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CITY OF SANTA CRUZ

WATER DEPARTMENT
MEMORANDUM

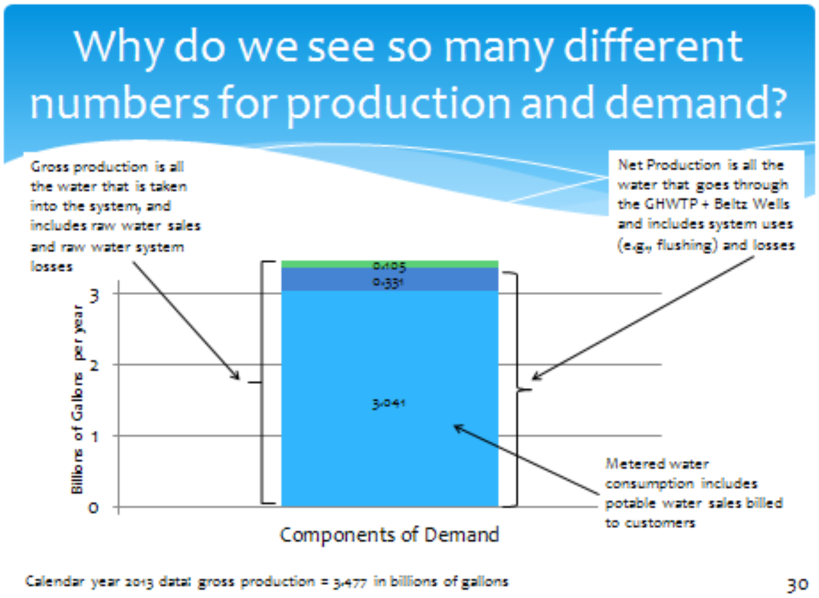
DATE: August 20, 2014

TO: Water Supply Advisory Committee

FROM: Toby Goddard

SUBJECT: System Water Losses and Water Loss Control

BACKGROUND: On June 26, 2014, The Water Supply Advisory Committee received a presentation providing an overview of water supply and demand characteristics in Santa Cruz. One of the topics introduced in the process of explaining the different terms and figures relative to annual water production and water demand was system water losses.



Why do we see so many different numbers for production and demand?

Gross production is all the water that is taken into the system, and includes raw water sales and raw water system losses

Net Production is all the water that goes through the GHWTP + Beltz Wells and includes system uses (e.g., flushing) and losses

Metered water consumption includes potable water sales billed to customers

Calendar year 2013 data: gross production = 3.477 in billions of gallons

Shortly thereafter, the New York Times published an article entitled “The Art of Water Recovery” examining the subject of water losses in public water systems and the potential to reduce leakage (Attachment 1). The article highlighted two important issues:

- According to the U.S. Environmental Protection Agency, public water systems lose, on average, one-sixth of their water – mainly from leaks in pipes; and

- The volume of leakage in the nation’s 55,000 drinking water systems is unknown, because few conduct water audits using standards established by the International Water Association (IWA) and the American Water Works Association (AWWA).

This paper provides current information about system water losses in Santa Cruz, and measures the City is taking to minimize system losses.

DISCUSSION: Total system water demand includes not only metered water sales but also authorized, unmetered uses from fire hydrants such as main flushing, fire fighting, street sweeping, and sewer flushing, as well as losses due to underground leaks. The difference between the amount of water produced at the City’s two water treatment plants entering the distribution system and the amount of water consumed, including both metered and unmetered uses, is referred to as system water losses.

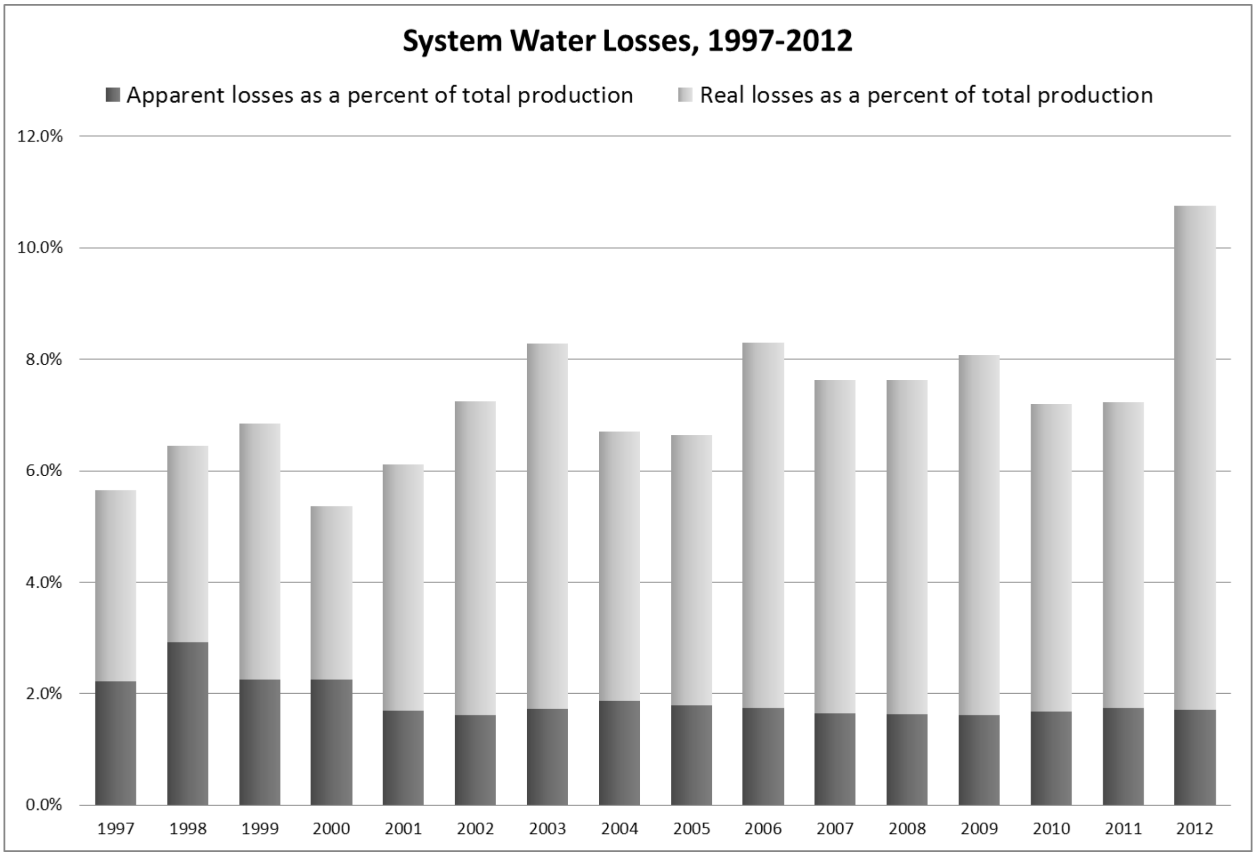
System losses have two components: 1) physical losses from leaking service lines, valves, and water mains, also referred to as “real” losses and 2) “apparent” losses in which potable water is consumed but goes underreported due to sales meter inaccuracies, billing and accounting errors, and other factors.

The Water Department first began conducting annual water audits of distribution system in 1997. The purpose of a water audit is to quantify how much water and revenue are lost through both physical leaks and apparent losses and to identify steps to minimize system losses and improve the operational efficiency of the water system. Until 2006, the Department followed the approach described in the AWWA M36 Manual of Water Supply Practices – Water Audits and Leak Detection. Starting in 2006, the City began to use the new, standardized water balance approach developed through the IWA and AWWA referenced in the New York Times article.

Under the California Urban Water Conservation Council’s MOU, Water Loss Control is listed as a Best Management Practice. Since 2009, agencies have been expected to use the new IWA/AWWA software to complete their annual water audits and to meet increasingly stringent requirements to support water loss control activities and identify areas for improved efficiency and cost recovery.

Annual Water Losses

Water audit results indicate system water losses vary from year to year but have averaged about 7.3 percent of total production over the last 15 years, or about 264 million gallons per year (mgy).

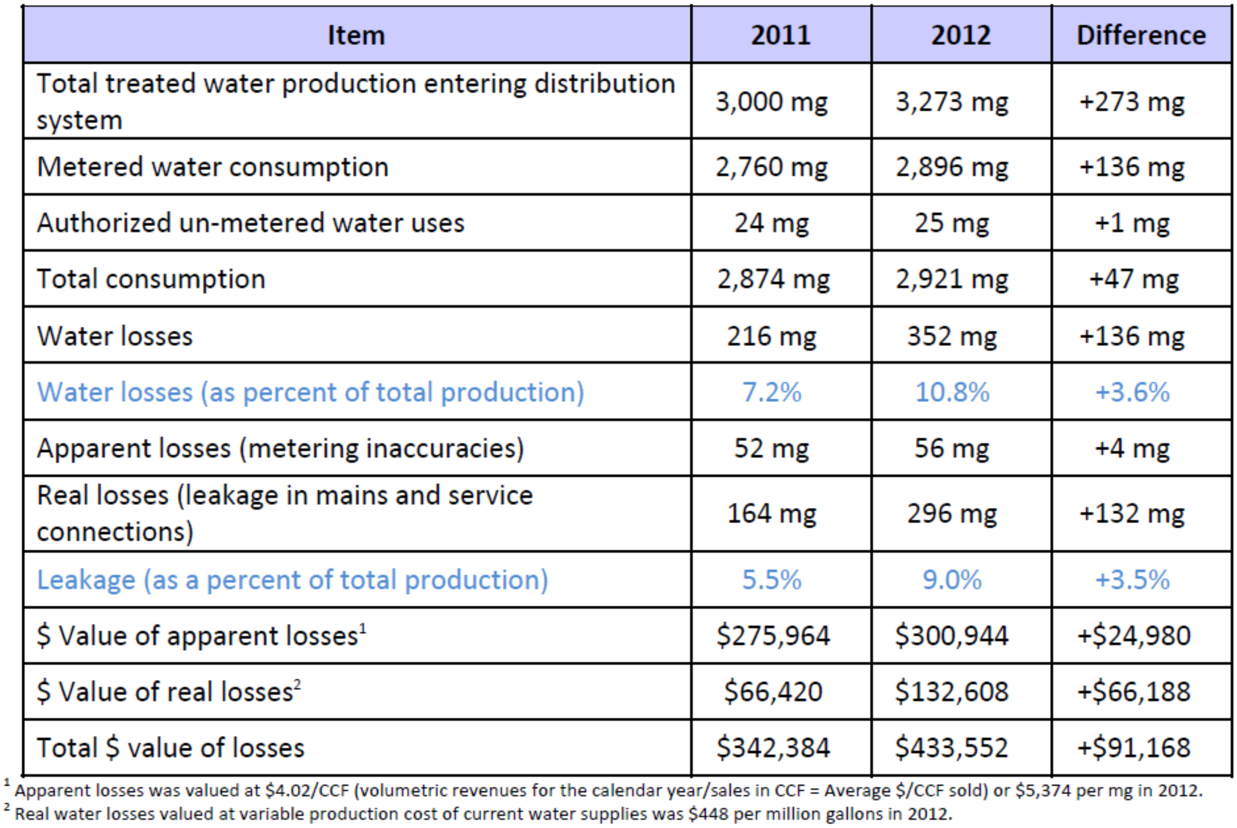


As seen in the chart above real water losses; i.e. distribution system leakage, is the larger of the two components that make up total system losses. Estimates of physical losses from underground leakage in service lines, water mains, valves, and distribution system controls average 5.4 percent of total production, or just under 200 mgy. Apparent losses are estimated at about 70 mgy or about 1.9 percent of all treated water entering the distribution system. There is considerable uncertainty, however, about the true magnitude between real and apparent water losses due to the fact that no formal, systematic meter testing program has been carried out by the Water Department for many years.

It can also be seen that in 2012, the City experienced a sudden jump in lost water to a level not previously seen. This occurred after a long period where the annual water loss rate had been relatively consistent. The cause of this sudden jump is yet to be understood.

Cost of Water Losses

The estimated cost to the City from system water losses is shown below using data from 2011 and 2012.



