MWRA WATER CONSERVATION GRANT PROJECT

PROJECT NUMBER 07-03/WCG

2008-2009

PREPARED BY:
MASSACHUSETTS WATER RESOURCES AUTHORITY

PREPARED FOR:

MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF RESOURCE PROTECTION

AND

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION 1

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PREPARED BY:
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Frederick A. Laskey, Executive Director

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Summary of MWRA Water Conservation Project and Lessons Learned

MWRA's Water Conservation Program targets both the MWRA-owned distribution system, as well as, member community-owned distribution systems. The purpose of the program is twofold: (1) to maintain average water demand below the system's safe yield of 300 million gallons per day (mgd) and (2) to help maintain the dry day wastewater flow to MWRA's Deer Island Wastewater Treatment Plant below 436 mgd [National Pollutant Discharge Elimination System (NPDES) permit limit]. Current average annual water demand is less than 220 mgd, well below the system's safe yield of 300 mgd. MWRA's dry day wastewater flow to Deer Island averages about 320 mgd; again, well below the NPDES permit limit of 436 mgd.

To expand its community-based water conservation programs during calendar year 2008, the Massachusetts Water Resources Authority (MWRA) applied for and received an $80,000 grant from the Massachusetts Department of Environmental Protection (MassDEP). MassDEP's Bureau of Resource Protection manages an annual Water Conservation Grant Program to assist public water systems and municipalities in addressing drinking water losses through local water conservation programs. Annually, MWRA encourages local water conservation by providing both educational materials and low-flow device kits to member communities and individual customers at no cost. The grant funds allowed MWRA to expand its 2008 water conservation outreach and education program for member communities with the implementation of two additional local projects (low-flow toilet retrofit rebates and water audits) to further promote drinking water conservation, reduce water usage, and reduce water loss.

MWRA Community Water Conservation Outreach and Education Program: In concert with the two new grant funded projects, MWRA instituted more aggressive marketing to local communities for its 2008 water conservation outreach campaign. The increased marketing effectively doubled prior year distributions of free water conservation educational materials and low-flow device kits to member communities and individual customers. During 2008, MWRA distributed over 490,000 water conservation public education/outreach brochures, 8,500 low-flow shower heads, 17,000 low-flow faucet (bath and kitchen) aerators, and 18,000 toilet leak detection dye tablets. The total potable water use savings from the distribution of educational brochures and low-flow fixtures is estimated at over 250,000 gallons per day (gpd), more than 90 million gallons (MG) for 2008, and more than 900 million gallons over a ten year period. The corresponding water retail charge savings is about $425,000 over one year and more than $4 million over ten years. Including both water and sewer charges, the one year estimated water/sewer use savings is $1.1 million and the ten year water/sewer use savings is $11 million for retail water customers in the MWRA service area.

Low-Flow Toilet Retrofit Rebate Project: To expand MWRA's 2008 water conservation outreach and education program for member communities, a new project was developed to provide a direct incentive for local communities to purchase/install low-flow (1.6 gallon per flush or less) toilets or toilet flush valves in municipal buildings to replace less efficient toilets that use a larger water volume per flush. For each eligible toilet retrofit (in city/town halls, public works buildings, schools, housing authorities, etc.) the community received a $100 rebate from MWRA. The project was a success with a total of 351 low-flow toilet retrofits being installed in ten separate communities. A total of $35,100 in reimbursement funds (351 rebates of

$100 each) were distributed to the ten local communities under the project. The 351 low-flow toilets installed under the rebate project are estimated to produce a water use savings of 10,000 gpd, 3.6 MG for 2008, and 36 MG over ten years. The corresponding water retail charge savings is $17,000 over one year and $170,000 over ten years. Including both water and sewer retail charges, the one year estimated water/sewer use savings is $45,000 and the ten year savings is $450,000.

Based on discussions with community representatives involved with the toilet retrofits, an average cost per installation was about $500 including the purchase of the new low-flow toilet and installation labor (not including the rebate). At this unit rate, the 351 low-flow toilet retrofits would have cost about $175,000 to install. Based only on water retail charge, the low-flow toilet installation costs would be recouped in about 10 years. Including both water and sewer charges, the low-flow toilet installation costs would be recouped in about 4 years.

Pilot Water Audit Project: To promote the benefits of municipal water audits, MWRA selected (via lottery) two member water communities to partner with. Water audits in Quincy and Somerville were conducted to balance the volume of water purchased from MWRA (wholesale purchase) with the volume billed (retail sales) and account for the remainder of non-billed water volume. The intent of a municipal water audit project is to help the community identify water system improvements to minimize its non-billed and unaccounted-for-water (UAW).

Somerville's water use analysis (3-year average 2005 through 2007) is summarized below:

Total Water Use	2290 MG/year	6.27 mgd	100 %
Retail Water Sales	1840 MG/year	5.04 mgd	80 %
Non-Billed Water Total	450 MG/year	1.23 mgd	20 %
Non-Billed Estimated Use	82 MG/year	0.22 mgd	4 %
Unaccounted-For-Water	368 MG/year	1.01 mgd	16 %
Unaccounted-For-Water Estimated as Leakage	135 MG/year	0.37 mgd	6 %
Unaccounted-For-Water Not Estimated	233 MG/year	0.64 mgd	10 %

For Somerville, the Water Audit Report analyses reasonably estimated and accounted for 217 MG per year of water use under the following non-billed categories: under-registration due to age of retail meters, unmetered retail accounts, municipal water use, water main breaks and water system leakage. For each of these different categories, Somerville is already in the process of lowering its water loss.

Somerville completed a pilot project during 2006/2007 to replace water meters on commercial and industrial accounts. Based on the success of the pilot program, the City is in the process of installing 13,500 new automatic meter reading water meters and a fixed-network system of data collection units. At the completion of this $5 million project, all water meters in the City will be newly replaced, currently unmetered accounts will be metered, and Somerville's under-

registration due to meter age and unmetered accounts (together estimated at about 41 MG per year) should be significantly reduced. The 41 MG per year represents a wholesale water and sewer cost of over $160,000 to Somerville. In addition, the potential increase of 41 MG per year in retail water sales equates to over $650,000 per year in currently unrealized water and sewer retail sales.

Leakage from all water systems includes both larger leaks that can be detected and repaired and "unavoidable" leakage from leaks that are too small to be detected. Water main breaks account for additional water loss. For Somerville, the Water Audit estimated total water loss from leaks and breaks at 152 MG per year, which represents a wholesale water cost of over $360,000 per year. Somerville has increased the frequency of leak detection and repair to reduce system leakage and continues to make water system improvements that will minimize water losses associated with breaks. These improvements are intended to reduce water loss and the associated cost, as well as, to minimize UAW.

Quincy's water use analysis (3 year average 2006 through 2008) is summarized below:

Total Water Use	3620 MG/year	9.92 mgd	100 %
Retail Water Sales	2710 MG/year	7.43 mgd	75 %
Non-Billed Water Total	910 MG/year	2.49 mgd	25 %
Non-Billed Estimated Use	185 MG/year	0.50 mgd	5 %
Unaccounted-For-Water	725 MG/year	1.99 mgd	20 %
Unaccounted-For-Water Estimated as Leakage	195 MG/year	0.54 mgd	5 %
Unaccounted-For-Water Not Estimated	530 MG/year	1.45 mgd	15 %

For Quincy, the Water Audit Report analyses reasonably estimated and accounted for 380 MG per year of water use under the following non-billed categories: under-registration due to age of retail meters, municipal water use, water main breaks and water system leakage. Unmetered accounts were not a problem for Quincy; however, the Water Audit identified under-registration of retail water volume due to meter age as Quincy's most immediate need for water system upgrade. Over half Quincy's retail water meters were installed over 40 years ago. Quincy has begun planning for a comprehensive meter replacement project for all 22,000 of the City's meters, as well as, installation of an automated meter reading system. This future project is estimated to cost $10 million. Quincy's under-registration due to age of retail meters was estimated at about 125 MG per year; however, it is likely that under-registration of meters accounted for even more of the non-billed total. The 125 MG per year represents a wholesale water and sewer cost of over $670,000 to Quincy. In addition, the potential increase of 125 MG per year in retail water sales equates to over $2.3 million per year in unrealized retail water and sewer fees. Installation of new meters and an automated meter reading system will minimize the cost of under-registration due to meter age, allow for an increase in the frequency of retail billing, and should lower UAW.

For Quincy, the Water Audit estimated total water loss from leaks and breaks at 205 MG per year, which represents a wholesale water cost of over $500,000 per year. The City may benefit from increasing its current every two-year frequency of leak detection and repair to reduce system leakage and the associated cost. In addition, Quincy should continue to make water system improvements that will minimize water losses associated with breaks, properly account for and reasonably estimate non-billed water volume, and minimize the City's UAW.

For the three year period analyzed in the Water Audit Reports, Somerville and Quincy's UAW represented 16 and 20 percent, respectively, of the total water use each City purchased annually from MWRA. The Massachusetts Water Conservation Standards recommend a performance standard of 10 percent UAW; therefore, both Somerville and Quincy do not yet meet the benchmark. As discussed above, Somerville has recently instituted system improvements and Quincy is in the planning process to implement improvements. Completion of these projects should lower UAW.

Retail sales by customer category (residential, commercial, industrial, institutional) were detailed in each of the Water Audit Reports. For Somerville, about 75 percent of the retail water sales were for residential accounts; while Quincy's residential portion of retail sales were 58 percent. Somerville and Quincy's total residential (indoor and outdoor) water use for the most recent year analyzed was 47 and 49 gpcd, respectively. Both communities' residential per capita water use are well within the recommend performance standard of 65 gpcd as defined in the Massachusetts Water Conservation Standards.

Some of the lessons learned that are detailed within this report are summarized in the bullets below.

- MWRA's relatively low-cost community water conservation outreach and education program (budgeted at $25,000 annually) provides significant water conservation and water/sewer charge reductions for retail water customers in the MWRA service area. In addition, more aggressive marketing of the outreach campaign for 2008, resulted in double the requests for free water conservation educational materials and low-flow device kits from member communities and individual customers.

- Rebates of $100 proved to be an effective direct incentive to encourage low-flow toilet retrofit projects to be implemented in municipal buildings and public housing units. Through implementation of the project, MWRA learned that most municipal buildings have been retrofitted with low-flow toilets (only 22 percent of the rebates went to municipal buildings). However, a significant need still exists with public housing authorities (housing authority's utilized 78 percent of the rebate funds).

