repairing leaks using existing water utility staff people rather than outside consultants. In many communities this is not feasible because of pre-existing work loads, lack of technical capacity, and inadequate equipment. On the other hand, developing local expertise may be beneficial for long term by creating jobs in your community and possibly selling this service to other communities.

To account for maintenance costs attributable to unaccounted-for-water, maintenance cost per unit volume of water must be computed. Divide the total dollar amount of production-related maintenance expense for the audit period by the total water volume produced during the period. Most of the maintenance expense will be due to pump maintenance.

Multiply unit costs by the volume of unaccounted-for-water to determine total cost of unaccounted-for-water. Water lost due to leakage only results in the loss of production costs for that volume of water. However, unaccounted-for-water that is due to under-registering customer meters results in the loss of production costs and revenue from sales.

FINDING UNACCOUNTED FOR WATER

If the utility's unaccounted-for-water is considered high, a systematic plan to reduce the percentage of unaccounted-for-water to an acceptable level should be developed. Estimated costs should be developed and included for the major plan components. At a minimum, the plan should address the four major causes of unaccounted-for-water:

1. inadequate record keeping and unmetered uses;
2. unauthorized use;
3. under-registering and improperly sized meters; and
4. leaks.

1. RECORD KEEPING AND UNMETERED USES

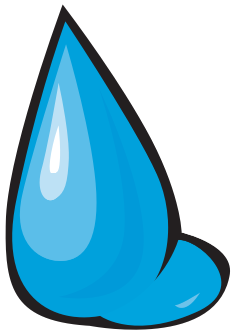
Accurate and detailed record keeping will help to identify much of a utility's unaccounted-for-water.

Record keeping includes three components:

- the utility's billing system and metered uses;
- estimates and records of unmetered water used by contractors, the fire department, street cleaning crews, and the utility for flushing water lines, draining or overflowing water tanks, or flushing and cleaning sewers; and
- records of known leaks and line breaks.

Record Keeping: Metered Use and Billing

The information obtained from a utility's meters and billing system is vital to many parts of its operation. Not only can this information be used to estimate unaccounted-for-water, but it is also the basis for billing, the utility’s revenue, and the characteristics of the utility's operations. Peak summer demand, changes in water use patterns, rate design, design information, and system stability all depend on accurate and up-to-date meter records. Good data management, including metered uses and billing records, is the heart and soul of a utility's record of where it has been and where it is going.



Good record keeping is an excellent way to keep track of both when water meters were installed and where and what type of meter problems are being found in the system. Form 1. INDIVIDUAL METER RECORD illustrates one method of keeping track of meters in the system. Computerized databases have replaced written forms in most modern systems, but the need for good record keeping will never be replaced.

With the advent of computerized billing systems, these records, in addition to allowing the utility to calculate its own unaccounted-for-water automatically, can be used to determine when customers may possibly have a leak or when their meters have begun to slow and need replacing. Many utilities now also use this information to print customer consumption history, conservation messages showing possible leaks or unusual use patterns, and other customized beneficial information.

Record Keeping: Unmetered Use

A utility should supply simple daily-usage forms to the fire department and other municipal departments to obtain monthly estimates of the amount of unmetered water that is used for public purposes. These uses include line flushing and fire fighting and training. To measure these flow rates, hand held pito tube gages or the "bucket and stop-watch" method can be used to estimate flow. These uses should be recorded and sent to the billing department.

Month: ________	**Tank size:** ____________
	1
	2
	3
	4
	5
	6
	7
	8
	9
	10
	11
	12
	13
	14
	15
	16
	17
	18
	19
	20
	21
	22
	23
	24
	25
	26
	27
	28
	29
	30
	31

Monthly Total: ____________

Form 3: WATER FOR FIRE FIGHTING AND TRAINING

Many utilities assign irrigation and construction contractors to specified hydrants that are metered and bill the contractor for water used on a monthly basis. The cost of a typical fire hydrant meter is approximately $1,700. The user could pay this for through a "recovery charge".

Record Keeping: Leakage and Line Breaks

In many distribution systems, one-half or more of the breaks and resulting leaks occur in as little as 10 percent of the system. To identify these problem areas, standard repair and maintenance reports are extremely important. The components where the leak or break occurs should be identified (i.e., main line valve, hydrant branch, main line, service pipe, tap and curb stop, corporation stop, etc.), and the type of pipe material should be specified. Consistent records of leaks and line breaks will allow the utility to determine what kinds of materials and which areas of the distribution system are losing most of the water. From these reports, a yearly compilation of all leaks and breaks can be made by geographic location, pipe material and type of component.