Item	2011	2012	Difference
Total treated water production entering distribution system	3,000 mg	3,273 mg	+273 mg
Metered water consumption	2,760 mg	2,896 mg	+136 mg
Authorized un-metered water uses	24 mg	25 mg	+1 mg
Total consumption	2,874 mg	2,921 mg	+47 mg
Water losses	216 mg	352 mg	+136 mg
Water losses (as percent of total production)	7.2%	10.8%	+3.6%
Apparent losses (metering inaccuracies)	52 mg	56 mg	+4 mg
Real losses (leakage in mains and service connections)	164 mg	296 mg	+132 mg
Leakage (as a percent of total production)	5.5%	9.0%	+3.5%
$ Value of apparent losses[1]	$275,964	$300,944	+$24,980
$ Value of real losses[2]	$66,420	$132,608	+$66,188
Total $ value of losses	$342,384	$433,552	+$91,168

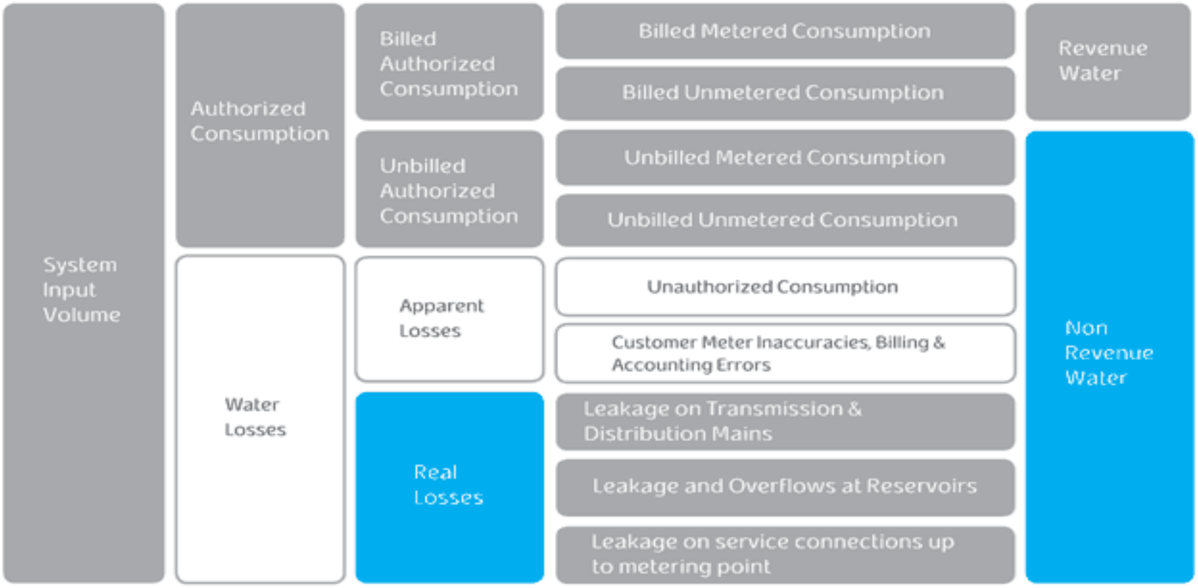
[1] Apparent losses was valued at $4.02/CCF (volumetric revenues for the calendar year/sales in CCF = Average $/CCF sold) or $5,374 per mg in 2012.

[2] Real water losses valued at variable production cost of current water supplies was $448 per million gallons in 2012.

Even though real losses are thought to be much larger by volume than are apparent losses, the lost revenue associated with inaccurate water meters represents a much greater cost to the utility than does underground leakage. This is because apparent losses are valued at the retail rate of about $4.00/CCF or $5,374/million gallons, whereas real losses are valued at the City’s variable cost of producing water based on the cost of electric power for pumping and chemicals for treatment, currently estimated at $448/million gallons. This latter value does not, however, take into account costs of labor, repair, or property damage that results from certain water system breaks, disruptions, and ruptures, which can be significant, as vividly dramatized by the recent major water main break near the UC Los Angeles campus.

Water Balance Model

The new IWA/AWWA water balance approach is based on the following diagram and associated terms and definitions. It is a tool to help utilities better understand and quantify water uses and losses relative to annual system input volumes. No longer is there any reference to the outdated term “unaccounted for water”. The water balance reflects that all drinking water managed by the utility is accounted for in the various categories of consumption and loss.



One of the most powerful features of the software is the numerical grading system where a specific rating is assigned to each of the analytical inputs when compiling and entering data to describe the confidence and accuracy of the data. These grades are helpful to assess priority areas for attention and to identify measures to improve water loss control.

The audit software also provides a variety of financial and operational performance indicators. These include the following:

- Nonrevenue water as percent by volume of water supplied,
- Nonrevenue water as percent by cost of operating system,
- Infrastructure leakage index – a ratio of a utility's current annual real losses to its unavoidable annual real losses (a theoretical reference value that represents the technically low limit of leakage given the length of mains, average pressure, and number of service connections.

The City's completed audit and associated worksheets for calendar year 2012 are included as Attachment 2.

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Approaches to Reduce Real Water Losses

Maintenance and improvement of the treated water distribution system is a major activity of the Water Department, and central to the Department’s mission of providing a clean, adequate, and reliable supply of water. The Water Distribution section consists of 23 certified personnel, and a group of 6 technicians, specialists, and a supervisor in the Meter Shop, all dedicated to maintaining and repairing the system 24/7. It is organized into several crews that focus on the following activities:

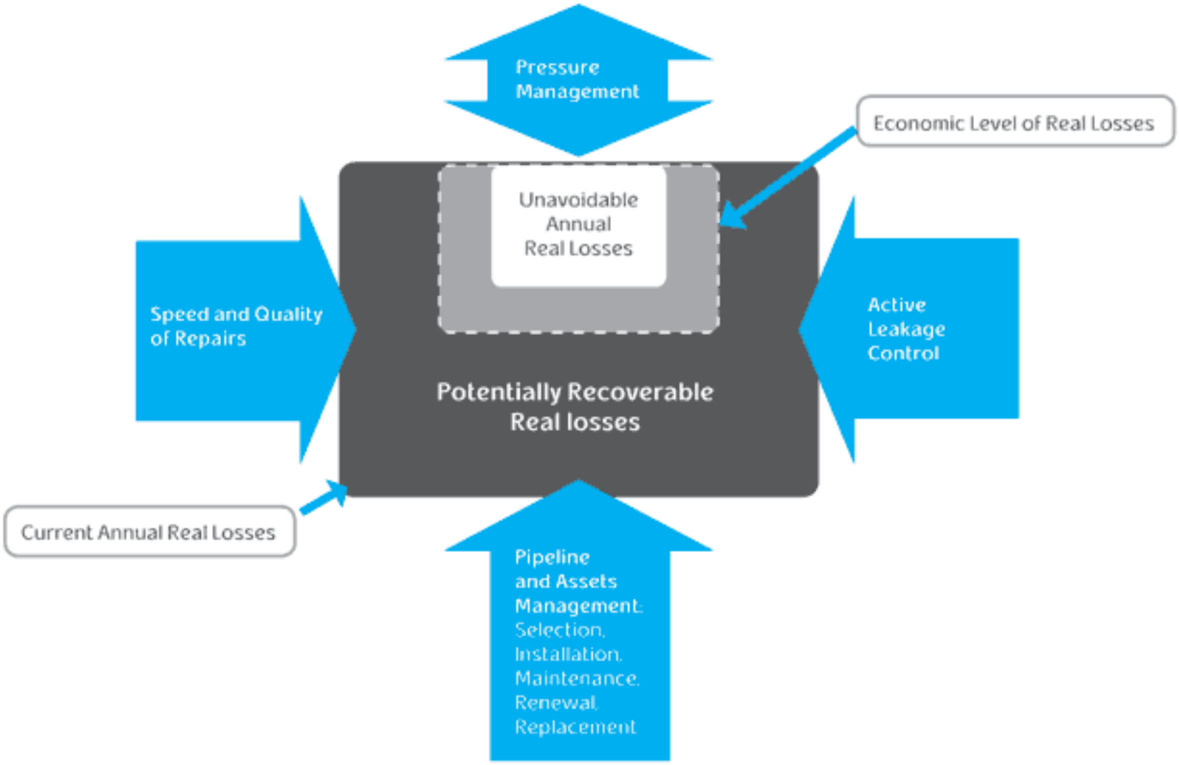
- Main replacement
- Service line renewal
- Leak repair
- Valve maintenance
- Utility location and leak detection

Annual water main replacement projects are coordinated by the Department’s Engineering section. Main replacement is guided by several factors. These include considerations for system reliability, water quality, fire flow, circulation, maintenance, as well as coordination with street paving and other public projects. The Distribution section also performs smaller main replacement projects, replacing about one mile of main per year.

Several years ago, the Department considered the idea to operate an active, acoustic leak detection program. It was decided, based on analysis of leak types and volumes, to undertake a different approach, though, which was to establish a crew to proactively replace polybutylene service lines with copper service lines. Polybutylene service lines were being found, both locally and elsewhere throughout the industry, to fail prematurely, and represented a significant source of leakage. Over 5,000 plastic service lines have been replaced over the last decade to help prevent future leaks from occurring.

A sheared fire hydrant is a one example of a real water loss

The following illustration shows the four potential areas where additional actions are possible to further reduce leakage to a level that is economically achievable. These actions include actively performing sonic leak detection surveys to find unreported leaks, optimizing leak repair activities, managing pressure, and increasing the level of water main and service line replacement. Of these four approaches, active leak detection and asset management are the two areas thought to be where the most potential exists on the City's distribution system. The Department already has a good record of responding quickly to leaks. The potential for leak reduction through pressure management is uncertain, but probably relatively low, given the large area served by the City's gravity zone, and the lack of discrete areas where pressure could be managed.

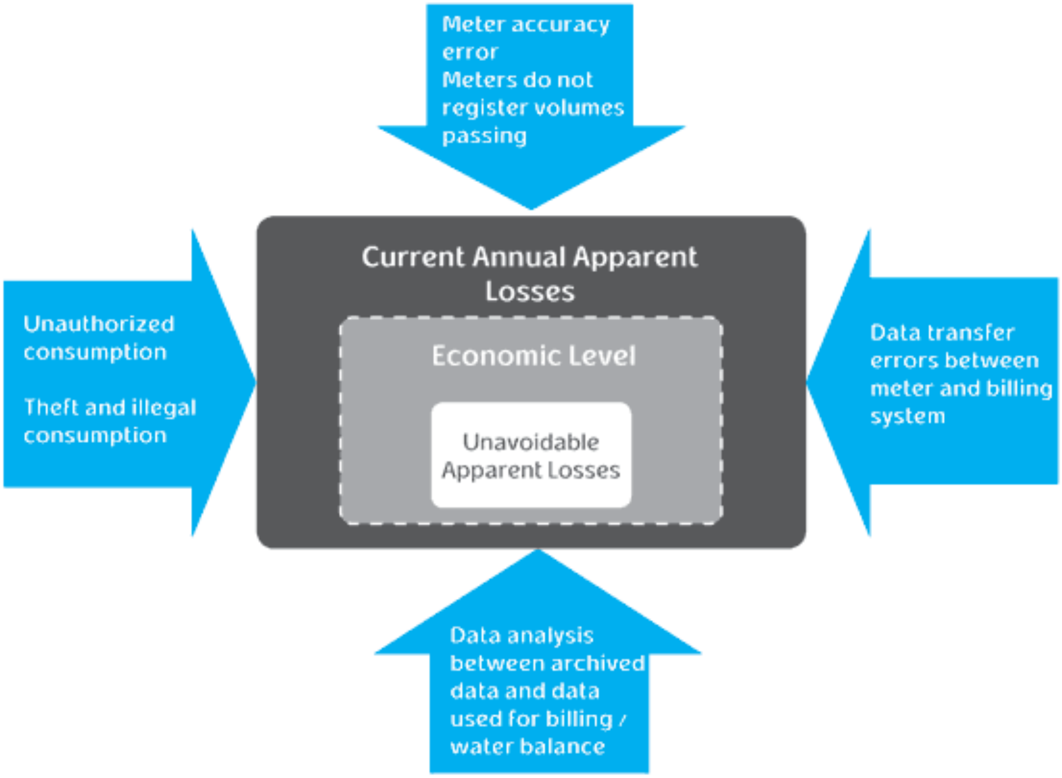


The idea with the illustration is there is a hierarchy of real losses that includes: 1) the utility's current level of losses, 2) some potentially lower level that is economical to achieve, and 3) some even lower level that represents the unavoidable minimum level of loss. Under this model, eliminating all physical water losses is not practical to achieve.