- Low-flow toilet installation costs (about $500 each) would be recouped in about 4 years based on water use savings from average retail water and sewer fees. For water customers that do not pay sewer fees (homes with septic systems), the low-flow toilet installation cost would be recouped in about 10 years.

- US EPA's WaterSense website (www.watersense.com) is an excellent source of information on WaterSense labeled products (manufacturers, models, etc.) that meet the EPA's criteria for water efficiency, quality, and product performance.

- A municipal water audit is a cost-effective tool to help a community identify water system improvements to minimize its non-billed and unaccounted-for-water. Significant cost savings can be achieved by minimizing the following non-billed categories: under-registration due to age of retail meters, unmetered retail accounts, municipal water use, water main breaks and water system leakage.

- Costs associated with a comprehensive meter replacement and automated meter reading project may be offset in 5 to10 years from increased retail water and sewer fees from prior under-registration of old meters.

1.1 Introduction

Water conservation and efficiency are important for meeting environmental goals and for ensuring reliable and efficient water service. To expand its community-based water conservation programs during calendar year 2008, the Massachusetts Water Resources Authority (MWRA) applied for and received an $80,000 grant from the Massachusetts Department of Environmental Protection (MassDEP) Bureau of Resource Protection. Annually, MWRA encourages local water conservation by providing both educational materials and low-flow device kits to member communities and individual customers at no cost. The grant funds allowed MWRA to expand its 2008 water conservation outreach and education program for member communities with the implementation of two additional local projects to further promote drinking water conservation and reduce water usage. The two grant funded projects were: 1) Low-Flow Toilet Retrofit Rebates, and 2) Pilot Water Audits. The MWRA Water Conservation Grant Project Scope of Services is provided as Appendix C. This Summary Report has been prepared and submitted to MassDEP to fulfill a grant requirement. The Report has also been shared with member communities and other regional stakeholders as a water conservation educational tool.

1.2 Overview of MWRA Water Conservation Program

MWRA's Water Conservation Program targets both the MWRA-owned distribution system, as well as, member community-owned distribution systems. The purpose of the program is twofold: (1) to maintain average water demand below the system's safe yield of 300 mgd and (2) to help maintain the dry day wastewater flow to MWRA's Deer Island Wastewater Treatment Plant below 436 mgd [National Pollutant Discharge Elimination System (NPDES) permit limit]. Current average annual water demand is less than 220 mgd, well below the system's safe yield of 300 mgd. MWRA's dry day wastewater flow to Deer Island averages about 320 mgd; again well below the NPDES permit limit of 436 mgd. MWRA's water conservation efforts include: leak detection/repair for the Authority-owned distribution system, regulatory requirements and assistance for leak detection/repair of member community-owned distribution systems, distribution of water conservation education brochures and low-flow water fixtures at no cost to regional customers, school environmental education, as well as, partnership in US EPA's WaterSense program. Additional efforts that support water conservation and efficiency include: volume-based wholesale billing, metering and monitoring of water sales to member communities, and technical assistance to communities for analysis of water use data that may indicate the presence of distribution system leaks.

To minimize water lost through leaks from the 260-mile Authority-owned distribution system, MWRA conducts an annual leak detection and repair program. Over the last five years, an average of 13 pipeline leaks per year have been detected with repairs saving an average of 0.5 mgd of water per year.

To ensure member communities identify and repair leaks in local-owned distribution systems, MWRA developed leak detection regulations that went into effect in July 1991. Under these regulations, communities purchasing water from MWRA are required to complete a leak detection survey of their entire distribution system (and repair detected leaks) at least once every two years. Communities can accomplish the survey in one of three ways: (1) using their own

crews, (2) hiring their own contractor, or (3) using MWRA's task-order leak detection contract. Leak detection services performed via MWRA's task-order contract are paid for by MWRA, and the costs are billed to the community the following year. Over the last five years, an average of 450 pipeline leaks per year have been detected on community-owned systems with repairs saving an average of 5.3 mgd of water per year.

To encourage local water conservation, MWRA provides both educational materials and low-flow device kits to member communities and individual customers at no cost. MWRA's outreach campaign includes letters to community officials and local environmental organizations, updates at regional meetings, e-mail reminders, and use of MWRA's web page. Details of this program are included in Sections 2.1 through 2.4 of this report. MWRA also maintains a dedicated water conservation informational telephone line (617-242-SAVE) to allow community representatives and the public direct access to MWRA staff as a technical resource. Additional information is available at MWRA's website at www.mwra.com.

MWRA continues to promote water conservation awareness for young people. The ongoing School Education Program is designed to provide a science-based curriculum using a four step process: educational curriculum development, conducting classroom presentations, wide-spread teacher training and continual follow-up, and support to educators. Educational materials have been designed for students from the elementary level to the high school level. Annually, MWRA staff make hundreds of classroom presentations and holds a poster/writing contest.

During FY08, MWRA teamed with the US EPA to become a WaterSense program partner to help consumers save water for future generations and reduce costs on their utility bills. WaterSense aims to decrease indoor and outdoor water use through water-efficient products and simple water-saving practices. The program encourages customers to look for WaterSense labeled products, which have been independently certified for efficiency and performance, and promotes water-saving techniques that reduce stress on water systems and the environment.

1.3 Overview of MassDEP Water Conservation Grant Program

The MassDEP Bureau of Resource Protection manages an annual Water Conservation Grant Program. The program provides grant funds to assist public water systems and municipalities in addressing drinking water losses through local water conservation programs, water audits, leak detection surveys, some diagnostic equipment and training, and rebates for low flow fixtures and retrofit kits. Both federal and state resources sustain this grant program in support of the Massachusetts Water Resources Commission and MassDEP's watershed management policies and water conservation initiatives, as well as, the Massachusetts water conservation standards (http://www.mass.gov/Eoeea/docs/eea/water/water_conservation_standards.pdf).

1.4 Background on MWRA

MWRA was established by the State Legislature in 1984 as an independent public authority. MWRA maintains responsibility for water distribution to 50 municipalities and wastewater collection and treatment from 45 municipalities. MWRA's facilities span from the Quabbin Reservoir in western Massachusetts to the Deer Island Treatment Plant in Boston Harbor. Approximately 2.5 million people, about 44 percent of the total population of Massachusetts, live in the communities served by MWRA. Some of the Authority's goals, purposes and objectives relate directly to water conservation and demand management efforts, including:

- Efficient and economical operation of water delivery;
- Programs for leak detection for member communities; and,
- Repair, replacement, rehabilitation, modernization and extension of the delivery of water within the service area of the Authority.

1.5 MWRA Regional Water System and Water Demand

From its inception, MWRA has made demand management/water conservation a high priority. In 1985, MWRA inherited a water system that had been exceeding its safe yield of 300 mgd for almost twenty years. In 1986, the MWRA Board of Directors, through a series of water policy decisions, opted to aggressively pursue demand management strategies rather than pursue options for increasing water supply. This commitment to demand management resulted in the implementation of a highly successful water conservation program that has been a role model for water conservation efforts both nationally and globally. The continued effectiveness of MWRA's conservation efforts is demonstrated by the fact that baseline water demand (water withdrawal from MWRA reservoirs) continues to remain stable or decline and is comfortably below the system's safe yield of 300 mgd as shown on Figure 1.1. For both calendar year 2007 and 2008, MWRA's average annual water demand was less than 220 mgd.

The regional water system (see Figure 1.2) is managed as a partnership with the Department of Conservation and Recreation (DCR), which maintains responsibility for managing the reservoirs and watersheds. The entire water system is made up water supply sources, water treatment facilities, transmission aqueducts, pumping and storage facilities and the distribution network. MWRA operates an elaborate system of over 400 miles of water tunnels and distribution mains, which in turn feed over 6,000 miles of locally-owned water distribution pipes. The Metropolitan Water Distribution System serves 44 of the MWRA's 50 member water communities and is separated into seven pressure zone service areas (see Figure 1.3). More information on the MWRA regional water system and water demand are available at www.mwra.com.