Alternately, a pin map can be used to track the geographic locations of leak and break repairs. Colour-coded pins can be used to differentiate between the various types of leaks and breaks, and the years they occurred. A good place to begin an intensive leak detection survey would be where the pins cluster together on the map.

Each leak found should be quantified and a record sent to the main office for recording. The volume of water lost in the leak can be estimated using the formula below, or the bucket and stopwatch can be used to estimate flow rates. If the leak is big enough, the dimensions of the hole dug during repair can be measured and used as the "bucket" by timing how long it takes to fill.

Leaks from Holes of Known Size

Find the volume of water lost through a hole 1/8 inch by 1 1/4 inch in size at 50 pounds of pressure.

First, calculate the area:

1/8 inch = 0.125 inches; 1-1/4 inch = 1.25 inches;

Area = 0.125 X 1.25 = 0.156 square inches. 0.156 square inches / 144 square inches per square foot = 0.00108 square feet.

The formula to calculate leak volume is:

Leak volume = 4.8 x (area of hole in square feet) x square root of (pressure in psi/0.433)

Therefore:

Leak volume = 4.8 x 0.00108 square feet x square root of (50 psi/0.433)

=0.0557 cubic feet per second (about equal to 1,750,000 cubic feet or almost 11 million imperial gallons per year!)

2. UNAUTHORIZED USE

Unaccounted-for-water can also be lost through different types of unauthorized uses. Construction and irrigation contractors may under-report authorized use or use water without proper authorization. Enforcement and imposition of fines by a city or increased vigilance and legal action by a utility will probably be required to curtail this problem.

Illegal taps are more likely in rural areas where a customer may be able to install a separate tap to irrigate a lawn or water livestock without being seen by neighbors. In addition, when an account is closed by turning the valve off rather than removing the meter, a customer may turn the valve on again. The customer then receives free water unless meter readers are required to check on disconnected accounts. If the meter is locked or removed, a disgruntled customer may resort to illegal access. Meter readers need to be trained to spot the various types of illegal taps. The use of master meters at various points in the distribution system (zone measurement) will also help identify sections of the system with high unaccounted-for- water losses.

3. WATER METERS

Meters are the cash registers, the monitors, and the most visible physical part of any utility system. The adage that "if you have meters, you have meter problems" is unfortunately all too true. However, with proper meter selection and installation in the first place followed by proper meter testing and

Water Meters are your Utility's Cash Register

Table 1: FLOW RANGES FOR WATER METERS					
Class 1 Turbine Meters (Primarily irrigation meters)			Positive Displacement Meters		
Size (Inches)	High Flow (gal/min)	Low Flow (gal/min)	Size (Inches)	High Flow (gal/min)	Low Flow (gal/min)
2	100	16			
3	150	24	2	100	2
4	200	40	3	150	4
6	500	80	4	200	7
8	600	140	6	500	12
10	900	225			
12	1200	400			
Class 2 Turbine Meters			Compound Meters		
Size (Inches)	High Flow (gal/min)	Low Flow (gal/min)	Size (Inches)	High Flow (gal/min)	Low Flow (gal/min)
2	160	4	2	100	.25
3	350	8	3	150	.5
4	630	15	4	200	.75
6	1400	30	6	500	1
8	2400	50	8	600	2
10	3800	75	10	900	4
			12	1200	7

Table obtained British Tire and Rubber Company (BTR)

maintenance, these problems can be minimized and the utility can have meters that:

(1) give accurate production and consumption information,

(2) show how much water the utility is losing or giving away,

(3) build customer confidence (as well as utility staff confidence), and

(4) maximize revenue!

Meter Selection

Choosing the proper water meter for the specific application is the first and most critical step. Choose poorly and the utility will have inaccuracy permanently installed in the system.

A variety of meters are available from a wide range of suppliers. They include electronic transit-time flow meters, pito tubes, impeller, and those most commonly found in municipal systems such as turbine, displacement, multi-jet, and compound meters. Electronic transit-flow meters, pito tube, and impeller type meters are typically found at water treatment plants and large pump or diversion works. Their selection and installation is just as critical, but they are usually installed as part of water treatment plant construction and are not the type of meters most utilities normally use for customer accounts.