Approaches to Reduce Apparent Water Losses

Apparent losses occur as a result of inefficiencies in the measurement, recording, archiving, or accounting operations used to track water volumes in a water utility. Unlike real losses, reducing apparent losses does not create new or more water, but it does improve revenue recovery and other benefits.

As with real water losses, there are four basic approaches to reducing apparent water losses, illustrated in the following diagram:



Inevitably, some water is used but not captured on a billing system due to all these different sources, and the City does not have good information at the present time to quantify their relative contribution. The Department knows of individual examples of situations where water is used but not recorded. For instance, movement on a fire service check meter is a type of water loss that goes unrecorded on the billing system, as does unauthorized usage on a closed account. While rare, a mis-programmed meter register or a meter that was not loaded up on the utility inventory system are examples of data transfer errors can also result in “missing water”. The Customer Service section and Meter Shop regularly run billing system reports known as the Meter Read Edit List and other controls to help identify and resolve such problems.

When it comes to apparent losses, though, the bigger unknown is the overall accuracy of the City’s 25,000+ meters. As meters age, the components inside meter registers wear down, causing under-registration of water volume, and, in some cases, reporting zero consumption. Beginning in the late 1990’s, the Water Department began a multiyear project converting from a manual to an automated meter reading (AMR) system to enable monthly billing, reduce risk of employee injury and accidents, and improve operational efficiency. This capital improvement project involved completing over 20,000 radio read meter installations that involved replacing, either completely or partially, the majority of the water meters on the water system, primarily in the smaller 5/8 and 1 inch size class. This project was completed in 2008. The last time a major meter replacement project was undertaken before then was in the late 1970's.

With the priority having been devoted primarily to the AMR conversion project for much of the last decade, no regular, formal meter testing program has been carried out by the City for many years. Some testing has been conducted on selected large meters on an intermittent basis. As mentioned above, it is currently estimated that about 2 percent of all treated water that enters the distribution system goes unrecorded due to meter inaccuracies. However, little current testing data exists either for the newly replaced small meter population or the current stock of large meters to understand the functional status or accurately gauge the level of meter error or sales revenue lost systemwide due to meter under-registration.

Water Loss Control in the Water Conservation Master Plan

One of the recommended measures in the City's proposed Water Conservation Master Plan is to contract with a firm specializing in water loss control to examine the City's water system and practices to better validate where losses are occurring, evaluate options, and set forth a formal strategy to improve water accountability and reduce lost water. The FY 2015 operating budget includes $150,000 to undertake this initial contract work.

Attachments

1. "The Art of Water Recovery", New York Times, July 10, 2014
2. 2012 AWWA Water Audit

The New York Times

The Opinion Pages

Fixes

The Art of Water Recovery

By DAVID BORNSTEIN

July 10, 2014 8:00 pm

Fixes looks at solutions to social problems and why they work.

Imagine that you run a company that sells bottled water. You spend lots of money, and use lots of energy, pumping the water out of the ground, purifying it and transporting it for sale. Then, one day, you discover that a large number of bottles never make it to the stores. They are falling through holes in the trucks.

Wouldn't you want to know what could be done about it? Wouldn't you be crazy to allow the situation to continue?

Well, that's what's happening with many water utilities in the United States. The Environmental Protection Agency estimates (pdf) that public water systems lose, on average, one-sixth of their water — mainly from leaks in pipes. The E.P.A. asserts that 75 percent of that water is recoverable. (In truth, the volume of leakage in the nation's 55,000 drinking-water systems is unknown, because few conduct water audits using the standards established by the International Water Association and the American Water Works Association.)

It's been widely reported that California is experiencing its worst drought in history. But take a look at the United States Drought Monitor: much of the country is abnormally dry or in drought. Internationally, the problem is even more serious. The World Bank reports that, over the next decade and a half, water availability may fall 40 percent short of global need (pdf).

Meanwhile, utilities in the developing world are hemorrhaging water. The World Bank estimates that water systems have real losses (leakages) of 8.6 trillion gallons per year, about half in developing countries (pdf, 11MB, p.6). That's enough to serve 150 million Americans (and we use a lot of water!)

Why don't utilities do more to recover it?

The results can be substantial. Consider Manila. From 2009 to 2013, with project management from an innovative young company called Miya, the utility that provides water to the western zone of Manila, Maynilad, reduced its so-called non-revenue water from 1.5 billion to 750 million liters per day, mainly by stemming leakages (pdf).

During that period, according to Irineo L. Dimaano, who directs Maynilad's non-revenue water work, the company reduced the volume of water it supplied into the system by 400 million liters per day, while simultaneously serving an additional 1.3 million people, increasing the proportion of customers who receive 24-hour service to 97 percent from 65 percent, improving water pressure, and doubling annual revenues.

This is an extreme case of the potential gains that can be made by tightening up a water system. But water leakage is widely overlooked — largely because it is technical and dull and politically unattractive. "Water loss is unsexy," said Mary Ann Dickinson, president of the Alliance for Water Efficiency. "There's no ribbon cutting for new plants. If you announce that you've recovered a million gallons a day, it looks like you weren't managing your system right in the first place."

Today's budding water loss industry grew out of the efforts of a bunch of brilliant, obsessive, far-thinking engineers in Britain who started something called the National Leakage Initiative in the early 1990s. Led by a man named Allan Lambert, they developed a methodology for categorizing and quantifying water leakage, and predicting losses, so they could rigorously determine how to reduce them.* This was vital in Britain, which had some of the world's oldest water systems.

Their efforts were famously successful. Lambert later led a task force for the International Water Association, which established new standards for water accounting (pdf). In recent years some states, notably, California, Georgia, Tennessee and Texas, have begun requiring that utilities conduct water audits, but they have not mandated targets for water loss reduction. In fact, no state mandates targets for water loss reduction using the new standards.

Today, the emergence of companies that specialize in reducing water losses, like Miya, represents an important step forward, much like the emergence of energy service companies in the 1970s and 1980s to reduce energy use.

Miya was founded in 2006 by Shari Arison, an American-Israeli businesswoman and billionaire. Over the past eight years, the company has assembled a team of water loss experts and deployed them in a dozen countries. What distinguishes its work is its whole system approach: it looks at a water system the way a doctor looks at the body's circulatory system.

Water systems are counterintuitive. It's commonly thought that water leakage can be solved simply by replacing the worst pipes, but that's usually just a short-term fix. The real key is understanding and managing pressure.

"When you have a pressurized system, what you do in one place affects all other places," said Meir Wietchner, Miya's chairman. Replace a leaky pipe segment and the pressure will increase in other segments and more leaks will sprout. "It's simple physics," he added. "And the larger the pressure the larger the leakage. If a hole that's receiving one unit of pressure will leak X gallons per day, with 2 units of pressure it will leak 4X, and with 3 units pressure it will leak 9X. It's a square function."

One of Allan Lambert's insights was to separate leaks into "bursts" and "background" losses (pdf). "It isn't the main leaks that cause the most loss of water," he said. "It's the long-running leaks that go on for months or years that aren't detected. One leaking toilet will lose as much water in two years as a burst in a four-inch main for a full day."

So how do you fix and manage a system that's leaking in tens or hundreds of thousands of places — and how do you do it cost effectively?

That was the problem that Glen Laville, the general manager for the Bahamas Water and Sewerage Corporation (W.S.C.), was facing. Before 2012, to serve the water needs of New Providence, the largest island in the Bahamas, each day the W.S.C. was supplying some 12 million imperial gallons to the system — and each day it was losing 6.5 to 7 million gallons. Over the years, piecemeal solutions had been tried — mainly replacing big pipes — but the leakage always returned.

In 2012, Miya won an $83 million 10-year contract to advance a more sustainable solution. "The other companies wanted to come in and change 20 to 30 miles of pipeline," said Laville. "We weren't looking for someone to come in and just give us a new infrastructure. We wanted a holistic approach."

One selling point was that 30 percent of the company's fees would be based on performance. To earn those payments, Miya would have to bring the leakage down to 2.5 million gallons per day by year five, and to 2 million gallons per day by year seven — and the levels would have to be maintained for the duration of the contract. (Reductions below that level become cost prohibitive.)

Work started in 2012. The company spent most of the year studying the problem, examining every component of the system, explained Sofia Kanellopoulou, the project manager for the Bahamas, who was formerly a deputy director of the Athens water utility. The system had 44,000 service connections — pipes from water mains to customers — and, in line with Lambert's findings from Britain, that's where 90 percent of the leaks were occurring.

There were many reasons for the leaks: Service connections hadn't been installed with proper pipes and fittings; water from the desalination plant contained substances that were damaging pipes; the water table was high, with saline intrusion from the sea, which was also corrosive.

Then there was a secondary problem exacerbated by the leakage itself. With so much water lost, the system sometimes ran short of supply, and water had to be rationed. (Not for tourists, though. The big hotels typically supply their own water.) Water rationing is common in the developing world — but the consequences are poorly understood. When pressure drops to zero in pipes, contaminants in the surrounding ground — including salt water or waste from nearby sewage lines — can get sucked into the water lines, which is terrible for public health. And when you empty a system and then re-pressurize it, the resultant "surge wave" further damages pipes. A steady, moderately low level of pressure is best — just as in the human body.

Finding leaks is painstaking work. It starts by dividing a large system into smaller "district metered areas" where pressure can be independently monitored and controlled. You analyze tons of data with computer programs. You stay up late. Most of the water moving through a system in the middle of the night is leakage. Because it's too costly to replace every leaky pipe or connection, the key is to figure out how to save the greatest volume of water with the least possible effort.

To do this, leak detectors with sophisticated sound equipment fan out around cities in the wee hours, listening closely to gauge the size of leaks below ground. (In the Bahamas that didn't work, however, because of electrical interference from power lines.) Fortunately, the water pipes are only a few feet under the ground, so access was relatively easy.

To date, the system has been partitioned into 30 pressure zones, and will be further subdivided. More than 2,500 leaks have been repaired, using materials that are suitable for local conditions. Meters have been installed and the system pressure is being carefully managed. Water losses are already down to 4.5 million gallons per day, reports Laville. This past May, the W.S.C. needed to supply only 10 million gallons per day to meet customers' needs, two million less than in 2012.

"Last year, with two desalination facilities running at full capacity, we had to ration water," said Laville. "Within nine months of starting this project, we got to a point where we no longer had to ration the water. And we're now at a point where we can tell the desalination plant to cut back on their supply."

Over the 10 years, Laville estimates that the project will save 10 billion gallons of water, 7 million gallons of diesel, and 33 gigawatts of electricity. "In the 10 years, the project will pay for itself," he added. "It's almost a no-brainer."

It's a major improvement. But Paul Fanner, Miya's project director in the Bahamas, comments: "We're not doing anything that special. We just have to get all the things right. If you do one or two things, it doesn't work. It's all interrelated. It's not rocket science, but to do it well is very rare."

What Laville likes most is that Miya has just four people from outside the Bahamas working on the project. "That is an amazing thing for a project of this size and complexity," he said. "They come in, they train locals, they transfer that technology, and then they let them loose. At the end of 10 years, we'll have a trained work force to continue the work."

Efforts to reduce water leakage are spreading around the world, albeit slowly (pdf). There have been big water recovery gains in Cambodia, Brazil, South Africa and Malaysia, among other places. But despite the fact that it's good for business, good for customers, and good for the environment, bankers and politicians still favor expanding production when there are shortfalls (even if the expanded production will have to flow through the old leaky pipes!)

"In many areas of the world, there's no need to produce more water if we just cut waste," said Wietchner. "But a lot of people are not willing to admit the level of loss they have."

Back to California. There are currently 17 desalination plants in the planning or construction stages in the state. The $1 billion Carlsbad Desalination Project — the largest desalination facility in the Western Hemisphere — will produce 50 million gallons of potable water daily for San Diego county.

But how much water could be saved by reducing leakages in California?

One study (pdf) conducted for the California Public Utilities Commission examined audits done by 17 water utilities and found that losses were 1.6 to 6.6 times higher than optimum levels. (See footnote, for a brief explanation of these numbers, known as Infrastructure Leakage Indices.) Assuming that 40 percent of the losses could be recovered economically, the study's lead author, Reinhard Sturm, estimated potential savings at 113 billion gallons per year — equivalent to the annual production of six Carlsbad projects.