Figure 1.1 – MWRA Reservoir Withdrawals

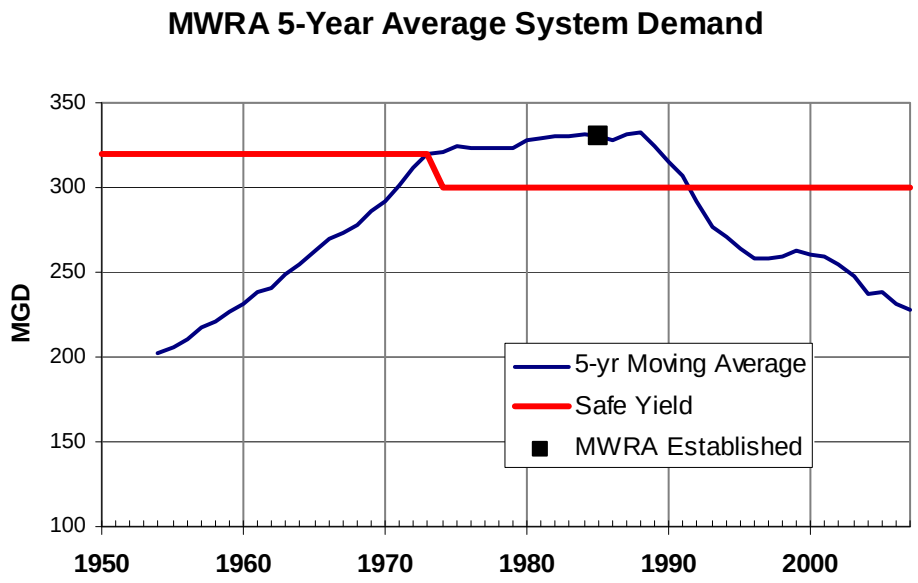


Figure 1.2 - MWRA Regional Water System

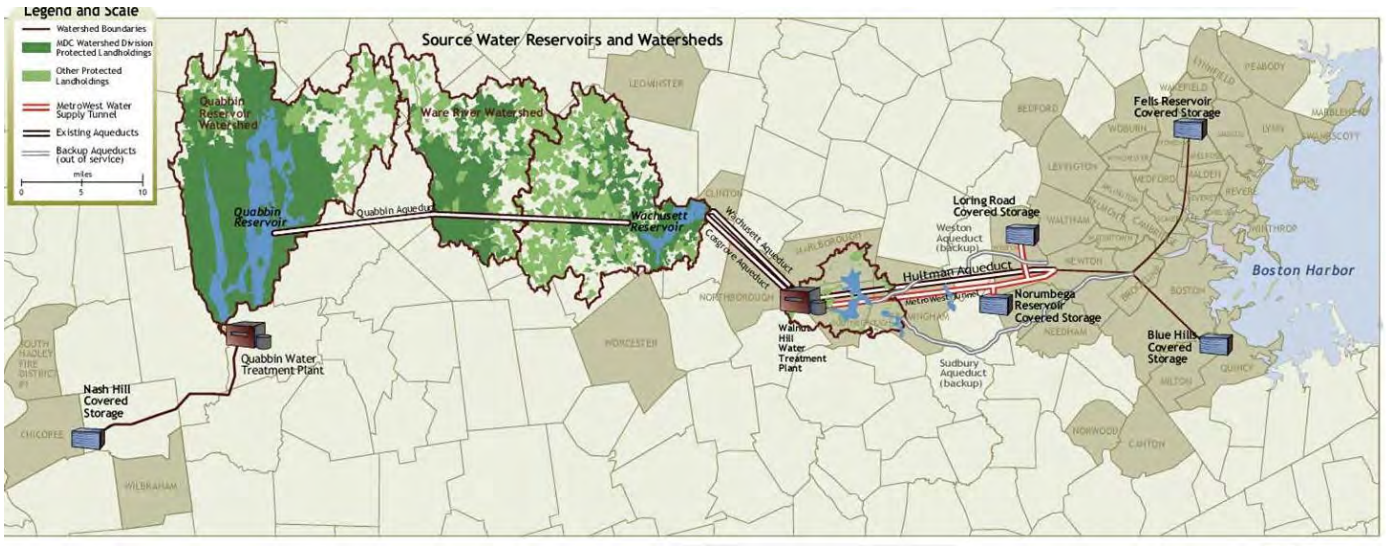
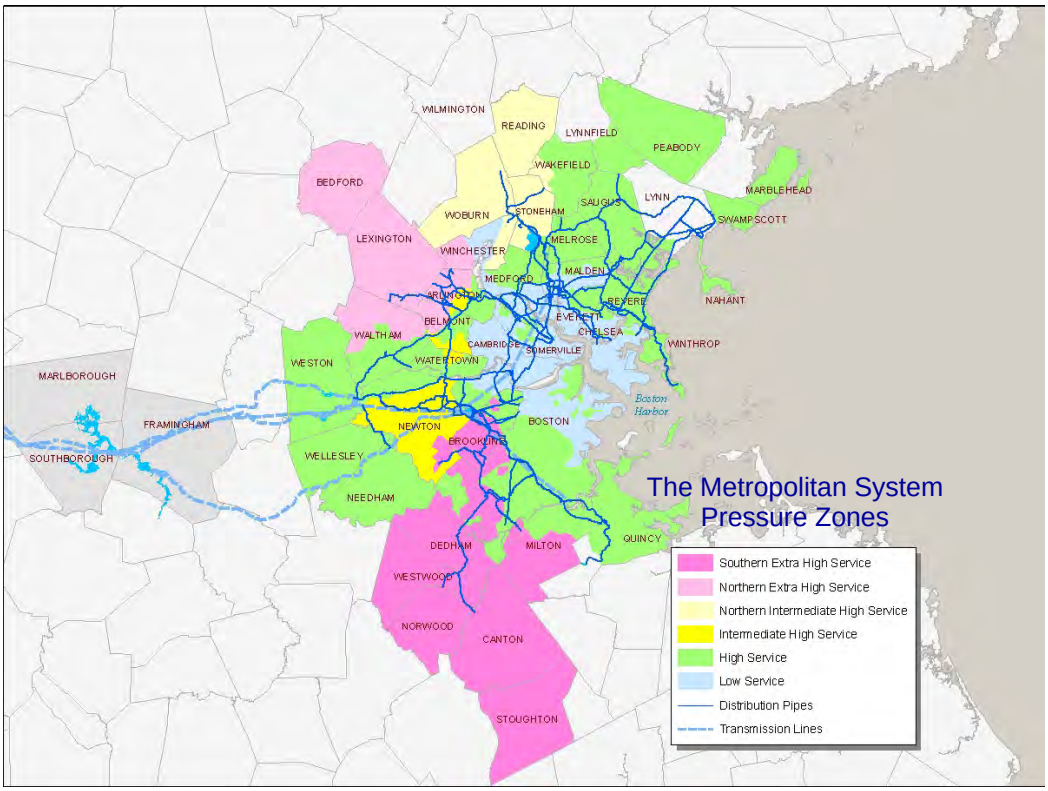


Figure 1.3 - Metropolitan Water Distribution System



1.6 Overview of Local Water Use

Water use by local municipalities can generally be classified into the following six types of uses: indoor residential, outdoor landscape, industrial/commercial/institutional (ICI), agricultural, municipal, and unaccounted-for water. Agricultural water use is generally minor in the MWRA service area; however, the other five types of uses make up the majority of local water use.

Based on data from municipal annual statistical reports filed with MassDEP for 2007, total residential (indoor and outdoor) water use in the 50 community MWRA service area averaged about 60 gpcd. Reported data for individual community use varied considerably. The Massachusetts Water Conservation Standards recommend a performance standard of 65 gpcd for residential water use. System-wide, MWRA meets the residential water use benchmark.

The Massachusetts Water Conservation Standards also recommend a performance standard of not more than 10 percent UAW. Based on data from municipal annual statistical reports filed with MassDEP for 2007, system-wide UAW averaged about 14 percent. Reported data for individual community UAW varied considerably. System-wide, MWRA does not yet meet the UAW benchmark. MWRA is working cooperative with member water communities to reduce local UAW. Results of the Pilot Water Audit portion of this project will help demonstrate system improvements pertinent to most local water departments that can help reduce UAW.

2.1 Printing of Water Conservation Brochures and Purchase of Low-Flow Fixtures

To encourage local water conservation, MWRA provides both educational materials and low-flow device kits to member communities and individual customers at no cost. Printing of water conservation brochures and purchase of low-flow fixtures is outlined in Task 1 of the MassDEP Grant Scope of Services. MWRA's water conservation public education materials include two brochures designed as bill-inserts for both MWRA and local distribution. Copies of the brochures are included in Appendix D and are described below:

- **"Indoor Water Conservation" Educational Brochure** - a colorful 3.5" x 6.5 " folded brochure emphasizing indoor water use (low-flow toilets, showerheads, faucets, washing machines, etc.), water efficient fixtures and appliances for the home, ways to find and fix leaks, and simple water saving tips.

- **"Outdoor Water Conservation" Educational Brochure** – a colorful 3.5" x 6.5" folded brochure emphasizing low water-use lawn and garden planting selection, water use needs, irrigation choices, and water conservation.

MWRA competitively bids bulk printing of the water conservation educational brochures. For the 2008 MassDEP-funded grant project, printing of the brochures was included as part of MWRA's "match" funds. The printing was bid in two separate purchase orders. First, 250,000 indoor water conservation brochures were printed/purchased at a cost of $9,225; second, 250,000 outdoor water conservation brochures were printed/purchased at a cost of $9,200. Two local printing companies won the two separate bids, each company qualified as a state certified woman-owned business enterprise (WBE).

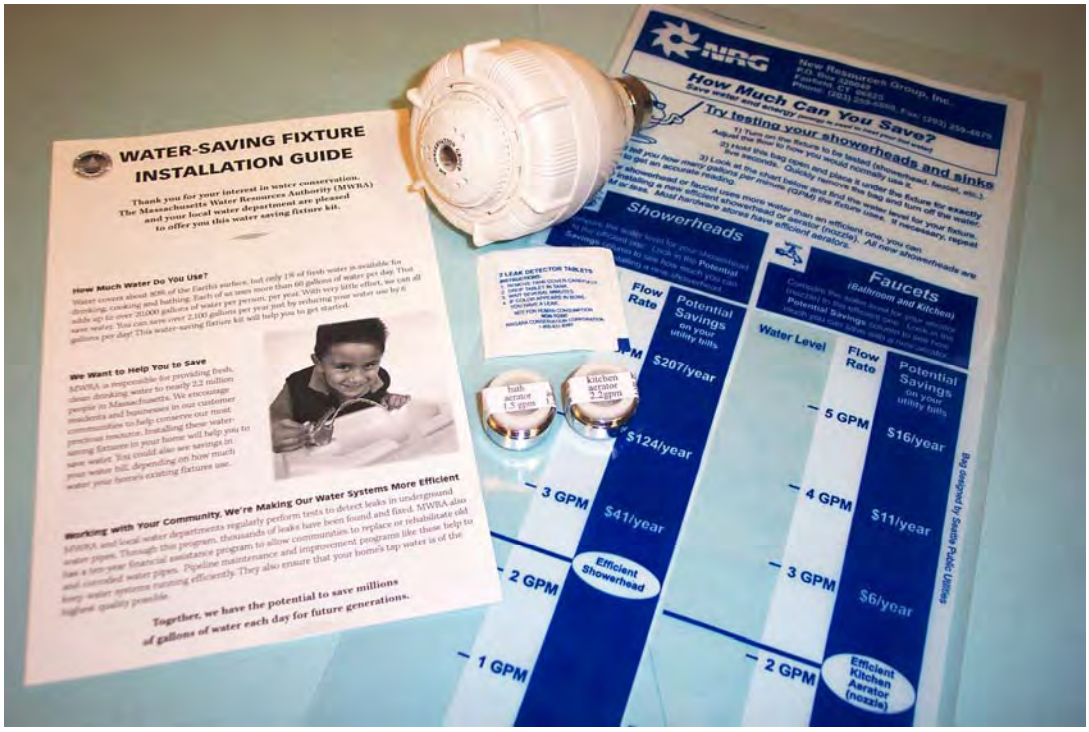
MWRA provides water conservation low-flow fixture retrofit kits at no cost to member communities, individual customers, housing authorities, property managers, environmental groups, etc. within the service area. The kits include:

- **A Low Flow Showerhead** – 2.5 gpm – plastic and chrome components;
- **Two Faucet Aerators** – 1.5 gpm for bathroom, 2.2 gpm for kitchen;
- **Dye Tablets** – to check for silent toilet leaks; and,
- **Installation Instructions.**

MWRA competitively bids bulk purchase of the water conservation kits. For the 2008 MassDEP funded grant project, purchase of the water conservation kits was included as part of MWRA's "match" funds. The purchase was bid in two separate purchase orders. In total, 6,400 low-flow showerheads, 8,000 faucet aerators, and 30,000 toilet leak detection dye tablets were purchased at a cost of $17,020. Two different suppliers won the two separate bids.