Positive displacement, multi-jet, turbine, and compound meters are the types most utilities install on customer accounts and work with on a daily basis. Table 1. FLOW RANGES FOR WATER METERS shows the flow ranges of the four most commonly used meters for customer accounts.

Proper meter selection begins with knowing how water will be used by that customer or user. Meters should be able to record the full range of expected flow rates. For example, a turbine meter should be used only where flows are within the meter's range of accuracy. If a turbine meter is used where flows below the operating range of the meter occur, most of the low flows will not register, and revenues will be lost.

For example, a two-inch Class II turbine meter (see Table 1) is accurate from a low flow of four (4) g.p.m. to a high flow of 160 g.p.m. If this meter is used for a customer with flows of 140 g.p.m. for two hours a day but a low flow of two (2) g.p.m. for 22 hours a day, most of the low flows will under-register or not register at all. Using the turbine meter will result in the loss of up to $1,500 per year in revenues if the water rate is $1.50 per 1,000 gallons. If sewer charges are based on monthly water use, this would be even higher. This customer's meter should be changed to a three-inch compound meter.

Meter Installation

Unfortunately, even the best or most expensive meters available will not be accurate if not installed correctly. Elbows, turns, tees, reducers, valves, or anything that causes turbulence will cause uneven flow in the pipe and thus inaccurate meter readings. Most manufacturers recommend that meters be installed on only straight runs of pipe. A total of at least 10 and preferably 15 pipe diameters of straight pipe should be in front (up-stream side) of the meter. If this is not possible, a basket pipe strainer can be used in front of the meter to help reduce turbulence, but even then, there should be five (5) or ten (10) diameters of straight run. Meters should be housed in vaults or meter boxes or inside structures to protect them from freezing and other damage.

Large meters, including both utility production meters at wells and water treatment plants and meters for larger commercial and industrial accounts, should be checked annually to insure that they are accurate to within acceptable levels. This applies to most meters larger than one and one half or two inches.

Types of Customer Service Meters

Positive displacement and smaller multi-jet meters are primarily used for residential customers, but are also available in two-inch to six-inch sizes. These meters measure low flows much more accurately than turbine meters, but they are unable to measure as wide a range of flows as compound meters. Typical applications include residences, and smaller commercial establishments with lower flow rates.

Turbine meters are used primarily where consistently high flows are expected. These meters are often found in larger water use rate installations such as hotels, large industries or for large landscape irrigation equipment. They are also commonly used in utility systems. They are the least expensive of the large meters and when properly sized, provide good accuracy, but they are not able to record lower flow rates. Class II turbine meters are the most common type of turbine meter on the market today. Class I turbine meters are rarely used today and then mainly for landscape irrigation applications.

Compound meters, as the name implies, combine the high flow ranges of a turbine meter with the low flow accuracy of positive displacement meters. At low flow rates, all of the water passes through the positive displacement meter, but as flow increases, a change-over valve opens and diverts flow to the turbine meter. These meters are more expensive than turbine or positive displacement and multi-jet meters and typically have higher maintenance cost, but are the most accurate meter over the widest range of flows and therefore most reliable in recording total use where both high and low flow ranges are expected.

Meter Testing

Even if the meter is selected correctly and installed properly, it does not guarantee that the meter will give accurate readings in the future. All meters should be checked periodically. Experience has shown that a significant portion of unaccounted-for-water is often the result of under-registering by worn or improperly sized meters.

For many utilities with a mix of residential, commercial and industrial customers, fewer than 10 percent of the customers will often use half or more of the water produced. Clearly, the utility will lose a significant amount of revenue when large meters even slightly under-register. For example, if the flow to a customer with a three-inch turbine meter and an average daily flow rate of 250 g.p.m. is under registering by 5 percent, the customer is receiving 6,570,000 gallons of unmetered water each year. Assuming a water rate of $1.50 per 1,000 gallons, the utility would be losing $9,855 in revenue per year.

Testing, repair and replacement schedules for small meters are often recommended by the meter manufacturer, but can vary depending on the chemistry and characteristics of the water and on the amount of water passing through the meter. Many recommend that smaller meters be tested in place at least every five (5) to ten (10) years. At a minimum, a random sampling of smaller meters should be tested annually. Meters less than 95 percent accurate at medium or high flow (2 g.p.m.

and 8-10 g.p.m., respectively), or that do not register low flows (0.25 to 0.5 g.p.m.) should be replaced. Others, regardless of age, can be left in place as long as they are accurate and readable.