It's vital to consider the impact on energy use and the environment. Water is often lost between the main pipe and the customer, which means it has already been extracted, treated and transported a very long way. That's expensive. All that energy is lost — and more has to be used — and that, of course, increases carbon emissions. California's water system is already the state's largest single energy user. At the same time, desalination plants are energy intensive. Electricity accounts for roughly half the cost of their water.

As noted, some states are requiring utilities to report water audits. And around the country, individuals like George Kunkel of the Philadelphia Water Department and Chris Leauber of the Water & Wastewater Authority of Wilson County, Tenn., and companies like Water Systems Optimization and Cavanaugh, are leading the way.

But given the scope of the problem – and the fact that utilities are asking their own customers to conserve water – far more attention is warranted. With properly conducted water audits and loss reduction targets, officials would be in a position to determine if shortfalls could be better met by reducing leakage than by increasing production. Right now, many have no way to know.

Part of the problem is good old-fashioned complaisance. "U.S. folks have the impression that they are already system tight and they don't need to do much more," said Mary Ann Dickinson, of the Alliance for Water Efficiency. "I believe they are mistaken and they need to run their numbers to verify where they are."

What's missing most is serious focus from governments, particularly at the state level. "Government policy makers are not paying attention to leakage," added Dickinson. "We want to see every state requiring their water utilities to look at this. That's what they did in the U.K., and the huge turnaround that occurred there is what we need to see in the U.S."

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* Note for wonks: Most people refer to water leakage in terms of percentage losses. However, Allan Lambert, the godfather of water-leakage reduction, argues against using percentages because they fail to provide a meaningful or consistent measure of the quality of a water system (and are easily manipulated). For

instance, if you add a few large customers to a leaky water system and make no repairs, percentage leakage will drop. (It will appear that you have improved things when you have only increased the denominator.)

Lambert favors a measure called Infrastructure Leakage Index (I.L.I.), which compares real losses to the lowest level that is technically achievable for a particular system. An I.L.I. of 4 means you're losing four times as much water as you would be losing if your system was optimally managed. I.L.I.s can be used to compare different systems, and also to estimate how difficult, and therefore costly, marginal gains will be to achieve.

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David Bornstein is the author of "How to Change the World," which has been published in 20 languages, and "The Price of a Dream: The Story of the Grameen Bank," and is co-author of "Social Entrepreneurship: What Everyone Needs to Know." He is a co-founder of the Solutions Journalism Network, which supports rigorous reporting about responses to social problems.

AWWA WLCC Free Water Audit Software: Reporting Worksheet

WAS v4.2

Back to Instructions

? Click to access definition

Water Audit Report for: City of Santa Cruz
Reporting Year: 2012 1/2012 - 12/2012

Please enter data in the white cells below. Where available, metered values should be used; if metered values are unavailable please estimate a value. Indicate your confidence in the accuracy of the input data by grading each component (1-10) using the drop-down list to the left of the input cell. Hover the mouse over the cell to obtain a description of the grades

All volumes to be entered as: MILLION GALLONS (US) PER YEAR

WATER SUPPLIED

<< Enter grading in column 'E'

Volume from own sources: ? 7 3,249.900 Million gallons (US)/yr (MG/Yr)
Master meter error adjustment (enter positive value): ? 9 23.080 under-registered MG/Yr
Water imported: ? 0.000 MG/Yr
Water exported: ? 0.000 MG/Yr

WATER SUPPLIED: 3,272.980 MG/Yr

AUTHORIZED CONSUMPTION

Click here: ?
for help using option
buttons below

Billed metered: ? 7 2,893.200 MG/Yr
Billed unmetered: ? 5 0.940 MG/Yr
Unbilled metered: ? 9 2.500 MG/Yr
Unbilled unmetered: ? 8 24.360 MG/Yr Pcnt: ○ ● Value: 24.360

Use buttons to select
percentage of water supplied
OR
value

AUTHORIZED CONSUMPTION: ? 2,921.000 MG/Yr

WATER LOSSES (Water Supplied - Authorized Consumption) 351.980 MG/Yr

Apparent Losses

Unauthorized consumption: ? 8 0.001 MG/Yr Pcnt: ○ ● Value: 0.001

Customer metering inaccuracies: ? 1 56.350 MG/Yr ○ ● 56.350
Systematic data handling errors: ? 4 0.001 MG/Yr

Choose this option to
enter a percentage of
billed metered
consumption. This is
NOT a default value ?

Apparent Losses: ? 56.352

Real Losses (Current Annual Real Losses or CARL)

Real Losses = Water Losses - Apparent Losses: ? 295.628 MG/Yr

WATER LOSSES: 351.980 MG/Yr

NON-REVENUE WATER

NON-REVENUE WATER: ? 378.840 MG/Yr

= Total Water Loss + Unbilled Metered + Unbilled Unmetered

SYSTEM DATA

Length of mains: ? 5 263.9 miles
Number of active AND inactive service connections: ? 6 24,575
Connection density: 93 conn./mile main
Average length of customer service line: ? 7 0.0 ft (pipe length between curbstop and customer meter or property boundary)

Average operating pressure: ? 10 89.0 psi

COST DATA

Total annual cost of operating water system: ? 8 $21,523,528 $/Year
Customer retail unit cost (applied to Apparent Losses): ? 7 $4.02 $/100 cubic feet (ccf)
Variable production cost (applied to Real Losses): ? 7 $448.00 $/Million gallons

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PERFORMANCE INDICATORS

Financial Indicators

Non-revenue water as percent by volume of Water Supplied: 11.6%
Non-revenue water as percent by cost of operating system: 2.1%
Annual cost of Apparent Losses: $302,833
Annual cost of Real Losses: $132,441

Operational Efficiency Indicators

Apparent Losses per service connection per day: 6.28 gallons/connection/day

Real Losses per service connection per day*: 32.96 gallons/connection/day

Real Losses per length of main per day*: N/A

Real Losses per service connection per day per psi pressure: 0.37 gallons/connection/day/psi

? Unavoidable Annual Real Losses (UARL): 166.13 million gallons/year

From Above, Real Losses = Current Annual Real Losses (CARL): 295.63 million gallons/year

? Infrastructure Leakage Index (ILI) [CARL/UARL]: 1.78

* only the most applicable of these two indicators will be calculated

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WATER AUDIT DATA VALIDITY SCORE:

***** YOUR SCORE IS: 68 out of 100 *****

A weighted scale for the components of consumption and water loss is included in the calculation of the Water Audit Data Validity Score

PRIORITY AREAS FOR ATTENTION:

Based on the information provided, audit accuracy can be improved by addressing the following components:

1: Volume from own sources
2: Customer metering inaccuracies
3: Billed unmetered

For more information, click here to see the Grading Matrix worksheet

AWWA WLCC Free Water Audit Software: Water Balance

WAS v4.2

Water Audit Report For:	Report Yr:
City of Santa Cruz	2012

<table>
<tr><td rowspan="8">Own Sources
(Adjusted for known errors)
3,272.980</td><td>Water Exported
0.000</td><td colspan="4">Billed Water Exported</td></tr>
<tr><td rowspan="10">Water Supplied
3,272.980</td><td rowspan="4">Authorized Consumption
2,921.000</td><td rowspan="2">Billed Authorized Consumption
2,894.140</td><td>Billed Metered Consumption (inc. water exported)
2,893.200</td><td rowspan="2">Revenue Water
2,894.140</td></tr>
<tr><td>Billed Unmetered Consumption
0.940</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption
26.860</td><td>Unbilled Metered Consumption
2.500</td><td rowspan="8">Non-Revenue Water (NRW)
378.840</td></tr>
<tr><td>Unbilled Unmetered Consumption
24.360</td></tr>
<tr><td rowspan="6">Water Losses
351.980</td><td rowspan="3">Apparent Losses
56.352</td><td>Unauthorized Consumption
0.001</td></tr>
<tr><td>Customer Metering Inaccuracies
56.350</td></tr>
<tr><td>Systematic Data Handling Errors
0.001</td></tr>
<tr><td rowspan="3">Water Imported
0.000</td><td rowspan="3">Real Losses
295.628</td><td>Leakage on Transmission and/or Distribution Mains
Not broken down</td></tr>
<tr><td>Leakage and Overflows at Utility's Storage Tanks
Not broken down</td></tr>
<tr><td>Leakage on Service Connections
Not broken down</td></tr>
</table>

AWWA WLCC Free Water Audit Software: Grading Matrix

Back to Instructions

WASv 4.2

In the Reporting Worksheet, grades were assigned to each component of the audit to describe the confidence and accuracy of the input data. The grading assigned to each audit component and the corresponding recommended improvements and actions are highlighted in yellow. Audit accuracy is likely to be improved by prioritizing those items shown in red

Grading

	n/a	1	2	3	4	5	6	7	8	9	10
Volume from own sources:	Select this grading only if the water utility purchases/imports all of its water resources (i.e. has no sources of its own)	Less than 25% of water production sources are metered, remaining sources are estimated. No regular meter accuracy testing.	25% - 50% of treated water production sources are metered; other sources estimated. No regular meter accuracy testing.	Conditions between 2 and 4	50% - 75% of treated water production sources are metered, other sources estimated. Occasional meter accuracy testing	Conditions between 4 and 6	At least 75% of treated water production sources are metered, or at least 90% of the source flow is derived from metered sources. Meter accuracy testing and/or electronic calibration conducted annually. Less than 25% of tested meters are found outside of +/- 6% accuracy.	Conditions between 6 and 8	100% of treated water production sources are metered, meter accuracy testing and electronic calibration conducted annually, less than 10% of meters are found outside of +/- 6% accuracy	Conditions between 8 and 10	100% of treated water production sources are metered, meter accuracy testing and electronic calibration conducted semi-annually, with less than 10% found outside of +/- 3% accuracy.
Improvements to attain higher data grading for "Volume from own Sources" component:	▨	to qualify for 2: Organize efforts to begin to collect data for determining volume from own sources	to qualify for 4: Locate all water production sources on maps and in field, launch meter accuracy testing for existing meters, begin to install meters on unmetered water production sources and replace any obsolete/defective meters		to qualify for 6: Formalize annual meter accuracy testing for all source meters. Complete installation of meters on unmetered water production sources and complete replacement of all obsolete/defective meters.		to qualify for 8: Conduct annual meter accuracy testing on all meters. Complete project to install new, or replace defective existing, meters so that entire production meter population is metered. Repair or replace meters outside of +/- 6% accuracy.		to qualify for 10: Maintain annual meter accuracy testing for all meters. Repair or replace meters outside of +/- 6% accuracy. Investigate new meter technology; pilot one or more replacements with innovative meters in attempt to improve meter accuracy.		to maintain 10: Standardize meter accuracy test frequency to semi-annual, or more frequent, for all meters. Repair or replace meters outside of +/- 3% accuracy. Continually investigate/pilot improving metering technology.
Master meter error adjustment:	Select n/a only if the water utility fails to have meters on its sources of supply, either its own source, and/or imported (purchased) water sources	Inventory information on meters and paper records of measured volumes in crude condition; data error cannot be determined	No automatic datalogging of production volumes; daily readings are scribed on paper records. Tank/storage elevation changes are not employed in calculating "Volume from own sources" component. Data is adjusted only when grossly evident data error occurs.	Conditions between 2 and 4	Production meter data is logged automatically in electronic format and reviewed at least on a monthly basis. "Volume from own sources" tabulations include estimate of daily changes in tanks/storage facilities. Meter data is adjusted when gross data errors occur, or occasional meter testing deems this necessary.	Conditions between 4 and 6	Hourly production meter data logged automatically & reviewed on at least a weekly basis. Data adjusted to correct gross error from equipment malfunction and error confirmed by meter accuracy testing. Tank/storage facility elevation changes are automatically used in calculating a balanced "Volume from own sources" component.	Conditions between 6 and 8	Continuous production meter data logged automatically & reviewed daily. Data adjusted to correct gross error from equipment malfunction & results of meter accuracy testing. Tank/storage facility elevation changes are automatically used in "Volume from own sources" tabulations.	Conditions between 8 and 10	Computerized system (SCADA or similar) automatically balances flows from all sources and storages; results reviewed daily. Mass balance technique compares production meter data to raw (untreated) water and treatment volumes to detect anomalies. Regular calibrations between SCADA and sources meters ensures minimal data transfer error.
Improvements to attain higher data grading for "Master meter error adjustment" component:	▨	to qualify for 2: Develop plan to restructure recordkeeping system to capture all flow data; set procedure to review data daily to detect input errors	to qualify for 4: Install automatic datalogging equipment on production meters. Identify tanks/storage facilities and include estimated daily volume of water added to, or subtracted from, "Water Supplied" volume based upon changes in storage		to qualify for 6: Review hourly production meter data for gross error on, at least, a weekly basis. Begin to install instrumentation on tanks/storage facilities to record elevation changes. Use daily net storage change to balance flows in calculating "Water Supplied" volume.		to qualify for 8: Complete installation of elevation instrumentation on all tanks/storage facilities. Continue to use daily net storage change in calculating balanced "Volume from own sources" component. Adjust production meter data for gross error and inaccuracy confirmed by testing.		to qualify for 10: Link all production and tank/storage facility elevation change data to a Supervisory Control & Data Acquisition (SCADA) System, or similar computerized monitoring/control system, and establish automatic flow balancing algorithm and regularly calibrate between SCADA and source meters.		to maintain 10: Monitor meter innovations for development of more accurate and less expensive flowmeters. Continue to replace or repair meters as they perform outside of desired accuracy limits.
Water Imported:	Select n/a if the water utility's supply is exclusively from its own water resources (no bulk purchased/ imported water)	Less than 25% of imported water sources are metered, remaining sources are estimated. No regular meter accuracy testing.	25% - 50% of imported water sources are metered; other sources estimated. No regular meter accuracy testing.	Conditions between 2 and 4	50% - 75% of imported water sources are metered, other sources estimated. Occasional meter accuracy testing	Conditions between 4 and 6	At least 75% of imported water sources are metered, meter accuracy testing and/or electronic calibration conducted annually. Less than 25% of tested meters are found outside of +/- 6% accuracy.	Conditions between 6 and 8	100% of imported water sources are metered, meter accuracy testing and/or electronic calibration conducted annually, less than 10% of meters are found outside of +/- 6% accuracy	Conditions between 8 and 10	100% of imported water sources are metered, meter accuracy testing and/or electronic calibration conducted semi-annually, with less than 10% found outside of +/- 3% accuracy.
Improvements to attain higher data grading for "Water Imported Volume" component:	▨	to qualify for 2: Review bulk water purchase agreements with partner suppliers; confirm requirements for use and maintenance of accurate metering. Identify needs for new or replacement meters with goal to meter all imported water sources.	To qualify for 4: Locate all imported water sources on maps and in field, launch meter accuracy testing for existing meters, begin to install meters on unmetered imported water interconnections and replace obsolete/defective meters		to qualify for 6: Formalize annual meter accuracy testing for all imported water meters. Continue installation of meters on unmetered exported water interconnections and replacement of obsolete/defective meters.		to qualify for 8: Complete project to install new, or replace defective, meters on all imported water interconnections. Maintain annual meter accuracy testing for all imported water meters. Repair or replace meters outside of +/- 6% accuracy.		to qualify for 10: Maintain annual meter accuracy testing for all meters. Repair or replace meters outside of +/- 6% accuracy. Investigate new meter technology; pilot one or more replacements with innovative meters in attempt to improve meter accuracy.		to maintain 10: Standardize meter accuracy test frequency to semi-annual, or more frequent, for all meters. Repair or replace meters outside of +/- 3% accuracy. Continually investigate/pilot improving metering technology.