The low-flow retrofit devices and installation instructions are shown in Figure 2.1 below:

Figure 2.1 - Low-Flow Water Conservation Fixtures



2.2 Water Conservation Education, Community Outreach, and Marketing for the Low-Flow Toilet Rebate and Pilot Water Audit Projects

Annually, MWRA performs a water conservation education and community outreach campaign to promote the free distribution of water conservation indoor/outdoor brochures and low-flow fixture retrofit kits. For the 2008 program, the outreach campaign was expanded to include marketing for the grant funded low-flow toilet rebate and pilot water audit projects as outlined in Task 2 of the MassDEP Grant Scope of Services. MWRA's Community Support Program maintains a database of regional contacts used for outreach, including community officials, advisory committees, government agencies, watershed associations, local environmental groups, etc. Member communities are encouraged to distribute the water conservation brochures to all retail customers. The brochures are provided to communities (or directly to their billing company) in bulk to be used as bill inserts and also distributed at local Water Department offices for walk-up customers. The brochures are also available in large quantities to environmental groups for distribution at enviro-fairs and/or other educational functions, as well as, to property managers, condominium associations, and individual customers. Low-flow fixture retrofit kits are distributed to communities, environmental groups, housing authorities, property managers, condominium associations, and individual customers. To order water conservation brochures and/or low-flow fixtures at no cost, applicants submit a Water Conservation Fixture & Literature

Request Form. Water conservation tips, educational information and the fixture/literature request form are available on MWRA's web page at www.mwra.com.
In early 2008, an informational memo promoting all aspects of MWRA's water conservation initiatives was mailed to community public works departments, water superintendents, municipal managers/administrators, municipal housing authorities, municipal school departments, and other local stakeholders. This initial mailing was supplemented with numerous follow-up letters and e-mails. To market the low-flow toilet rebate and pilot water audit projects, informational flyers were developed that presented the details and requirements of each project. The flyers were included in the outreach correspondence, distributed at regional advisory committee meetings, and posted on MWRA's web page. Examples of MWRA's community outreach and marketing tools are presented in Appendix E, including the following items:

- Water Conservation Fixture & Literature Request Form;
- Water Conservation Initiatives Memo;
- Low-Flow Toilet Retrofit Rebate Project Flyer;
- Pilot Water Audit Project Flyer; and,
- Sample Letter to Communities Promoting Water Conservation.

2.3 Distribution of Water Conservation Educational Brochures and Low-Flow Fixtures

Distribution of water conservation educational materials and low-flow fixtures is outlined in Task 3 of the MassDEP Grant Scope of Services. Distribution of bulk orders of water conservation brochures and low-flow fixtures are scheduled by MWRA staff for convenient pick-up by member communities. For MWRA's largest customer community, the Boston Water and Sewer Commission (BWSC), deliveries of water conservation brochures are scheduled with MWRA's printer to be delivered directly to BWSC's mail house. Distribution of all water conservation materials are tracked in a spreadsheet format by three user categories: community Public Works Departments; multi-unit users including housing authorities, condo associations, property management groups, etc.; and individual customers/homeowners. For each user category, contact information is compiled in the spreadsheet, including: community/organization name, customer name, mailing address, and phone/fax numbers; and the date the water conservation items were distributed. The spreadsheets used to track the distribution of water conservation brochures and low-flow fixtures for 2008 is summarized in Appendix F and in Table 2.1.

Table 2.1

Summary of MWRA's Distribution of Water Conservation Brochures and Low-Flow Fixtures in 2008

	Indoor Brochure	Outdoor Brochure	Total Brochures	Low-Flow Shower Head	Low-Flow Bathroom Aerator	Low-Flow Kitchen Aerator	Total Low-Flow Devices	Dye Tabs
Homeowners	416	416	832	720	868	528	2,116	866
Multi-Units	7,442	2,734	10,176	2,326	2,382	2,252	6,960	2,775
DPWs	241,575	238,075	479,650	5,549	5,635	5,335	16,519	14,605
Total	249,433	241,225	490,658	8,595	8,885	8,115	25,595	18,246

2.4 Estimate of Water Use Reduction and Cost Savings from Distribution of Low-Flow Fixtures and Educational Brochures

MWRA's program for the installation of low-flow shower heads (2.5 gpm or less) and faucet aerators (1.5 gpm for bathroom faucets and 2.2 gpm for kitchen faucets), as well as, the use of dye tablets to identify toilet leaks, has been analyzed to estimate the annual quantitative water use reduction and resulting cost savings. To perform this analysis, Amy Vickers' *Handbook of Water Use and Conservation* (see reference 1) was MWRA's primary reference tool to researched typical indoor residential water use. Detailed information on per capita indoor water use by fixture for both non-conserving and conserving single family homes in North America is summarized in Table 2.2

Table 2.2

Average Indoor Water Use[1]

	Non-Conserving Home		Conserving Home	
Fixture	gpcd	percent	gpcd	percent
Toilets	19	27	8	18
Clothes Washer	15	21	10	22
Showers	12	17	9	20
Faucets	11	16	11	24
Bathtub/Other	2	3	2	5
Dishwasher	1	2	1	2
Leaks	10	14	4	9
Total	70	100	45	100

Low-Flow Showerheads: As noted in Table 2.2, average residential use for showerheads is about 12 gpcd or about 17 percent of a typical 70 gpcd non-conserving household. Showers are estimated to be the third largest household water user, after toilets and clothes washers. The installation of a low-flow showerhead (2.5 gpm or less) can improve water efficiency. Pre-1980, showerhead water use typically ranged from 5 to 8 gpm. During the 1980s, the water use for showerheads decreased to a range of 2.75 to 4 gpm. In 1994, the federal maximum water use requirements lowered the showerhead allowable flow rate to 2.5 gpm (at 80 psi) and 2.2 gpm (at 60 psi). To estimate water use reduction from the 8,595 showerheads distributed by MWRA during 2008, the following assumptions were made:

- Of the 3,046 showerheads distributed to homeowners and multi-units, a relatively high percentage of installs is assumed (75 percent installed or 2285 showerheads) because

these residents specifically requested the low-flow showerhead from MWRA using the mail-in request form;
- Of the 5,549 showerheads distributed to DPWs for redistribution to homeowners at the Water Department, a lower percentage of installs is assumed (50 percent installed or 2775 showerheads) because these residents did not specifically request the low-flow showerhead via mail-in request form;
- All 5,060 showerheads estimated to be installed produced an average water use savings of 1 gpm;
- Each showerhead installed was operated for an average of 30 minutes per day;
- The average MWRA retail customer water rate was $3.54 per 100 cubic feet or $4,722 per MG (2007 data); and,
- The average MWRA retail customer sewer rate was $5.82 per 100 cubic feet or $7,756 per MG (2007 data).

Based on these figures, each installed showerhead is estimated to produce a water use savings of 30 gpd and the total 5,060 installed showerheads are estimated to produce a water use savings of 150,000 gpd. Over one year the estimated water use savings is 55 MG; over ten years the estimated water use savings is 550 MG. The corresponding water retail charge savings is $260,000 over one year and $2.6 million over ten years. Including both water and sewer charges, the one year estimated water/sewer use savings is $680,000 and the ten year savings is $6.8 million.

Low-Flow Faucet Aerators: As noted in Table 2.2, average residential use for kitchen and bath faucets is about 11 gpcd or about 16 percent of a typical 70 gpcd non-conserving household. Faucet use is estimated to be the fourth largest household water user. The installation of low-flow faucet aerators (1.5 gpm or less for bathroom faucets and 2.2 gpm or less for kitchen faucets) can improve water efficiency. Pre-1980, household faucet water use typically ranged from 3 to 7 gpm. During the 1980s, the water use for faucets decreased to a range of 2.75 to 3 gpm. In 1994, the federal maximum water use requirements lowered the allowable flow rate for faucets to 2.5 gpm (at 80 psi) and 2.2 gpm (at 60 psi). To estimate water use reduction from the 17,000 faucet aerators distributed by MWRA during 2008, the following assumptions were made:

- Of the 6,030 kitchen and bath faucet aerators distributed to homeowners and multi-units, a relatively high percentage of installs is assumed (75 percent installed or 4523 faucet aerators) because these residents specifically requested the low-flow devices from MWRA using the mail-in request form;
- Of the 10,970 kitchen and bath faucet aerators distributed to DPWs for redistribution to homeowners at the Water Department, a lower percentage of installs is assumed (50 percent installed or 5,485 faucet aerators) because these residents did not specifically request the low-flow devices via mail-in request form;
- All 10,008 faucet aerators estimated to be installed produced an average water use savings of 1 gpm of use;
- Each faucet with a low-flow aerator installed was operated for an average of 10 minutes per day;

- The average MWRA retail customer water rate was $3.54 per 100 cubic feet or $4,722 per MG (2007 data); and,
- The average MWRA retail customer sewer rate was $5.82 per 100 cubic feet or $7,756 per MG (2007 data).

Based on these figures, each installed faucet aerator is estimated to produce a water use savings of 10 gpd and the total 10,008 installed faucet aerators are estimated to produce a water use savings of 100,000 gpd. Over one year the estimated water use savings is 36 MG; over ten years the estimated water use savings is 360 MG. The corresponding water retail charge savings is $170,000 over one year and $1.7 million over ten years. Including both water and sewer charges, the one year estimated water/sewer use savings is $450,000 and the ten year savings is $4.5 million.