Many utilities use computerized billing records to identify "slow" or even stopped meters. These meters begin to register lower readings over a several month period. This often indicates that the meter has a problem. In a similar manner, these billing records can be used to identify meters that suddenly begin to register significantly higher flows. This can indicate that the customer has a leak; the customer can be notified of this possibility and told how to check for leaks. This service also has many positive public relations benefits.

The decision to repair or replace a meter is an economic one. Many utilities have their own meter repair facilities, while others chose to remove the meter and send it to a commercial shop for repair or use the old meter as a trade-in for a new or rebuilt meter. There are pros and cons to each of these methods, but all will result in more accurate meters (cash registers).

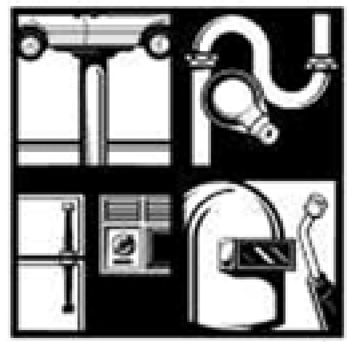
4. LEAK DETECTION AND REPAIR

In addition to saving the water lost through leakage, a leak detection program can pay for itself in reduced water production costs, reduced future repair costs and deferred plant expansion.

To be effective, a leak detection and repair program should be ongoing and continuous. Even as record keeping is improved and meters are being installed, tested and replaced, the utility should be aggressively involved in leak detection and line repairs. An ongoing list of leaks detected and repairs completed is useful in developing a specific leak detection plan for a utility.

All utilities should have an ongoing program to locate and repair leaks that become visible or "surface." However, there are often leaks in the system that do not surface. These leaks are not visible since they can drain or leak:

- into sanitary and storm sewer manholes and lines;
- into porous underground formations like limestone;
- into absorbent soils like sand and gravel;
- into creeks and river beds;
- through a leaking check valve or foot valve at a water well;
- from the overflow of a storage tank due to a malfunctioning level control valve; and
- through valves between pressure zones, which will cause inaccurate pumping data.



Procedures and Equipment

1. Experience has shown that the best results have been obtained by listening for leaks at all system contact points such as water meters, valves, hydrants and blow-offs. A portable listening device, field notebook, hammer, screwdriver, flashlight and cover key are essential items.

2. The average two-person survey crew can survey about two miles of main per day if the main is located in a city or subdivision and all valves, hydrants and meters are checked.

3. If you propose not to listen for leaks at all available listening points, what plans will be made for checking missed points later?

4. Describe how the leak detection team and the leak repair crew will work together. A citizen or utility employee who sees the water leaking out of the ground or building normally reports the leak. The leak detection team should be called in first or at the same time as the repair crew to pinpoint the leak. In other cases, the leak detection crew might

discover a leak, pinpoint it and initiate the work order.

5. What measures will be used to minimize the chance of digging "dry holes"?

6. Describe the methods that will be used to determine the flow rates for excavated leaks. The formula for calculating approximate flow rates for typical leaks, including an example, is noted earlier in this publication.

Utilities must decide whether to have their own crew conduct the leak detection survey or hire a consulting firm to conduct the survey. Groups of small communities may wish to consider buying and operating leak detection equipment as a co-operative, sharing equipment and expertise. A small system might be surveyed in a few weeks or months, while a larger city might require a full-time crew, covering a portion of the system each year. The cost per mile for hiring consultants to conduct a leak detection survey depends on the number of listening points that will be checked and the size of the system. A survey that checks all meters, valves and hydrants will be considerably more expensive than a survey that just checks hydrants and valves at intersections. The utility should determine which portions of the system are most likely to have leaks and survey those areas first.

Steps in Conducting a Leak Detection and Repair Program

1. The area in the distribution system to be surveyed should be mapped using the results of the water audit. Higher priority should be given to areas with high leak potential. Items to consider include records of previous leaks (as indicated by the pin map), type of pipe, age of pipe, soil conditions, pressures, ground settlement, and installation procedures).

2. Next, the plans of the distribution system should be used to divide the system into districts (containing between four and 40 miles of main) that can be "valved off" so that flows into each district can be measured through a single line. Sales meters can be read before and after the test, and consumption can be compared with measured flow into the isolated area.

3. The costs of measuring flows into subdistricts, plus surveying selected subdistricts with sonic equipment must be weighed against the costs of surveying the entire district with sonic equipment. If continuous flow recording-devices are used to establish ratios of the minimum night flow rate to the average daily flow rate, subdistricts with ratios of more than 30 percent should be the first priority in the leak detection survey.