Grading											
	n/a	1	2	3	4	5	6	7	8	9	10
Water Exported:	Select n/a if the water utility sells no bulk water to neighboring water utilities (no exported water sales)	Less than 25% of exported water sources are metered, remaining sources are estimated. No regular meter accuracy testing.	25% - 50% of exported water sources are metered; other sources estimated. No regular meter accuracy testing.	Conditions between 2 and 4	50% - 75% of exported water sources are metered, other sources estimated. Occasional meter accuracy testing	Conditions between 4 and 6	At least 75% of exported water sources are metered, meter accuracy testing and/or electronic calibration conducted annually. Less than 25% of tested meters are found outside of +/- 6% accuracy.	Conditions between 6 and 8	100% of exported water sources are metered, meter accuracy testing and/or electronic calibration conducted annually, less than 10% of meters are found outside of +/- 6% accuracy	Conditions between 8 and 10	100% of exported water sources are metered, meter accuracy testing and/or electronic calibration conducted semi-annually, with less than 10% found outside of +/- 3% accuracy.
Improvements to attain higher data grading for "Water Exported Volume" component:	▨	to qualify for 2: Review bulk water sales agreements with partner suppliers; confirm requirements for use & upkeep of accurate metering. Identify needs to install new, or replace defective meters as needed.	To qualify for 4: Locate all exported water sources on maps and in field, launch meter accuracy testing for existing meters, begin to install meters on unmetered exported water interconnections and replace obsolete/defective meters		to qualify for 6: Formalize annual meter accuracy testing for all exported water meters. Continue installation of meters on unmetered exported water interconnections and replacement of obsolete/defective meters.		to qualify for 8: Complete project to install new, or replace defective, meters on all exported water interconnections. Maintain annual meter accuracy testing for all imported water meters. Repair or replace meters outside of +/- 6% accuracy.		to qualify for 10: Maintain annual meter accuracy testing for all meters. Repair or replace meters outside of +/- 6% accuracy. Investigate new meter technology; pilot one or more replacements with innovative meters in attempt to improve meter accuracy.		to maintain 10: Standardize meter accuracy test frequency to semi-annual, or more frequent, for all meters. Repair or replace meters outside of +/- 3% accuracy. Continually investigate/pilot improving metering technology.
AUTHORIZED CONSUMPTION											
Billed metered:	n/a (not applicable). Select n/a only if the entire customer population is not metered and is billed for water service on a flat or fixed rate basis. In such a case the volume entered must be zero.	Less than 50% of customers with volume-based billings from meter readings; flat or fixed rate billed for the majority of the customer population	At least 50% of customers with volume-based billing from meter reads; flat rate billed for others. Manual meter reading, under 50% read success rate, remainder estimated. Limited meter records, no regular meter testing or replacement. Billing data maintained on paper records, with no auditing.	Conditions between 2 and 4	At least 75% of customers with volume-based billing from meter reads; flat or fixed rate billed for remainder. Manual meter reading used, at least 50% meter read success rate, failed reads are estimated. Purchase records verify age of customer meters; only very limited meter accuracy testing is conducted. Customer meters replaced only upon complete failure. Computerized billing records, but only periodic internal auditing conducted.	Conditions between 4 and 6	At least 90% of customers with volume-based billing from meter reads; remaining accounts are estimated. Manual customer meter reading gives at least 80% customer meter reading success rate, failed reads are estimated. Good customer meter records, limited meter accuracy testing, regular replacement of oldest meters. Computerized billing records with routine auditing of global statistics.	Conditions between 6 and 8	At least 97% of customers with volume-based billing from meter reads. At least 90% customer meter read success rate; or minimum 80% read success rate with planning and budgeting for trials of Automatic Metering Reading (AMR) in one or more pilot areas. Good customer meter records. Regular meter accuracy testing guides replacement of statistically significant number of meters each year. Routine auditing of computerized billing records for global and detailed statistics; verified periodically by third party.	Conditions between 8 and 10	At least 99% of customers with volume-based billing from meter reads. At least 95% customer meter reading success rate; or minimum 80% meter reading success rate, with Automatic Meter Reading (AMR) trials underway. Statistically significant customer meter testing and replacement program in place. Computerized billing with routine, detailed auditing, including field investigation of representative sample of accounts. Annual audit verification by third party.
Improvements to attain higher data grading for "Billed Metered Consumption" component:	If n/a is selected because the customer meter population is unmetered, consider establishing a new policy to meter the customer population and employ water rates based upon metered volumes.	to qualify for 2: Conduct investigations or trials of customer meters to select appropriate meter models. Budget funding for meter installations. Investigate volume based water rate structures.	to qualify for 4: Purchase and install meters on unmetered accounts. Implement policies to improve meter reading success. Catalog meter information during meter read visits to identify age/model of existing meters. Test a minimal number of meters for accuracy. Install computerized billing system.		to qualify for 6: Purchase and install meters on unmetered accounts. Eliminate flat fee billing and establish appropriate water rate structure based upon measured consumption. Continue to achieve verifiable success in removing manual meter reading barriers. Expand meter accuracy testing. Launch regular meter replacement program. Conduct routine audit of global statistics.		to qualify for 8: Purchase and install meters on unmetered accounts. Assess cost-effectiveness of Automatic Meter Reading (AMR) system for portion or entire system; or achieve ongoing improvements in manual meter reading success rate. Refine meter accuracy testing program. Set meter replacement goals based upon accuracy test results. Refine routine auditing procedures based upon third party guidance.		to qualify for 10: Purchase and install meters on unmetered accounts. Launch Automatic Meter Reading (AMR) system trials if manual meter reading success rate of at least 95% is not achieved within a five-year program. Continue meter accuracy testing program. Conduct planning and budgeting for large scale meter replacement based upon meter life cycle analysis using cumulative flow target. Continue routine auditing and require annual third party review.		to maintain 10: Regular internal and third party auditing, and meter accuracy testing ensures that accurate customer meter readings are obtained and entered as the basis for volume based billing. Stay abreast of improvements in Advanced Metering Infrastructure (AMI) and information management. Plan and budget for justified upgrades in metering, meter reading and billing data management.
Billed unmetered:	Select n/a if it is the policy of the water utility to meter all customer connections and it has been confirmed by detailed auditing that all customers do indeed have a water meter; i.e. no unmetered accounts exist	Water utility policy does not require customer metering; flat or fixed fee billed. No data collected on customer consumption. Only estimates available are derived from data estimation methods using average fixture count multiplied by number of connections, or similar approach.	Water utility policy does not require customer metering; flat or fixed fee billed. Some metered accounts exist in parts of the system (pilot areas or District Metered Areas) with consumption recorded on portable dataloggers. Data from these sample meters are used to infer consumption for the total customer population. Site specific estimation methods are used for unusual buildings/water uses.	Conditions between 2 and 4	Water utility policy does require metering and volume based billing but lacks written procedures and employs casual oversight, resulting in up to 20% of billed accounts believed to be unmetered. A rough estimate of the annual consumption for all unmetered accounts is included in the annual water audit, with no inspection of individual unmetered accounts.	Conditions between 4 and 6	Water utility policy does require metering and volume based billing but exemption exist for a portion of accounts such as municipal buildings. As many as 15% of billed accounts are unmetered due to this exemption or meter installation difficulties. Only a group estimate of annual consumption for all unmetered accounts is included in the annual water audit, with no inspection of individual unmetered accounts.	Conditions between 6 and 8	Water utility policy requires metering and volume based billing for all customer accounts. However, less than 5% of billed accounts remain unmetered because because installation is hindered by unusual circumstances. The goal is to minimize the number of unmetered accounts. Reliable estimates of consumption are obtained for unmetered accounts via site specific estimation methods.	Conditions between 8 and 10	Water utility policy requires metering and volume based billing for all customer accounts. Less than 2% of billed accounts are unmetered and exist because meter installation is hindered by unusual circumstances. The goal exists to minimize the number of unmetered accounts to the extent that is economical. Reliable estimates of consumption are obtained at these accounts via site specific estimation methods.