Leaking Toilets/Dye Tabs: As noted in Table 2.2, average residential water loss from leakage is about 10 gpcd or about 14 percent of a typical 70 gpcd non-conserving household. Much of this water loss is attributable to toilet leakage[1]. Studies have identified that toilet leakage generally increases with the age of the fixture and water losses can vary from only a few gallons per day to over 100 gallons per day. Water loss from leaks is estimated to be the fifth largest household water user. Smaller leaks in toilets are often silent, allowing them to go undetected for extended periods. Larger toilet leaks may be detected by a running water sound or a visible trickle of water into the toilet bowl. Both small and large leaks can be quickly detected using dye tablets placed inside the toilet tank. If a toilet leak is present, the dyed water will be visible in the toilet bowl within a few minutes. Surveys of residential toilets (in New York City and San Diego)[1] reported about 5% of 3.5 gpf toilets leaked. To estimate water use reduction from the 18,246 toilet dye tablets distributed by MWRA during 2008, the following assumptions were made:

- Of the total 18,246 toilet dye tablets distributed, one of each 50 distributed (2%) will result in a detected toilet leak that will be repaired (total of 365 repaired toilet leaks);
- All 365 repaired toilet leaks were relatively small leaks in the 5 to 15 gpd range with an average water use savings of 10 gpd;
- The average MWRA retail customer water rate was $3.54 per 100 cubic feet or $4,722 per million gallons (2007 data); and,
- The average MWRA retail customer sewer rate was $5.82 per 100 cubic feet or $7,756 per million gallons (2007 data).

Based on these figures, the total 365 repaired toilet leaks identified by distributed dye tablets are estimated to produce a water use savings of 4,000 gpd. Over one year the estimated water use savings is 1.5 MG; over ten years the estimated water use savings is 15 MG. The corresponding water retail charge savings is $7,000 over one year and $70,000 over ten years. Including both water and sewer charges, the one year estimated water/sewer use savings is $18,000 and the ten year savings is $180,000.

Water Conservation Educational Brochures: Distribution of over 490,000 water conservation public education/outreach brochures to retail water customers will provide additional water conservation savings that is not able to be quantified. The “Indoor” brochures provide water conservation education on topics including: low-flow toilets, water efficient showerheads, low-

flow faucet aerators, water and energy efficient appliances, and finding/fixing household water leaks. Education on these items will produce water savings through many of the previously quantified water conservation measures. The "Outdoor" brochures provide water conservation education on topics including: lawn and garden watering, automatic sprinklers, drip irrigation, rain barrels, and low water-use plants. Education on these items will produce additional water savings beyond the water conservation measures previously discussed.

Fixture and Brochure Summary: In summary, the total potable water use savings from the distribution of low-flow fixtures and educational brochures is estimated at over 250,000 gpd, more than 90 MG for 2008 and more than 900 million gallons over a ten year period. The corresponding water retail charge savings is about $425,000 over one year and more than $4 million over ten years. Including both water and sewer charges, the one year estimated water/sewer use savings is $1.1 million and the ten year water/sewer use savings is $11 million for retail water customers in the MWRA service area. See summary table 2.3 below.

Table 2.3

Water Use Reduction and Cost Savings from Distribution of Low-Flow Fixtures

	Estimated Number Installed	Water Savings (gpd)	Water Savings (MG/year)	Water Only Cost Savings	Water and Sewer Cost Savings
Low-Flow Showerhead	5,060	150,000	55	$250,000	$680,000
Low-Flow Faucet Aerators	10,008	100,000	36	$170,000	$450,000
Leaking Toilets Replaced After Dye Tab Test	365	4,000	2	$7,000	$18,000
TOTAL	**15,433**	**254,000**	**93**	**$427,000**	**$1,148,000**

MWRA considers its public education materials and low-flow fixture distribution programs a success. Significant water conservation and regional cost savings have been achieved during the study period for this report (calendar year 2008), as well as prior years. MWRA plans to continue this program with a target annual budget of $25,000 for educational brochure printing and low-flow fixture purchase.

3.1 2008 Low-Flow Toilet Retrofit Rebate Project

To expand MWRA's water conservation outreach and education program for member communities, a new project was developed for 2008 to provide a direct incentive for local communities to purchase/install low-flow toilets or toilet flush valves that do not exceed 1.6 gallons per flush (gpf) in municipal buildings to replace less efficient toilets that use a larger water volume per flush. For each eligible toilet retrofit (in city/town halls, public works buildings, schools, housing authorities, etc.) the community received a $100 rebate from MWRA. Community outreach and marketing for this project was performed as detailed in Section 2.2. The primary marketing tool was the Low-Flow Toilet Retrofit Rebate Project Flyer, presented in Appendix E.

MWRA's target total expenditure was $40,000, derived from 400 rebates of $100 each. MWRA initially allocated nine (9) $100 rebates to each of the 44 eligible member water communities. Communities interested in participating in the project were required to reserve their allocated rebates by a specific deadline (May 16, 2008). After the deadline, MWRA reallocated the unreserved funds to communities based on demonstrated need and ability to meet the project schedule. Community representatives installed low-flow toilets at pre-approved locations using their own staff or an independent plumbing contractor. Member water communities applied to MWRA for the $100 rebates by submitting a Low-Flow Toilet Retrofit Rebate Project Reimbursement Request Form along with a copy of the purchase and/or installation receipt, and before/after photos to document the retrofit installation, as outlined in Task 4 of the MassDEP Grant Scope of Services. The Low-Flow Toilet Retrofit Rebate Project Reimbursement Request Form is presented as Appendix G. All Rebate Request Forms were required to be submitted to MWRA by an established deadline (November 28, 2008). MWRA developed a database to track rebate participants and installation locations (including property owners and addresses). The completed database is provided as Appendix H. At the conclusion of the project, 351 low-flow toilet retrofit rebates were distributed to a total of ten community participants as listed in Table 3.1. A few communities that initially committed to participation ultimately did not purchase and/or install the low-flow toilets resulting in the reduction from the target of 400 rebates to the actual distribution of 351 low-flow toilet retrofit rebates. The 49 toilet rebates that were not utilized were due to: local staffing issues, communities identifying that target toilets had already been low-flow retrofitted, toilet replacement construction could not be accomplished during the project time frame, etc.

Table 3.1

Community	Agency Receiving Rebate	Number of Rebates
Canton	Canton Housing Authority	12
Chelsea	Public Works Department	10
Lexington	Lexington Housing Authority	47
Marblehead	Public Works Department	15
Marlborough	Public Works Department	10
Quincy	Quincy Housing Authority	100
Revere	Public Works Department	10
Saugus	Public Works Department	30
Stoughton	Stoughton Housing Authority	100
Woburn	Public Works and School Depts	17
Total		351

As noted above, each rebate applicant was required to submit before/after photos to document the retrofit installation. Samples of the photos are displayed in Figures 3.1 through 3.4.

Figure 3.1 Sample High-Flow Toilet Before Retrofit in a Public Building

Figure 3.2 Sample Low-Flow Toilet After Retrofit in a Public Building

Figure 3.3 Sample High-Flow Toilet Before Retrofit in a Public Housing Unit

Figure 3.4 Sample Low-Flow Toilet After Retrofit in a Public Housing Unit

During the Low-Flow Toilet Retrofit Rebate project, MWRA received a number of inquiries from communities regarding recommendations for low-flow toilet manufacturers, models, etc. MWRA staff encouraged applicants to review the US EPA's WaterSense website (www.watersense.com). This site includes information on WaterSense labeled products that meet the EPA's criteria for water efficiency, quality, and product performance.

3.2 Estimate of Water Use Reduction and Cost Savings from the 2008 Low-Flow Toilet Retrofit Rebate Project

Water use reduction from MWRA's Low-Flow Toilet Retrofit Rebate project targeted toilets in municipal-owned buildings and municipal housing authorities. These were targeted because there may be less incentive for municipal-owned toilets to be low-flow retrofitted than residential toilet retrofits that produce a direct water/cost savings for the homeowner. The rebate was used to provide an incentive to the local community and/or housing authority to promote installation of low-flow toilets.

As noted in Table 2.2, average residential use for toilets is about 19 gpcd or about 27 percent of a typical 70 gpcd non-conserving household. Toilets are estimated to be the largest household water user for non-conserving homes. The installation of a low-flow toilet (1.6 gpf or less) can improve water efficiency. Pre-1980, toilet water use typically ranged from 5 to 5.5 gpf and even up to 7 gpf for pre-1950 toilets. During the 1980s, water use for toilets decreased to a range of 3.5 to 4.5 gpf. In 1989, Massachusetts became the first state to require all new or retrofitted toilets use 1.6 gpf or less. Subsequently, the federal maximum water use requirements lowered the allowable flow rate for toilets nation-wide to 1.6 gpf in 1994 (residential toilets) and 1997 (most commercial toilets). To estimate water use reduction from the 351 low-flow toilets installed under the 2008 MWRA rebate project, the following assumptions were made:

- Of the total 351 toilets retrofitted, all of the high flow toilets that were replaced were assumed (conservatively) to be 1980-1989 era models that used 3.5 to 4.5 gpf or an average of 4.0 gpf:
- All newly installed low-flow toilets were assumed to use 1.6 gpf with an average savings of 2.4 gpf;
- Of the total 351 toilets retrofitted, 274 toilets were located in public housing units that were assumed to have usage similar to an average household (2.6 residents per unit and five flushes per person per day)[1] for a total of 13 flushes per day per toilet;
- Of the total 351 toilets retrofitted, 77 toilets were located in public buildings or schools that were assumed to have usage similar to that reported for office buildings (20 gpd savings per low-flow toilet installed)[1];
- The average MWRA retail customer water rate was $3.54 per 100 cubic feet or $4,722 per million gallons (2007 data); and,
- The average MWRA retail customer sewer rate was $5.82 per 100 cubic feet or $7,756 per million gallons (2007 data).

Based on these figures, each low-flow toilet installed in a public housing unit is estimated to produce a water use savings of 31 gpd and the total 274 low-flow toilets installed in public housing units are estimated to produce a water use savings of 8500 gpd. The total 77 low-flow

toilets installed in public buildings and schools are estimated to produce a water use savings of 1500 gpd. In total, the 351 low-flow toilets installed under the rebate project are estimated to produce a water use savings of 10,000 gpd. For 2008, the estimated water use savings is 3.6 MG; over ten years the estimated water use savings is 36 MG. The corresponding water retail charge savings is $17,000 over one year and $170,000 over ten years. Including both water and sewer charges, the one year estimated water/sewer use savings is $45,000 and the ten year savings is $450,000. See summary table 3.2 below.