4. Once districts and subdistricts are prioritized, a schedule and budget for the leak detection survey should be established.

5. The survey crew should verify the location and condition of the valves, hydrants, meters, service lines, etc., during their field work and note broken or missing valve and meter covers, inaccessible valves or meters, inoperable hydrants and valves, and missing hydrant caps. This information about the distribution system is an important secondary benefit of the leak detection survey. The surveyors should also be trained to spot any unauthorized connections.

6. After the leak detection survey is completed, the utility must determine if sufficient funds are available to complete the repairs or in some cases, line replacement, within the current fiscal year or whether repair costs must be spread out over two or more years. If the repairs will be spread out, the repairs should be prioritized by type of leak based on the amount of water lost in a year. If an estimate of water loss cannot be made, leaks should be repaired in the following order: mains, service lines, valves, meters, and hydrants. Usually, leaks in a main result in the loss of much more water than service and hydrant leaks and should be repaired first. Although the cost of repairing a main leak is considerably higher than repairing a hydrant leak, the benefits of repairing a main leak are higher (in terms of the cost of water purchased and production costs). This is because a greater quantity of water is being saved.

7. The crew chief should be responsible for estimating or confirming the rate of water loss once the leak is uncovered and for verifying that all information concerning the leak and its repair are properly recorded and reported.

8. After completion of an initial leak detection program, smaller utilities should plan a follow-up program in three to five years. Large municipal or investor-owned utilities should consider an on-going program with either a part-time or full-time crew. The reduction in unaccounted-for water through the initial survey will only be temporary without continued commitment to detection and repair.

On-going leak detection methods include using a variety of flow measurement devices, sonic and acoustic equipment and computerized correlation devices. Sonic and acoustic devices are used to listen for leak sounds in mains or service lines.

Typical Sonic Leak Detection Equipment

1 Electronics Modules/Meters
2 Headset
3 Ground Mike
4 Ground Mike Handle
5 Test Rod Mike
6 Test Rod Extension
7 Detachable Test Rod
8 Optional Test Rod Magnet
9 Meter Module with Charger
10 Resonant Plate

Build it Right the First Time to Reduce Unaccounted-for-Water

Proper installation is the most important first step to reducing unaccounted-for-water. This concept, while certainly not new, is crucial to consider when installing a new system, expanding a system to serve new customers or areas, or making repairs to your existing system. Building it right the first time can help reduce unaccounted-for-water and water leaks.

System Design and Layout

1. Choose an engineer and inspector carefully
2. Ensure design and specifications are clear and correct
3. Consider this partial list of items:
    - Valve location
    - Sub-metering
    - Looping and flush valves
    - Meter selection (type and size), location and set-up
    - Materials selection
    - Pressure planes
    - Easements, permits, and location
    - Pre-installation considerations
    - Preparations for inspection
    - Materials handling and storage
    - Checking materials for compliance with specifications installation
    - Trenching, bedding, backfill, etc.
    - Proper pipe and fittings connection
    - Road and railroad crossings—sleeving
    - Corrosion control
    - Line tracing
    - Thrust blocking etc.
    - Hook-ups
    - Pressure testing
    - As-built maps, and
    - INSPECTION - It will not be built right if construction is not inspected on a regular basis.

Future Actions

After the first year's run-through, you can ensure relevant information is placed in one file, such as making a note immediately if there is water lost due a water main break, or a fire, or skating rink being flooded. Updates will then take very little time or effort. If you notice that demand for water is suddenly much higher, you can easily and quickly check your records to see if they give a clue for the reason for the problem

Conclusion

In Manitoba, as well as throughout much of the country, water has become a precious commodity. Every utility should be a leader in promoting conservation and setting an example for its customers by reducing unaccounted-for-water to the lowest reasonable level. The utility will benefit by saving the production costs of the water lost through leakage while simultaneously increasing revenues through a comprehensive meter management program. In addition, capital expenditures for system expansion may be deferred through recapture of unaccounted-for-water. The customers also will benefit since the utility's costs will increase more slowly, resulting in less frequent rate increases, thereby improving customer relations with the utility. In short, everyone benefits when a utility has an effective program to reduce unaccounted-for-water.

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Where To Go For Help

For further information, contact your local prairie Farm Rehabilitation Administration (PFRA), Manitoba Water Services Board or Manitoba Conservation representative.

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