Grading											
	n/a	1	2	3	4	5	6	7	8	9	10
Improvements to attain higher data grading for "Billed Unmetered Consumption" component:	▨	to qualify for 2: Investigate a new water utility policy to require metering of the customer population, and a reduction of unmetered accounts. Conduct pilot metering project by installing water meters in small sample of customer accounts and datalogging the water consumption.	to qualify for 4: Implement a new water utility policy requiring customer metering. Expand pilot metering study to include several different meter types, which will provide data for economic assessment of full scale metering options. Assess sites with access difficulties to devise means to obtain water consumption volumes.		to qualify for 6: Budget for staff resources to review billing records to identify unmetered properties. Specify metering needs and funding requirements to install sufficient meters to significant reduce the number of unmetered accounts		to qualify for 8: Install customer meters on a full scale basis. Refine metering policy and procedures to ensure that all accounts, including municipal properties, are designated for meters. Implement procedures to obtain reliable consumption estimate for unmetered accounts awaiting meter installation.		to qualify for 10: Continue customer meter installation throughout the service area, with a goal to minimize unmetered accounts. Sustain the effort to investigate accounts with access difficulties to devise means to install water meters or otherwise measure water consumption.		to maintain 10: Continue to refine estimation methods for unmetered consumption and explore means to establish metering, for as many billed unmetered accounts as is economically feasible.
Unbilled metered:	select n/a if all billing-exempt consumption is unmetered.	Billing practices exempt certain accounts, such as municipal buildings, but written policies do not exist; and a reliable count of unbilled metered accounts is unavailable. Meter upkeep and meter reading on these accounts is rare and not considered a priority. Due to poor recordkeeping and lack of auditing, water consumption for all such accounts is purely guesstimated.	Billing practices exempt certain accounts, such as municipal buildings, but only scattered, dated written directives exist to justify this practice. A reliable count of unbilled metered accounts is unavailable. Sporadic meter replacement and meter reading occurs on an as-needed basis. The total annual water consumption for all unbilled, metered accounts is estimated based upon approximating the number of accounts and assigning consumption from actively billed accounts of same meter size.	Conditions between 2 and 4	Dated written procedures permit billing exemption for specific accounts, such as municipal properties, but are unclear regarding certain other types of accounts. Meter reading is given low priority and is sporadic. Consumption is quantified from meter readings where available. The total number of unbilled, unmetered accounts must be estimated along with consumption volumes.	Conditions between 4 and 6	Written policies regarding billing exemptions exist but adherence in practice is questionable. Metering and meter reading for municipal buildings is reliable but sporadic for other unbilled metered accounts. Periodic auditing of such accounts is conducted. Water consumption is quantified directly from meter readings where available, but the majority of the consumption is estimated.	Conditions between 6 and 8	Written policy identifies the types of accounts granted a billing exemption. Customer meter management and meter reading are considered secondary priorities, but meter reading is conducted at least annually to obtain consumption volumes for the annual water audit. High level auditing of billing records ensures that a reliable census of such accounts exists.	Conditions between 8 and 10	Clearly written policy identifies the types of accounts given a billing exemption, with emphasis on keeping such accounts to a minimum. Customer meter management and meter reading for these accounts is given proper priority and is reliably conducted. Regular auditing confirms this. Total water consumption for these accounts is taken from reliable readings from accurate meters.
Improvements to attain higher data grading for "Unbilled metered Consumption" component:	▨	to qualify for 2: Reassess the water utility's policy allowing certain accounts to be granted a billing exemption. Draft an outline of a new written policy for billing exemptions, with clear justification as to why any accounts should be exempt from billing, and with the intention to keep the number of such accounts to a minimum.	to qualify for 4: Review historic written directives and policy documents allowing certain accounts to be billing-exempt. Draft an outline of a written policy for billing exemptions, identify criteria that grants an exemption, with a goal of keeping this number of accounts to a minimum.		to qualify for 6: Draft a new written policy regarding billing exemptions based upon consensus criteria allowing this occurrence. Assign resources to audit meter records and billing records to obtain census of unbilled metered accounts.		to qualify for 8: Communicate billing exemption policy throughout the organization and implement procedures that ensure proper account management. Conduct inspections of accounts confirmed in unbilled metered status and verify that accurate meters exist and are scheduled for routine meter readings.		to qualify for 10: Ensure that meter management (meter accuracy testing, meter replacement) and meter reading activities are accorded the same priority as billed accounts. Establish ongoing annual auditing process to ensure that water consumption is reliably collected and provided to the annual water audit process.		to maintain 10: Reassess philosophy in allowing any water uses to go "unbilled". It is possible to meter and bill all accounts, even if the fee charged for water consumption is discounted or waived. Metering and billing all accounts ensures that water consumption is tracked and water waste from plumbing leaks is detected and minimized.
Unbilled unmetered:	▨	Extent of unbilled, unmetered consumption is unknown due to unclear policies and poor recordkeeping. Total consumption is quantified based upon a purely subjective estimate.	Clear extent of unbilled, unmetered consumption is unknown, but a number of events are randomly documented each year, confirming existence of such consumption, but without sufficient documentation to quantify an accurate estimate of the annual volume consumed.	Conditions between 2 and 4	Extent of unbilled, unmetered consumption is partially known, and procedures exist to document certain events such as miscellaneous fire hydrant uses. Formulae is used to quantify the consumption from such events (time running x typical flowrate x number of events).	Default value of 1.25% of system input volume is employed	Coherent policies exist for some forms of unbilled, unmetered consumption but others await closer evaluation. Reasonable recordkeeping for the managed uses exists and allows for annual volumes to be quantified by inference, but unsupervised uses are guesstimated.	Conditions between 6 and 8	Clear policies and good recordkeeping exist for some uses (ex: unmetered fire connections registering consumption), but other uses (ex: miscellaneous uses of fire hydrants) have limited oversight. Total consumption is a mix of well quantified use such as from formulae (time x typical flow) or temporary meters, and relatively subjective estimates of less regulated use.	Conditions between 8 and 10	Clear policies exist to identify permitted use of water in unbilled, unmetered fashion, with the intention of minimizing this type of consumption. Good records document each occurrence and consumption is quantified via formulae (time x typical flow) or use of temporary meters.
Improvements to attain higher data grading for "Unbilled Unmetered Consumption" component:	▨	to qualify for 5: Utilize accepted default value of 1.25% of system input volume as an expedient means to gain a reasonable quantification of this use. to qualify for 2: Establish a policy regarding what water uses should be allowed as unbilled and unmetered. Consider tracking a small sample of one such use (ex: fire hydrant flushings).	to qualify for 5: Utilize accepted default value of 1.25% of system input volume as an expedient means to gain a reasonable quantification of this use. to qualify for 4: Evaluate the documentation of events that have been observed. Meet with user groups (ex: for fire hydrants - fire departments, contractors to ascertain their need for water from fire hydrants).		to qualify for 5: Utilize accepted default value of 1.25% of system input volume as expedient means to gain a reasonable quantification of all such use. This is particularly appropriate for water utilities who are in the early stages of the water auditing process.	to qualify for 6 or greater: Finalize policy and do field checks. Proceed if top-down audit exists and/or a great volume of such use is suspected.	to qualify for 8: Assess water utility policy and procedures to ensure that fire hydrant permits are issued for use by persons outside of the utility. Create written procedures for use and documentation of fire hydrants by water utility personnel.		to qualify for 10: Refine written procedures to ensure that all uses of unbilled, unmetered water are overseen by a structured permitting process managed by water utility personnel. Reassess policy to determine if some of these uses have value in being converted to billed and/or metered status.		to maintain 10: Continue to refine policy and procedures with intention of reducing the number of allowable uses of water in unbilled and unmetered fashion. Any uses that can feasibly become billed and metered should be converted eventually.
APPARENT LOSSES											

Grading											
	n/a	1	2	3	4	5	6	7	8	9	10
Unauthorized consumption:		Extent of unauthorized consumption is unknown due to unclear policies and poor recordkeeping. Total unauthorized consumption is guesstimated.	Unauthorized consumption is a known occurrence, but its extent is a mystery. There are no requirements to document observed events, but periodic field reports capture some of these occurrences. Total unauthorized consumption is approximated from this limited data.	conditions between 2 and 4	Procedures exist to document some unauthorized consumption such as observed unauthorized fire hydrant openings. Use formulae to quantify this consumption (time running x typical flowrate x number of events).	Default value of 0.25% of system input volume is employed	Coherent policies exist for some forms of unauthorized consumption but others await closer evaluation. Reasonable surveillance and recordkeeping exist for occurrences that fall under the policy. Volumes quantified by inference from these records. Unsupervised uses are guesstimated.	Conditions between 6 and 8	Clear policies and good recordkeeping exist for certain events (ex: tampering with water meters); other occurrences have limited oversight. Total consumption is a combination of volumes from formulae (time x typical flow) and subjective estimates of unconfirmed consumption.	Conditions between 8 and 10	Clear policies exist to identify all known unauthorized uses of water. Staff and procedures exist to provide enforcement of policies and detect violations. Each occurrence is quantified via formulae (time x typical flow) or similar methods.
Improvements to attain higher data grading for "Unauthorized Consumption" component:		to qualify for 5: Use accepted default of 0.25% of system input volume. to qualify for 2: Review utility policy regarding what water uses are considered unauthorized, and consider tracking a small sample of one such occurrence (ex: unauthorized fire hydrant openings)	to qualify for 5: Use accepted default of 0.25% of system input volume to qualify for 4: Review utility policy regarding what water uses are considered unauthorized, and consider tracking a small sample of one such occurrence (ex: unauthorized fire hydrant openings)		to qualify for 5: Utilize accepted default value of 0.25% of system input volume as expedient means to gain a reasonable quantification of all such use. This is particularly appropriate for water utilities who are in the early stages of the water auditing process.	to qualify for 6 or greater: Finalize policy and do field checks. Proceed if top-down audit exists and/or a great volume of such use is suspected.	to qualify for 8: Assess water utility policies to ensure that all known occurrences of unauthorized consumption are outlawed, and that appropriate penalties are prescribed. Create written procedures for use and documentation of various occurrences of unauthorized consumption as they are uncovered.		to qualify for 10: Refine written procedures and assign staff to seek out likely occurrences of unauthorized consumption. Explore new locking devices, monitors and other technologies designed to detect and thwart unauthorized consumption.		to maintain 10: Continue to refine policy and procedures to eliminate any loopholes that allow or tacitly encourage unauthorized consumption. Continue to be vigilant in documentation and enforcement efforts.
Customer metering inaccuracies:	select n/a only if the entire customer population is unmetered. In such a case the volume entered must be zero.	Customer meters exist, but with unorganized paper records on meters; no meter accuracy testing or meter replacement program. Workflow is driven chaotically by customer complaints with no proactive management. Loss volume due to aggregate meter inaccuracy is guesstimated.	Poor recordkeeping and meter oversight is recognized by water utility management who has allotted staff and funding resources to organize improved recordkeeping and start meter accuracy testing. Existing paper records gathered and organized to provide cursory disposition of meter population.	Conditions between 2 and 4	Reliable recordkeeping exists; meter information is improving as meters are replaced. Meter accuracy testing is conducted annually for a small number of meters. Limited number of oldest meters replaced each year. Inaccuracy volume is largely an estimate, but refined based upon limited testing data.	Conditions between 4 and 6	A reliable electronic recordkeeping system for meters exists. Population includes a mix of new high performing meters and dated meters with suspect accuracy. Routine, but limited, meter accuracy testing and meter replacement occur. Inaccuracy volume is quantified using a mix of reliable and less certain data.	Conditions between 6 and 8	Ongoing meter replacement and accuracy testing result in highly accurate customer meter population. Testing is conducted on samples of meters at varying lifespans to determine optimum replacement time for various types of meters.	Conditions between 8 and 10	Good records of number, type and size of customer meters; ongoing meter replacement occurs. Regular meter accuracy testing gives reliable measure of composite inaccuracy volume for the system. New metering technology is embraced to keep overall accuracy improving.
Improvements to attain higher data grading for "Customer meter inaccuracy volume" component:	If n/a is selected because the customer meter population is unmetered, consider establishing a new policy to meter the customer population and employ water rates based upon metered volumes.	to qualify for 2: Gather available meter purchase records. Conduct testing on a small number of meters believed to be the most inaccurate. Review staffing needs of metering group and budget for necessary resources to better organize meter management.	to qualify for 4: Implement a reliable record keeping system for customer meter histories, preferably using electronic methods typically linked to, or part of, the Customer Billing System or Customer Information System. Expand meter accuracy testing to a larger group of meters.		to qualify for 6: Standardize procedures for meter recordkeeping with the electronic information system. Accelerate meter accuracy testing and meter replacements guided by testing results.		to qualify for 8: Expand annual meter accuracy testing to evaluate a statistically significant number of meter makes/models. Expand meter replacement program to replace statistically significant number of poor performing meters each year.		to qualify for 10: Continue efforts to manage meter population with reliable recordkeeping, meter testing and replacement. Evaluate new meter types and install one or more types in 5-10 customer accounts each year in order to pilot improving metering technology.		to maintain 10: Increase the number of meters tested and replaced as justified by meter accuracy test data. Continually monitor development of new technology in Advanced Metering Infrastructure (AMI) to grasp opportunities for greater accuracy in metering and customer consumption data.
Systematic Data Handling Error:	Note: all water utilities incur some amount of this error. Even in water utilities with unmetered customer populations and fixed rate billing, errors occur in annual billing tabulations. Enter a positive value for the volume and select a grading.	Vague policy for permitting (creating new customer accounts) and billing. Billing data maintained on paper records which are in disarray. No audits conducted to confirm billing data handling efficiency. Unknown number of customers escape routine billing due to lack of billing process oversight.	Policy for permitting and billing exists but needs refinement. Billing data maintained on paper records or insufficiently capable electronic database. Only periodic unstructured auditing work conducted to confirm billing data handling efficiency. Volume of unbilled water due to billing lapses is a guess.	Conditions between 2 and 4	Policy and procedures for permitting and billing exist but needs refinement. Computerized billing system exists, but is dated or lacks needed functionality. Periodic, limited internal audits conducted and confirm with approximate accuracy the consumption volumes lost to billing lapses.	Conditions between 4 and 6	Policy for permitting and billing is adequate and reviewed periodically. Computerized billing system in use with basic reporting available. Any effect of billing adjustments on measured consumption volumes is well understood. Internal checks of billing data error conducted annually. Reasonably accurate quantification of consumption volume lost to billing lapses is obtained.	Conditions between 6 and 8	Permitting and billing policy reviewed at least biannually. Computerized billing system includes an array of reports to confirm billing data and system functionality. Annual internal checks conducted with periodic third party audit. Accountability checks flag billing lapses. Consumption lost to billing lapses is well quantified and reducing year-by-year.	Conditions between 8 and 10	Sound policy exists for permitting of all customer billing accounts. Robust computerized billing system gives high functionality and reporting capabilities. Assessment of policy and data handling errors conducted internally and audited by third party annually, ensuring consumption lost to billing lapses is minimized and detected as it occurs.
Improvements to attain higher data grading for "Systematic Data Handling Error volume" component:		to qualify for 2: Draft written policy for permitting and billing. Investigate and budget for computerized customer billing system. Conduct initial audit of billing records by flow-charting the basic business processes of the customer account/billing function.	to qualify for 4: Finalize written policy for permitting and billing. Implement a computerized customer billing system. Conduct initial audit of billing records as part of this process.		to qualify for 6: Refine permitting and billing procedures and ensure consistency with the utility policy regarding billing, and minimize opportunity for missed billings. Upgrade or replace customer billing system for needed functionality - ensure that billing adjustments don't corrupt the value of consumption volumes. Procedurize internal annual audit process.		to qualify for 8: Formalize regular review of permitting and billing practices. Enhance reporting capability of computerized billing system. Formalize regular auditing process to reveal scope of data handling error.		to qualify for 10: Close policy/procedure loopholes that allow some customer accounts to go unbilled, or data handling errors to exist. Ensure that internal and third party audits are conducted annually.		to maintain 10: Stay abreast of customer information management developments and innovations. Monitor developments of Advanced Metering Infrastructure (AMI) and integrate technology to ensure that customer endpoint information is well-monitored and errors/lapses are at an economic minimum.