Table 3.2

Water Use Reduction and Cost Savings from Low-Flow Toilet Retrofits

	Estimated Number Installed	Water Savings (gpd)	Water Savings (MG/year)	Water Only Cost Savings	Water and Sewer Cost Savings
Low-Flow Toilets at Public Housing	274	8,500	3.1	$14,600	$39,000
Low-Flow Toilets at Public Buildings	77	1,500	0.5	$2,400	$6,000
TOTAL	**351**	**10,000**	**3.6**	**$17,000**	**$45,000**

Based on discussions with community representatives involved with the toilet retrofits, an average cost per installation was about $500 including the purchase of the new low-flow toilet and installation labor (not including the rebate). At this unit rate, the 351 low-flow toilet retrofits would have cost about $175,000 to install. Based only on water retail charge, the low-flow toilet installation costs would be recouped in about 10 years. Including both water and sewer charges, the low-flow toilet installation costs would be recouped in about 4 years.

MWRA considers its Low-Flow Toilet Retrofit Rebate Project a success. The return period to recoup the cost of a toilet retrofit proved to be reasonable. Also, municipalities were receptive to the program given the $100 rebate to offset a portion of their costs. MWRA recommends local communities and regional stakeholders consider similar low-flow toilet retrofit projects.

4.1 2008 Community Pilot Water Audit Project

To expand MWRA's water conservation outreach and education program for member communities, a new project was developed for 2008 to help promote the benefits of municipal water audits. Community outreach and marketing for this project was performed as detailed in Section 2.2. The primary marketing tool was the Pilot Water Audit Project Flyer, presented in Appendix E. All member water communities interested in participating in the pilot water audit project were asked to sign-up with MWRA by a specific deadline (April 18, 2008). A total of 11 communities expressed interest and MWRA selected (via lottery) two member water communities to partner with for the local water audits. Water audits in Quincy and Somerville were conducted to balance the volume of water purchased from MWRA (wholesale purchase) with the volume billed (retail sales) and account for the remainder of non-billed water volume as outlined as Tasks 5 and 6 of the MassDEP Grant Scope of Services. An independent consultant was utilized to perform the audits and the project scope of work was established to help the communities minimize their non-billed and unaccounted-for-water (UAW). MWRA's target total expenditure for two community water audits was not-to-exceed $50,000 (derived from $40,000 MassDEP grant funds and $10,000 in MWRA "match" funds). To conduct the water audits, kick-off meetings were held and community representatives were asked to provide key information on the local water system, including:

- Distribution system study;
- Two most recent leak detection survey reports;
- Meter information (size, age), broken down into categories (residential, commercial, etc);
- Consumption data (by category);
- Billing information (rates, frequency);
- Municipal water use estimates; and,
- Annual Statistical Reports for the last several years.

For each of the communities, a Water Audit Summary Report was prepared by the consultant and provided to MWRA. The full audit reports for Somerville and Quincy are provided as Appendices I and J, respectively. MassDEP's water audit worksheets (Forms 1 through 6) are provided as attachments to each Water Audit Report. A summary of the findings, recommendations, and water savings for each of the pilot water audits are provided below in Sections 4.2 and 4.3.

For additional information on water audits, communities should review the Water Management Act Program Guidance Document and Forms for a Water Audit (available at www.mass.gov/dep/water/approvals/guidance.pdf) and the Water Resources Commission MA Water Conservation Standards - see the System Water Audits and Leak Detection section (available at www.mass.gov/envir/mwrc/pdf/Conservation_Standards.pdf). A good municipal reference for water audits and water loss reduction is Julian Thornton's *Water Loss Control Manual* (see Reference 2).

4.2 Summary of Somerville Water Audit and Water Savings

The Pilot Water Audit Report for Somerville, MA presents eight separate sections detailing the following information:

Section 1: City of Somerville Background Information
Section 2: Review of Billing and Accounting Procedures
Section 3: Water Sales
Section 4: Non-Billed Water Volume and Cost
Section 5: Meter Adjustment Percentage Estimates
Section 6: Non-Billed Estimates
Section 7: Summary of Findings
Section 8: Recommendations for Future Improvements

The City of Somerville is an urban, mostly residential community comprised of 77,400 residents in a 4.2 square mile area located just north of the City of Cambridge. Somerville purchases all its water from MWRA via seven master meter locations, five of which serve the low pressure zone and two of which serve the high pressure zone. Somerville's water distribution system consists of 121 miles of water main, 75 percent of which were constructed between 1868 and 1950. Six to 12-inch water mains account for 92 percent of the distribution system; 68 percent of the pipe is unlined.

In the Water Audit Report, the volume of water purchased by Somerville from MWRA (total water use) was compared with the volume of water sold (retail sales). The comparison was performed for the three year period 2005 through 2007. An average of 2290 MG per year of water (6.27 mgd) was purchased annually from MWRA, while an average of 1840 MG per year of water was sold to retail customers. The difference between the total water use and retail sales, defined as the City's non-billed water volume, averaged 450 MG per year. A detailed analysis was performed to reasonably estimate, to the maximum extent possible, sources of the City's non-billed water volume. The analysis determined 82 MG per year of the non-billed water volume could be reasonably estimated and accounted for under the following categories of water use: 26 MG per year for under-registration due to age of retail meters, 15 MG per year for unmetered retail accounts, 24 MG per year for municipal water use, and 17 MG per year for water main breaks. The remaining 368 MG per year of non-billed water volume is characterized as unaccounted-for-water (UAW). Somerville's UAW represents about 16 percent of the total water use the City purchases annually from MWRA. The Massachusetts Water Conservation Standards recommend a performance standard of 10 percent UAW, therefore, Somerville is currently above the UAW benchmark.

Additional analysis in the Water Audit determined 135 MG per year of the non-billed water volume could be reasonably estimated as leakage from the water system. Per MassDEP guidelines, estimated water system leakage is defined and calculated as part of the systems UAW. However, estimating the portion of UAW that may be attributable to leakage allows for quantification of the remaining portion of UAW (233 MG per year) that has not been identified within the Water Audit Report. This remaining portion of UAW is likely spread out among all of the categories of non-billed water, including: under-registration due to meter age, unmetered

retail accounts, municipal water use, water main breaks, water theft, and water system leakage. It is likely that the annual volume of non-billed water for each of these categories is larger than that estimated in the Water Audit.

Somerville's water use analysis (3-year average 2005 through 2007) is summarized below:

Total Water Use	2290 MG/year	6.27 mgd	100 %
Retail Water Sales	1840 MG/year	5.04 mgd	80 %
Non-Billed Water Total	450 MG/year	1.23 mgd	20 %
Non-Billed Estimated Use	82 MG/year	0.22 mgd	4 %
Unaccounted-For-Water	368 MG/year	1.01 mgd	16 %
Unaccounted-For-Water Estimated as Leakage	135 MG/year	0.37 mgd	6 %
Unaccounted-For-Water Not Estimated	233 MG/year	0.64 mgd	10 %

The analyses used to develop estimates for non-billed water is presented in Sections 5 and 6 of the Water Audit Report. Somerville is already in the process of lowering its water loss. Specific actions and potential for water and cost savings are detailed below.

Under-Registration due to Meter Age: Somerville completed a pilot project during 2006/2007 to replace water meters on commercial and industrial accounts. Based on the success of the pilot program, the City is in the process of installing 13,500 new automatic meter reading water meters and a fixed-network system of data collection units. At the completion of this $4 million project, all water meters in the City will be newly replaced and the City will move to bi-monthly billing for all retail accounts. In Section 5 of the Audit Report, Somerville's under-registration due to age of retail meters (prior to meter replacements) was estimated at about 26 MG per year (0.07 mgd). However, it is likely that under-registration of the old meters accounted for even more of the non-billed total estimated because many retail meters did not have an age associated with them. The 26 MG per year represents a wholesale water and sewer cost of over $100,000 per year to Somerville. In addition, the potential increase of 26 MG per year in retail water sales equates to over $410,000 per year based on Somerville's current water and sewer retail rate. Installation of new meters will minimize the cost of under-registration due to meter age and should lower UAW.

Unmetered Accounts: As part of Somerville's water meter replacement project, new meters will be installed in each of the 42 previously unmetered buildings. The unmetered accounts are comprised mostly of non-profit institutions (primarily churches). In Section 6 of the Audit Report, Somerville's non-billed water use from unmetered accounts was estimated at about 15 MG per year (0.04 mgd). However, it is possible that this estimate may under-represent the actual consumption by the unmetered accounts. The 15 MG per year represents a wholesale water and sewer cost of over $60,000 per year to Somerville. In addition, the potential increase of 15 MG per year in retail water sales equates to over $240,000 per year based on Somerville's

current water and sewer retail rate. Installation of new meters on unmetered accounts will eliminate this cost and should lower UAW.

Municipal Water Use: Municipal water use includes hydrant testing and flushing by the Fire Department, water system flushing by the Water Department, street cleaning and sewer cleaning by Public Works, and traffic island and park lawn watering. In Section 6 of the Audit Report, Somerville's municipal water use was analyzed and it was determined that some prior estimates for municipal water use at fire hydrants had been significantly under estimated. As estimated in the Audit Report, Somerville's municipal water use was about 24 MG per year (0.07 mgd). Based on this data and current wholesale water cost, municipal water use is estimated to cost the City over $60,000 per year. As Somerville renovates City parks and retrofits retail water meters, new meters are being installed for traffic island/park watering which will help to accurately estimate municipal water use and the associated cost. These system improvements will help to minimize UAW.

Water Main Breaks: During 2008, water main breaks accounted for about 17 MG (0.05 mgd) of water loss, as detailed in Section 6 of the Water Audit Report. Based on the 2008 breaks data and current wholesale water cost, water loss from main breaks is estimated to cost the City about $40,000 per year. Given that main breaks have been occurring throughout the water distribution system rather than clustered in a specific location, there does not appear to be a way to target the reduction of water main breaks. However, the City of Somerville continues to make water system improvements that will minimize water losses associated with breaks. For example, as part of the City's lead abatement program, many of the water main gates are being replaced. The new gates are now being used to control water loss during main breaks. In addition, over the past eight years Somerville has invested over $8.0 million in water main replacement and cleaning and lining projects through MWRA's Local Pipeline Assistance (interest-free loan) Program. The City has replaced over 7.5 miles of unlined cast iron water main and 1300 lead service connections, and cleaned and lined over 2.3 miles of previously unlined cast iron main. Continued annual system improvements will help to minimize UAW.