Grading

	n/a	1	2	3	4	5	6	7	8	9	10
SYSTEM DATA											
Length of mains:	▨	Poorly assembled and maintained paper as-built records of existing water main installations makes accurate determination of system pipe length impossible. Length of mains is guesstimated.	Paper records in poor condition (no annual tracking of installations & abandonments). Poor procedures to ensure that new water mains installed by developers are accurately documented.	Conditions between 2 and 4	Sound policy and procedures for permitting and documenting new water main installations, but gaps in management result in a uncertain degree of error in tabulation of mains length.	Conditions between 4 and 6	Sound policy and procedures exist for permitting and commissioning new water mains. Highly accurate paper records with regular field validation; or electronic records and asset management system in good condition. Includes system backup.	Conditions between 6 and 8	Sound policy and procedures exist for permitting and commissioning new water mains. Electronic recordkeeping and asset management system are used to store and manage data.	Conditions between 8 and 10	Sound policy exists for managing water mains extensions and replacements. Geographic Information System (GIS) data and asset management database agree and random field validation proves truth of databases.
Improvements to attain higher data grading for "Length of Water Mains" component:	▨	to qualify for 2: Assign personnel to inventory current as-built records and compare with customer billing system records and highway plans. Assemble policy documents regarding permitting and documentation of water main installations by the utility and building developers; identify gaps in procedure that result in poor documentation.	to qualify for 4: Complete inventory of paper records of water main installations & abandonments for a number of years prior to audit year. Review policy and procedures for commissioning and documenting new water main installation and abandonments.		to qualify for 6: Finalize updates/improvements to policy and procedures for permitting/commissioning new main installations. Confirm inventory of records for five years prior to audit year; correct any errors or omissions.		to qualify for 8: Launch random field checks of limited number of locations. Convert to electronic databases with backup as justified.		to qualify for 10: Link Geographic Information System (GIS) and asset management databases, conduct field verification of data.		to maintain 10: Continue with standardization and random field validation to improve knowledge of system.
Number of active AND inactive service connections:	▨	Vague permitting (of new service connections) policy and poor paper recordkeeping of customer connections/billings result in suspect determination of the number of service connections, which may be 10-15% in error from actual count.	General permitting policy exists but paper records, procedural gaps, and weak oversight result in questionable total for number of connections, which may vary 5-10% of actual count.	Conditions between 2 and 4	Permitting policy and procedures exist, but with some gaps in performance and oversight. Computerized information management system is being brought online to replace dated paper recordkeeping system. Reasonably accurate tracking of service connection installations & abandonments; but count can be up to 5% in error from actual total.	Conditions between 4 and 6	Permitting policy and procedures are adequate and reviewed periodically. Computerized information management system is in use with annual installations & abandonments totaled. Very limited field verifications and audits. Error in count of number of service connections is believed to be no more that 3%.	Conditions between 6 and 8	Permitting policy and procedures reviewed at least biannually. Well-managed computerized information management system and routine, periodic field checks and internal system audits allows counts of connections that is no more than 2% in error.	Conditions between 8 and 10	Sound permitting policy and well managed and audited procedures ensure reliable management of service connection population. Computerized information management system and Geographic Information System (GIS) information agree; field validation proves truth of databases. Count of connections believed to be in error by less than 1%.
Improvements to attain higher data grading for "Number of Active and Inactive customer service connections" component:	▨	to qualify for 2: Draft new policy and procedures for permitting and billing. Research and collect paper records of installations & abandonments for several years prior to audit year.	to qualify for 4: Refine policy and procedures for permitting and billing. Research computerized recordkeeping system (Customer Information System or Customer Billing System) to improve documentation format for service connections.		to qualify for 6: Refine procedures to ensure consistency with permitting policy to establish new service connections or decommission existing connections. Improve process to include all totals for at least five years prior to audit year.		to qualify for 8: Formalize regular review of permitting policy and procedures. Launch random field checks of limited number of locations. Develop reports and auditing mechanisms for computerized information management system.		to qualify for 10: Close any procedural loopholes that allow installations to go undocumented. Link computerized information management system with Geographic Information System (GIS) and formalize field inspection and information system auditing processes. Documentation of new or decommissioned service connections encounters several levels of checks and balances.		to maintain 10: Continue with standardization and random field validation to improve knowledge of system.
Average length of customer service line:	Note: if customer water meters are located outside of the customer building next to the curbstop or boundary separating utility/customer responsibility, follow the grading description for 10(a). Also see the Service Connection Diagram worksheet.	Gradings 1-9 apply if customer properties are **unmetered**, if customer meters exist and are located **inside the customer building premises, or if the water utility owns and is responsible for the entire service connection piping from the water main to the customer building**. In any of these cases the average distance between the curbstop or boundary separating utility/customer responsibility for service connection piping, and the typical first point of use (ex: faucet) or the customer meter must be quantified. Gradings of 1-9 are used to grade the validity of the means to quantify this value. (See the "Service Connection Diagram" worksheet)									Either of two conditions can be met to obtain a grading of 10: a) The customer water meter is located outside of the customer building adjacent to the curbstop or boundary separating utility/customer responsibility for the service connection piping. In this case enter a value of zero in the Reporting Worksheet with a grading of 10. b). Customer water meters are located inside customer buildings, or the properties are unmetered. In either case the distance is highly reliable since data is drawn from a Geographic Information System (GIS) and confirmed by routine field checks.
		Vague policy exists to define the delineation of water utility ownership and customer ownership of the service connection piping. Curbstops are perceived as the breakpoint but these have not been well-maintained or documented. Most are buried or obscured. Their location varies widely from site-to-site, and estimating this distance is arbitrary due to the unknown location of many curbstops.	Policy requires that the curbstop serves as the delineation point between water utility ownership and customer ownership of the service connection piping. The piping from the water main to the curbstop is the property of the water utility; and the piping from the curbstop to the customer building is owned by the customer. Curbstop locations are not well documented and the average distance is based upon a limited number of locations measured in the field.	Conditions between 2 and 4	Good policy requires that the curbstop serves as the delineation point between water utility ownership and customer ownership of the service connection piping. Curbstops are generally installed as needed and are reasonably documented. Their location varies widely from site-to-site, and an estimate of this distance is hindered by the availability of paper records.	Conditions between 4 and 6	Clear policy exists to define utility/customer responsibility for service connection piping. Accurate, well-maintained paper or basic electronic recordkeeping system exists. Periodic field checks confirm piping lengths for a sample of customer properties.	Conditions between 6 and 8	Clearly worded policy standardizes the location of curbstops and meters, which are inspected upon installation. Accurate and well maintained electronic records exist with periodic field checks to confirm locations of service lines, curbstops and customer meter pits. An accurate number of customer properties from the customer billing system allows for reliable averaging of this length.	Conditions between 8 and 10	

	Grading										
	n/a	1	2	3	4	5	6	7	8	9	10
Improvements to attain higher data grading for "Average Length of Customer Service Line" component:		to qualify for 2: Research and collect paper records of service line installations. Inspect several sites in the field using pipe locators to locate curbstops. Obtain the length of this small sample of connections in this manner.	to qualify for 4: Formalize and communicate policy delineating utility/customer responsibilities for service connection piping. Assess accuracy of paper records by field inspection of a small sample of service connections using pipe locators as needed. Research the potential migration to a computerized information management system to store service connection data.		to qualify for 6: Establish coherent procedures to ensure that policy for curbstop, meter installation and documentation is followed. Gain consensus within the water utility for the establishment of a computerized information management system.		to qualify for 8: Implement an electronic means of recordkeeping, typically via a customer information system or customer billing system. Standardize the process to conduct field checks of limited number of locations.		to qualify for 10: Link customer information management system and Geographic Information System (GIS), standardize process for field verification of data.		to maintain 10: Continue with standardization and random field validation to improve knowledge of system.
Average operating pressure:		Available records are poorly assembled and maintained paper records of supply pump characteristics and water distribution system operating conditions. Average pressure is guesstimated based upon this information and ground elevations from crude topographical maps. Widely varying distribution system pressures due to undulating terrain, high system head loss and weak/erratic pressure controls further compromise the validity of the average pressure calculation.	Limited telemetry monitoring of scattered sites provides some static pressure data, which is recorded in handwritten logbooks. Pressure data is gathered at individual sites only when low pressure complaints arise. Average pressure is determined by averaging relatively crude data, and is affected by significant variation in ground elevations, system head loss and gaps in pressure controls in the distribution system.	Conditions between 2 and 4	Effective pressure controls separate different pressure zones; moderate pressure variation across the system, occasional open boundary valves are discovered that breech pressure zones. Basic telemetry monitoring of the distribution system logs pressure data electronically. Pressure data gathered by gauges or dataloggers at fire hydrants or buildings when low pressure complaints arise, and during fire flow tests and system flushing. Reliable topographical data exists. Average pressure is calculated using this mix of data.	Conditions between 4 and 6	Reliable pressure controls separate distinct pressure zones; only very occasional open boundary valves are encountered that breech pressure zones. Well-covered telemetry monitoring of the distribution system logs extensive pressure data electronically. Pressure gathered by gauges/dataloggers at fire hydrants and buildings when low pressure complaints arise, and during fire flow tests and system flushing. Average pressure is determined by using this mix of reliable data.	Conditions between 6 and 8	Well-managed, discrete pressure zones exist with generally predictable pressure fluctuations. A current full-scale SCADA System exists to monitor the water distribution system and collect data, including real time pressure readings at representative sites across the system. The average system pressure is determined from reliable SCADA System data.	Conditions between 8 and 10	Well-managed pressure districts/zones, SCADA System and hydraulic model exist to give very precise pressure data across the water distribution system. Average system pressure is reliably calculated from extensive, reliable, and cross-checked data.
Improvements to attain higher data grading for "Average Operating Pressure" component:		to qualify for 2: Employ pressure gauging and/or datalogging equipment to obtain pressure measurements from fire hydrants. Locate accurate topographical maps of service area in order to confirm ground elevations. Research pump data sheets to find pump pressure/flow characteristics	to qualify for 4: Formalize a procedure to use pressure gauging/datalogging equipment to gather pressure data during various system events such as low pressure complaints, or operational testing. Gather pump pressure and flow data at different flow regimes. Identify faulty pressure controls (pressure reducing valves, altitude valves, partially open boundary valves) and plan to properly configure pressure zones. Make all pressure data from these efforts available to generate system-wide average pressure.		to qualify for 6: Expand the use of pressure gauging/datalogging equipment to gather scattered pressure data at a representative set of sites, based upon pressure zones or areas. Utilize pump pressure and flow data to determine supply head entering each pressure zone or district. Correct any faulty pressure controls (pressure reducing valves, altitude valves, partially open boundary valves) to ensure properly configured pressure zones. Use expanded pressure dataset from these activities to generate system-wide average pressure.		to qualify for 8: Install a Supervisory Control and Data Acquisition (SCADA) System to monitor system parameters and control operations. Set regular calibration schedule for instrumentation to insure data accuracy. Obtain accurate topographical data and utilize pressure data gathered from field surveys to provide extensive, reliable data for pressure averaging.		to qualify for 10: Obtain average pressure data from hydraulic model of the distribution system that has been calibrated via field measurements in the water distribution system and confirmed in comparisons with SCADA System data.		to maintain 10: Continue to refine the hydraulic model of the distribution system and consider linking it with SCADA System for real-time pressure data calibration, and averaging.

Grading											
	n/a	1	2	3	4	5	6	7	8	9	10
COST DATA											
Total annual cost of operating water system:	▨	Incomplete paper records and lack of documentation on many operating functions making calculation of water system operating costs a pure guesstimate	Reasonably maintained, but incomplete, paper or electronic accounting provides data to estimate the major portion of water system operating costs.	Conditions between 2 and 4	Electronic, industry-standard cost accounting system in place. Gaps in data known to exist, periodic internal reviews conducted but not a structured audit.	Conditions between 4 and 6	Reliable electronic, industry-standard cost accounting system in place, with all pertinent water system operating costs tracked. Data audited periodically by utility personnel, not a Certified Public Accountant (CPA).	Conditions between 6 and 8	Reliable electronic, industry-standard cost accounting system in place, with all pertinent water system operating costs tracked. Data audited at least annually by utility personnel, and periodically by third-party CPA.	Conditions between 8 and 10	Reliable electronic, industry-standard cost accounting system in place, with all pertinent water system operating costs tracked. Data audited annually by utility personnel and by third-party CPA.
Improvements to attain higher data grading for "Total Annual Cost of Operating the Water System" component:	▨	to qualify for 2: Gather available records, institute new procedures to regularly collect and audit basic cost data of most important operations functions.	to qualify for 4: Implement an electronic cost accounting system, structured according to accounting standards for water utilities		to qualify for 6: Establish process for periodic internal audit of water system operating costs; identify cost data gaps and institute procedures for tracking these outstanding costs.		to qualify for 8: Standardize the process to conduct routine financial audit on an annual basis.		to qualify for 10: Standardize the process to conduct a third-party financial audit by a CPA on an annual basis.		to maintain 10: Maintain program, stay abreast of expenses subject to erratic cost changes and budget/track costs proactively
Customer retail unit cost (applied to Apparent Losses):	▨	Antiquated, cumbersome water rate structure is use, with periodic historic amendments that were poorly documented and implemented; resulting in classes of customers being billed inconsistent charges. The actual composite billing rate likely differs significantly from the published water rate structure, but a lack of auditing leaves the degree of error indeterminate.	Dated, cumbersome water rate structure, not always employed consistently in actual billing operations. The actual composite billing rate is known to differ from the published water rate structure, and a reasonably accurate estimate of the degree of error is determined, allowing a composite billing rate to be quantified.	Conditions between 2 and 4	Straight-forward water rate structure in use, but not updated in several years. Billing operations reliably employ the rate structure. The composite billing rate is derived from a single customer class such as residential customer accounts, neglecting the effect of different rates from varying customer classes.	Customer population unmetered. Fixed fee charged; single composite number derived from multiple customer classes.	Clearly written, up-to-date water rate structure is in force and is applied reliably in billing operations. Composite customer rate is determined using a weighted average residential rate using volumes of water in each rate block.	Conditions between 6 and 8	Effective water rate structure is in force and is applied reliably in billing operations. Composite customer rate is determined using a weighted average composite consumption rate, including residential, commercial, industrial and any other customer classes within the water rate structure.	Conditions between 8 and 10	Third party reviewed weighted average composite consumption rate (includes residential, commercial, industrial, etc.)
Improvements to attain higher data grading for "Customer Retail Unit Cost" component:	▨	to qualify for 2: Formalize the process to implement water rates, including a secure documentation procedure. Create a current, formal water rate document and gain approval from all stakeholders.	to qualify for 4: Review the water rate structure and update/formalize as needed. Assess billing operations to ensure that actual billing operations incorporate the established water rate structure.		to qualify for 6: Evaluate volume of water used in each usage block by residential users. Multiply volumes by full rate structure.	Meter customers and charge rates based upon water volumes	to qualify for 8: Evaluate volume of water used in each usage block by all classifications of users. Multiply volumes by full rate structure.		to qualify for 10: Conduct a periodic third-party audit of water used in each usage block by all classifications of users. Multiply volumes by full rate structure.		to maintain 10: Keep water rate structure current in addressing the water utility's revenue needs. Update the calculation of the customer unit rate as new rate components, customer classes, or other components are modified.
Variable production cost (applied to Real Losses):	Note: if the water utility purchases/imports its entire water supply, then enter the unit purchase cost of the bulk water supply in the Reporting Worksheet with a grading of 10	Incomplete paper records and lack of documentation on primary operating functions (electric power and treatment costs most importantly) makes calculation of variable production costs a pure guesstimate	Reasonably maintained, but incomplete, paper or electronic accounting provides data to roughly estimate the basic operations costs (pumping power costs and treatment costs) and calculate a unit variable production cost.	Conditions between 2 and 4	Electronic, industry-standard cost accounting system in place. Electric power and treatment costs are reliably tracked and allow accurate calculation of unit variable production costs based on these two inputs only. All costs are audited internally on a periodic basis.	Conditions between 4 and 6	Reliable electronic, industry-standard cost accounting system in place, with all pertinent water system operating costs tracked. Pertinent additional costs beyond power and treatment (ex: liability, residuals management, etc.) are included in the unit variable production cost. Data audited at least annually by utility personnel.	Conditions between 6 and 8	Reliable electronic, industry-standard cost accounting system in place, with all pertinent variable production costs tracked. Data audited at least annually by utility personnel, and periodically by third-party.	Conditions between 8 and 10	Either of two conditions can be met to obtain a grading of 10: 1) Third party CPA audit of all primary and secondary cost components on an annual basis. or: 2) Water supply is entirely purchased as bulk imported water, and unit purchase cost serves as the variable production cost.
Improvements to attain higher data grading for "Variable Production Cost" component:	▨	to qualify for 2: Gather available records, institute new procedures to regularly collect and audit basic cost data and most important operations functions.	to qualify for 4: Implement an electronic cost accounting system, structured according to accounting standards for water utilities		to qualify for 6: Formalize process for regular internal audits of production costs. Assess whether additional costs (liability, residuals management, etc.) should be included to calculate a more accurate variable production cost.		to qualify for 8: Formalize the accounting process to include primary cost components (power, treatment) as well as secondary components (liability, residuals management, etc.) Conduct periodic third-party audits.		to qualify for 10: Standardize the process to conduct a third-party financial audit by a CPA on an annual basis.		to maintain 10: Maintain program, stay abreast of expenses subject to erratic cost changes and budget/track costs proactively

AWWA WLCC Free Water Audit Software: Determining Water Loss Standing

WAS v4.2

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Water Loss Control Planning Guide

	Water Audit Data Validity Level / Score				
Functional Focus Area	**Level I** (0-25)	**Level II** (26-50)	**Level III** (51-70)	**Level IV** (71-90)	**Level V** (91-100)
Audit Data Collection	Launch auditing and loss control team; address production metering deficiencies	Analyze business process for customer metering and billing functions and water supply operations. Identify data gaps.	Establish/revise policies and procedures for data collection	Refine data collection practices and establish as routine business process	Annual water audit is a reliable gauge of year-to-year water efficiency standing
Short-term loss control	Research information on leak detection programs. Begin flowcharting analysis of customer billing system	Conduct loss assessment investigations on a sample portion of the system: customer meter testing, leak survey, unauthorized consumption, etc.	Establish ongoing mechanisms for customer meter accuracy testing, active leakage control and infrastructure monitoring	Refine, enhance or expand ongoing programs based upon economic justification	Stay abreast of improvements in metering, meter reading, billing, leakage management and infrastructure rehabilitation
Long-term loss control		Begin to assess long-term needs requiring large expenditure: customer meter replacement, water main replacement program, new customer billing system or Automatic Meter Reading (AMR) system.	Begin to assemble economic business case for long-term needs based upon improved data becoming available through the water audit process.	Conduct detailed planning, budgeting and launch of comprehensive improvements for metering, billing or infrastructure management	Continue incremental improvements in short-term and long-term loss control interventions
Target-setting			Establish long-term apparent and real loss reduction goals (+10 year horizon)	Establish mid-range (5 year horizon) apparent and real loss reduction goals	Evaluate and refine loss control goals on a yearly basis
Benchmarking			Preliminary Comparisons - can begin to rely upon the Infrastructure Leakage Index (ILI) for performance comparisons for real losses (see below table)	Performance Benchmarking - ILI is meaningful in comparing real loss standing	Identify Best Practices/ Best in class - the ILI is very reliable as a real loss performance indicator for best in class service

For validity scores of 50 or below, the shaded blocks should not be focus areas until better data validity is achieved.

Once data has been entered into the Reporting Worksheet, the performance indicators are automatically calculated. How does a water utility operator know how well his or her system is performing? The AWWA Water Loss Control Committee provided the following table to assist water utilities is gauging an approximate Infrastructure Leakage Index (ILI) that is appropriate for their water system and local conditions. The lower the amount of leakage and real losses that exist in the system, then the lower the ILI value will be.

Note: this table offers an approximate guideline for leakage reduction target-setting. The best means of setting such targets include performing an economic assessment of various loss control methods. However, this table is useful if such an assessment is not possible.

General Guidelines for Setting a Target ILI
(without doing a full economic analysis of leakage control options)

Target ILI Range	Financial Considerations	Operational Considerations	Water Resources Considerations
1.0 - 3.0	Water resources are costly to develop or purchase; ability to increase revenues via water rates is greatly limited because of regulation or low ratepayer affordability.	Operating with system leakage above this level would require expansion of existing infrastructure and/or additional water resources to meet the demand.	Available resources are greatly limited and are very difficult and/or environmentally unsound to develop.
>3.0 -5.0	Water resources can be developed or purchased at reasonable expense; periodic water rate increases can be feasibly imposed and are tolerated by the customer population.	Existing water supply infrastructure capability is sufficient to meet long-term demand as long as reasonable leakage management controls are in place.	Water resources are believed to be sufficient to meet long-term needs, but demand management interventions (leakage management, water conservation) are included in the long-term planning.
>5.0 - 8.0	Cost to purchase or obtain/treat water is low, as are rates charged to customers.	Superior reliability, capacity and integrity of the water supply infrastructure make it relatively immune to supply shortages.	Water resources are plentiful, reliable, and easily extracted.
Greater than 8.0	Although operational and financial considerations may allow a long-term ILI greater than 8.0, such a level of leakage is not an effective utilization of water as a resource. Setting a target level greater than 8.0 - other than as an incremental goal to a smaller long-term target - is discouraged.		
Less than 1.0	If the calculated Infrastructure Leakage Index (ILI) value for your system is 1.0 or less, two possibilities exist. a) you are maintaining your leakage at low levels in a class with the top worldwide performers in leakage control. b) A portion of your data may be flawed, causing your losses to be greatly understated. This is likely if you calculate a low ILI value but do not employ extensive leakage control practices in your operations. In such cases it is beneficial to validate the data by performing field measurements to confirm the accuracy of production and customer meters, or to identify any other potential sources of error in the data.		