Water System Leakage: Leakage from all water systems includes both larger leaks that can be detected and repaired and "unavoidable" leakage from leaks that are too small to be detected. Formerly, the City of Somerville performed leak detection surveys every 2 years, as required under MWRA leak detection regulations. However, in recent years, the City has started performing leak detection surveys every year. Further, they have been alternating between using digital correlation and sensors. By combining these two methods, the City of Somerville is ensuring that they are making every effort possible to detect and fix leaks in their distribution system. Absent water use or pressure data that indicates a problem, more frequent leak detection than annual efforts would likely not be cost effective. In Section 6 of the Audit Report, Somerville's detectable water system leakage was estimated at about 50 MG per year (0.14 mgd) and unavoidable leakage was estimated at about 85 MG per year (0.23 mgd). The total 135 MG per year (0.37 mgd) estimated water system leakage accounts for a wholesale water cost to Somerville of over $320,000 per year. Somerville's increased frequency of leak detection and repair should reduce system leakage and the associated cost, as well as, help to minimize UAW.

Somerville's retail sales by customer category are detailed in Section 3 of the Water Audit Report. For 2007 data, about 75 percent of the retail water sales are for residential accounts; while commercial, industrial, and institutional accounts represent the remaining 10 percent, 11 percent, and 4 percent, respectively. Somerville's total residential (indoor and outdoor) water use for 2007 averaged 47 gpcd. The City's residential per capita water use is well within the recommend performance standard of 65 gpcd, as defined in the Massachusetts Water Conservation Standards. Somerville's 2007 retail water sales by customer category are summarized below:

2007 Retail Water Sales	1770 MG	4.85 mgd	100 %
Residential	1334 MG	3.65 mgd	75 %
Commercial	175 MG	0.48 mgd	10 %
Industrial	191 MG	0.52 mgd	11 %
Institutional	71 MG	0.20 mgd	4 %

In summary, the City of Somerville is taking the necessary steps to upgrade retail water metering, increase the frequency of retail billing, minimize water system leakage, minimize water loss from water main breaks, properly account for and reasonably estimate non-billed water volume, and minimize the City's UAW volume. These actions will help reduce the total 450 MG per year of estimated non-billed water use identified in the Water Audit Report, as well as, the cost to Somerville in wholesale water and sewer fees and unrealized retail water payments.

4.3 Summary of Quincy Water Audit and Water Savings

The Pilot Water Audit Report for Quincy, MA presents eight separate sections detailing the following information:

Section 1: City of Quincy Background Information
Section 2: Review of Billing and Accounting Procedures
Section 3: Water Sales
Section 4: Non-Billed Water Volume and Cost
Section 5: Meter Adjustment Percentage Estimates
Section 6: Non-Billed Estimates
Section 7: Summary of Findings
Section 8: Recommendations for Future Improvements

The City of Quincy is an urban, mostly residential community comprised of 91,600 residents in a 17 square mile area located southeast of Boston on the Neponset and Weymouth Fore Rivers. Twenty-three percent of the land area of Quincy is comprised of the Blue Hills Reservation. Quincy purchases all its water from MWRA via five master meter locations. Quincy's water distribution system consists of 237 miles of water main. Six to 16-inch water mains account for 96 percent of the distribution system; 35 percent of the pipe is unlined. The City is divided into the main service system and four additional high service systems.

In the Water Audit Report, the volume of water purchased by Quincy from MWRA (total water use) was compared with the volume of water sold (retail sales). The comparison was performed for the three year period 2006 through 2008. An average of 3620 MG per year of water (9.92 mgd) was purchased annually from MWRA, while an average of 2710 MG per year of water was sold to retail customers. The difference between the total water use and retail sales, defined as the City's non-billed water volume, averaged 910 MG per year. A detailed analysis was performed to reasonably estimate, to the maximum extent possible, sources of the City's non-billed water volume. The analysis determined 185 MG per year of the non-billed water volume could be reasonably estimated and accounted for under the following categories of water use: 125 MG per year for under-registration due to age of retail meters, 50 MG per year for municipal water use, and 10 MG per year for water main breaks. The remaining 725 MG per year of non-billed water volume is characterized as unaccounted-for-water (UAW). Quincy's UAW represents about 20 percent of the total water use the City purchases annually from MWRA. The Massachusetts Water Conservation Standards recommend a performance standard of 10 percent UAW, therefore, Quincy is currently above the UAW benchmark.

Additional analysis in the Water Audit determined 195 MG per year of the non-billed water volume could be reasonably estimated as leakage from the water system. Per DEP guidelines, estimated water system leakage is defined and calculated as part of the systems UAW. However, estimating the portion of UAW that may be attributable to leakage allows for quantification of the remaining portion of UAW (530 MG per year) that has not been identified within the Water Audit Report. This remaining portion of UAW is likely spread out among all of the categories of non-billed water, including: under-registration due to meter age, unmetered retail accounts, municipal water use, water main breaks, water theft, and water system leakage. It is likely that the annual volume of non-billed water for each of these categories is larger than that estimated in the Water Audit.

Quincy's water use analysis (3-year average 2006 through 2008) is summarized below:

Total Water Use	3620 MG/year	9.92 mgd	100 %
Retail Water Sales	2710 MG/year	7.43 mgd	75 %
Non-Billed Water Total	910 MG/year	2.49 mgd	25 %
Non-Billed Estimated Use	185 MG/year	0.50 mgd	5 %
Unaccounted-For-Water	725 MG/year	1.99 mgd	20 %
Unaccounted-For-Water Estimated as Leakage	195 MG/year	0.54 mgd	5 %
Unaccounted-For-Water Not Estimated	530 MG/year	1.45 mgd	15 %

The analysis used to develop estimates for non-billed water is presented in Sections 5 and 6 of the Water Audit Report. Quincy is already in the process of lowering its water loss. Specific actions and potential for water and cost savings are detailed below.

Under-Registration due to Meter Age: Over half of Quincy's retail water meters were installed over 40 years ago. In general, water meters should be replaced every 15-20 years. Quincy has begun planning for a comprehensive meter replacement project for all 22,000 of the City's meters, as well as, installation of an automated meter reading system. This future project is estimated to cost $10 million. In Section 5 of the Audit Report, Quincy's under-registration due to age of retail meters was estimated at about 125 MG per year (0.34 mgd). However, it is likely that under-registration of meters accounted for even more of the non-billed total estimated because many retail meters did not have an accurate age associated with them. The 125 MG per year represents a wholesale water and sewer cost of over $670,000 per year to Quincy. In addition, the potential increase of 125 MG per year in retail water sales equates to over $2.3 million per year based on Quincy's current water and sewer retail rate. Installation of new meters will minimize the cost of under-registration due to meter age and should lower UAW.

Unmetered Accounts: Quincy has few unmetered buildings therefore, no estimated non-billed water volume was allocated to unmetered accounts. Future installation of new meters on all unmetered accounts should lower UAW.

Municipal Water Use: Municipal water use includes hydrant testing and flushing by the Fire Department, water system flushing by the Water Department, street cleaning and sewer/drain cleaning by Public Works. In Section 6 of the Audit Report, Quincy's municipal water use was analyzed and estimated at 50 MG per year (0.14 mgd). Based on this data and current wholesale water cost, municipal water use is estimated to cost the City over $125,000 per year.

Water Main Breaks: During 2008, water main breaks accounted for about 10 MG (0.03 mgd) of water loss, as detailed in Section 6 of the Water Audit Report. Based on the 2008 breaks data and current wholesale water cost, water loss from main breaks is estimated to cost the City about $25,000 per year. Given that main breaks have been occurring throughout the water distribution system rather than clustered in a specific location, there does not appear to be a way to target the reduction of water main breaks. However, the City continues to make water system improvements that will minimize water losses associated with breaks. Over the past eight years Quincy has invested over $13.0 million to replace 16.8 miles of old unlined water mains through MWRA's Local Pipeline Assistance (interest-free loan) Program. Continued annual system improvements will help to reduce water main breaks and minimize UAW.

Water System Leakage: Leakage from all water systems includes both larger leaks that can be detected and repaired and "unavoidable" leakage from leaks that are too small to be detected. The City of Quincy performs leak detection surveys every 2 years, as required under MWRA leak detection regulations. The City has alternated between using a leak detection contractor and in-house Water Department crews to perform the surveys. In Section 6 of the Audit Report, Quincy's detectable water system leakage was estimated at about 62 MG per year (0.17 mgd) and unavoidable leakage was estimated at about 133 MG per year (0.36 mgd). The total 195 MG per year (0.53 mgd) estimated water system leakage accounts for a wholesale water cost to Quincy of over $490,000 per year. Increased frequency of leak detection and repair may reduce system leakage and the associated cost, as well as, help to minimize UAW.

Quincy's retail sales by customer category are detailed in Section 3 of the Water Audit Report. For 2008 data, about 58 percent of the retail water sales were estimated to be for residential accounts; while commercial, industrial, and institutional accounts represent the remaining 42 percent. Quincy's total residential (indoor and outdoor) water use for 2008 was calculated to be 49 gpcd. The City's residential per capita water use meets the recommend performance standard of 65 gpcd, as defined in the Massachusetts Water Conservation Standards. However, it should be noted that Quincy's residential water use was estimated based on meter size because billing records used for the analysis did not identify account categories. Quincy's 2008 retail water sales by customer category are summarized below:

2008 Retail Water Sales	2824 MG	7.73 mgd	100 %
Residential	1633 MG	4.48 mgd	58 %
Commercial/Industrial/Institutional	1191 MG	3.26 mgd	42 %

In summary, the Water Audit Report has identified under-registration of retail water volume due to meter age as an important water system upgrade. Quincy has begun planning for a comprehensive meter replacement project for all 22,000 of the City's retail water meters, as well as, installation of an automated meter reading system. This future project is estimated to cost $10 million. Completion of this project will help reduce the estimated 125 MG per year of under-registration due to age of retail meters. This project will also allow for an increase in the frequency of retail billing, which may help retail customers more easily evaluate their water bills and recognize if water conservation and cost savings can be achieved. In addition, Quincy should continue to implement projects to minimize water system leakage, minimize water loss from water main breaks, properly account for and reasonably estimate non-billed water volume, and minimize the City's UAW volume. These actions will help reduce the total 910 MG per year (2.49 mgd) of estimated non-billed water use identified in the Water Audit Report, as well as, the cost to Quincy in wholesale water and sewer fees and unrealized retail water payments.

Appendices

Appendix A

References and Web Sites for Additional Information

References:

1 Vickers, Amy; *Handbook of Water Use and Conservation*, WaterPlow Press, Amherst, MA, 2001

2 Thornton, Julian; *Water Loss Control Manual*, McGraw-Hill, New York, 2002

Web Sites for Additional Information:

www.allianceforwaterefficiency.org - Alliance for Water Efficiency

www.awwa.org - American Water Works Association

www.epa.gov/region1 - US Environmental Protection Agency, Region 1

www.epa.gov/watersense/index.htm - US EPA WaterSense Water Conservation

www.itseasybeinggreen.com - Its Easy Being Green

www.mass.gov – Massachusetts Government Home Page

www.mass.gov/dcr - Massachusetts Department of Conservation and Recreation

www.mass.gov/dep - Massachusetts Department of Environmental Protection

www.mass.gov/dep/water/wlpgprog.htm - Massachusetts DEP, Water Conservation Grant Program

www.mass.gov/dep/water/approvals/guidance.pdf - Massachusetts DEP Water Management Act Program, Guidance Document and Forms for a Water Audit

(www.mass.gov/Eoeea/docs/eea/water/water_conservation_standards.pdf - Water Conservation Standards developed by the Massachusetts Executive Office of Environmental Affairs and Water Resources Commission

www.mwra.com – Massachusetts Water Resources Authority

www.newwa.org - New England Water Works Association

www.waterefficiency.net/elements-2009/water-audit-program.aspx - WATER EFFICIENCY, The Journal for Water Conservation Professionals

www.wateruseitwisely.com - Water Use It Wisely

Appendix B

Glossary and Abbreviations

BWSC - Boston Water and Sewer Commission

DCR - Massachusetts Department of Conservation and Recreation

dye tabs – Tablets of colored dye that dissolve when dropped into a toilet tank and will provide evidence of a small water leak if the dye enters the toilet bowl after a few minutes

EPA – United Stated Environmental Protection Agency

gpcd - gallons per capita per day

gpd - gallons per day

gpf - gallons per flush (for toilets, flush valves, or urinals)

gpm – gallons per minute

ICI – industrial, commercial, and institutional water users

low-flow fixtures - Shower heads that use 2.5 gpm or less; kitchen faucet aerators that use 2.2 gpm or less, and bathroom faucet aerators that use 1.5 gpm or less

leak detection – methods for identifying water leakage from pipes, plumbing fixtures, and fittings

leak detection regulations – Code of Massachusetts Regulations, Title 360: Massachusetts Water Resources Authority, Chapter 12.00: Leak Detection Regulations (360 CMR 12.00)

low-flow toilet - A toilet (or toilet flush valve) that uses 1.6 gallon per flush or less

MassDEP - Massachusetts Department of Environmental Protection

MG – million gallons

mgd - million gallons per day

MWRA - Massachusetts Water Resources Authority

NPDES - National Pollutant Discharge Elimination System

psi - pounds per square inch

safe yield – the maximum amount of surface water or groundwater that can be withdrawn from a source over time without compromising its quality or its ability to continue providing the same amount of water

UAW - Unaccounted-for water, Water that does not go through a meter (e.g. water lost from unmetered accounts, faulty water meters, pipeline leaks, theft, etc.) and can not be accurately estimated and accounted for by the utility

US EPA - United States Environmental Protection Agency

water audit – a systematic accounting of water in a municipal supply system (production, transmission and distribution) or an end user (residential, ICI, agricultural, etc.) conducted to identify opportunities for system improvements, water-use reductions and to reduce water loss.

WaterSense - US EPA's water conservation partnership program for WaterSense labeled water-efficient products

Appendix C

Scope of Services

MWRA Water Conservation Grant Project
Project Number 07-03/WCG

I. Purpose

The goals of this project are to promote drinking water conservation and reduce water usage within the member communities of the Massachusetts Water Resources Authority (MWRA – hereinafter also referred to as the "Grantee"). The goals and specific work elements of each grant program are provided below.

The Grantee seeks to expand its water conservation public outreach and education program to include an incentive program to promote customer communities to purchase and install low flow toilets (1.6 gallon per flush or less) and conduct water audits on two to three community water systems. The goal is to educate MWRA member communities and retail water customers on the environmental and economic benefits of water conservation.

The Grantee will work with two to three pilot communities to balance the volume of water purchased from MWRA (wholesale purchase) with the volume billed (retail sales) and account for the remainder of non-billed water volume. A summary report will be shared with other MWRA communities as a water conservation educational tool.

The Grantee must certify that the skill level of the appropriate employee(s) and/or subcontractor is adequate to perform the contracted tasks to high industry standards, and that the work conducted is done so in accordance with such standards (i.e., the AWWA standards). The Grantee may purchase water conservation education and outreach materials but costs related to the development of such materials are not eligible for reimbursement.

As outlined within the MassDEP's guidance document, the Grantee must quantify the water savings from all project related activities in gallons per year and approximate dollar value.

II. Scope of Services

The scope of services for this contract shall consist of the following tasks and deliverables as outlined below, consistent with the Grantee's technical proposal received on July 18, 2007 and as outlined in the RFR of June 8, 2007. In order for a deliverable to be considered complete under the contract, the deliverable must be completed in accordance with the contract specifications and contract schedule, must be approved by MassDEP, and must otherwise satisfy the contract provision, as determined by the MassDEP.

TASK 1: Purchase of Educational Materials for the Water Conservation Program
Encourage water conservation and promote public awareness of the long-term economic and environmental benefits of water conservation through a community wide social marketing campaign. Print 200,000 MassDEP approved water conservation brochures budgeted at $10,000 ($0.05 per copy). Purchase 6,000 low flow water conservation fixtures budgeted at $10,000 ($5.00 per kit, consisting of one low-flow shower head, two faucet aerators, and one packet of dye tablets). Purchase/print informational flyers and forms for low flow toilet rebates.

Deliverables 1:
- Draft MassDEP approved educational and outreach materials submitted for review and written approval **prior** to printing or purchase, and distribution
- Copy of MassDEP approved educational and outreach materials.
- Document printing of 200,000 MassDEP approved water conservation brochures;
- Document purchase of 6,000 water conservation fixtures;

TASK 2: Marketing the Outreach and Water Conservation Device Rebate Program
Conduct educational outreach via MassDEP approved informational flyers, letters, and emails to local communities, watershed groups, housing authorities, environmental groups, retailers, local newspapers, etc. MassDEP approved informational flyers, rebate forms, and appropriate links to other web sites will be posted on the Grantee's website. Educational materials will be provided to MWRA member communities for distribution to their customers. As part of this marketing Task the low-flow retrofit program comprising Task 4 (below) will also be directly marketed to the MWRA's member communities.

Deliverables 2:
- Draft water conservation educational and outreach materials submitted for review and written approval prior to printing and distribution
- Copy of MassDEP approved educational and outreach materials and documentation of educational materials distributed
- Documentation of educational materials distributed
- Demonstration of water use reduction achieved as a result of Task 2 activities.

TASK 3: Distribution of Water Conservation Materials and kits
Distribute MassDEP approved outreach/education brochures (see Task 2) to local communities, watershed associations, etc. based on response from letters and emails under Task 2. The water conservation education brochures and water conservation device kits will be distributed to communities and retail customers based on response from letters and emails. A database to track participants will be implemented.

Deliverables 3:
- Documentation of the distribution of water conservation kits.
- Demonstration of water use reduction achieved as a result of Task 3 activities.

TASK 4: Process Rebate Requests
Rebate will require a copy of the sales receipt and before and after photos to document installation. A $100 rebate will be provided for purchase and installation of a 1.6 gallon per flush toilets or toilet flush valves for tankless toilets that replace older, less efficient toilets. MWRA member community water customers will apply to MWRA for the rebate by submitting a one-page information sheet along with a copy of the purchase receipt and before and after photos to document the installation has been made. The $40,000 rebate target maximum expenditure is estimated based on approximately 400 toilet rebates. The rebates will be limited to public buildings within MWRA member communities and the MWRA member communities themselves will apply for the toilet rebates. The MWRA will develop and implement a database to track participants.

Deliverables 4:
- Database tracking property owners and addresses provided rebates.
- Written confirmation from the Grantee that approximately 400 low-flow plumbing fixtures have been purchased and installed, including a listing of the number and type of fixtures purchased and installed, the locations, and the dates of replacement.
- Calculation of a year's worth of savings as a result of the newly installed low-flow fixtures.

TASK 5: Select Pilot Water Audit Communities
Communities to participate in the pilot water audits will be selected following discussions with community staff and the MWRA Advisory Board to identify interested and appropriate communities. MWRA member communities with unaccounted for water rates greater than 10% will be given priority to apply for inclusion as a pilot water audit community. The two to three pilot water audit communities will be selected via a lottery from those that express interest in the program.

Deliverables 5:
Listing of selected pilot communities and key community contacts

TASK 6: Conduct Pilot Community Water Audits
Conduct two to three water audits to balance the volume of drinking water produced with the volume billed and account for the remaining water (loss). Use the MassDEP guidance available through the Water Management Act Program – *Water Management Act Program Guidance Document for a Water Audit and Leak Detection Survey* - found in Attachment D and within the MassDEP's website
http://www.mass.gov/dep/water/approvals/guidance.pdf

Tasks to be completed for the water audit will include, but not be limited to the following:
- Review of data pertinent to the existing water system including general system information and data on source meters and metered connections.
- Review of purchase and sales records in order to determine the quantity of water pumped from the MWRA and the quantity of water sold over the past three years. Estimate quantity of unmetered sold water.

- Review of operation and maintenance records to estimate costs for pumping and treating the water for the past three years.
- Review of billing and accounting procedures, including meter reading, printing of billing statements, and calculation of total water use for sources of error. Adjust water sales records to reflect any error found in billing and accounting procedures.
- Review of the latest master meter calibration test results and adjustment of the source quantities to reflect inaccuracies.
- Review of the Grantee's past meter testing results.
- Review of the most recent leak detection survey. Utilize acquired information to determine the amount of unaccounted-for water in the system or the quantity of water that is potential leakage and estimate the cost per year due to the water losses.
- Complete water audit worksheets with calculated water losses for each community audited.
- Provide recommendations for improvements to the system including billing and accounting procedures, maintenance programs, and water usage.

Deliverables 6:

- Completed water audit survey and reporting forms - as per Department guidance including items listed above - for each audited community.
- Technical memo summarizing the method or methods by which data was collected, schedule by which master meters are calibrated, and recommendations needed to improve recording of water flows for sources of supply and distribution system measurement systems

Task 7: Reporting

The Grantee will submit the following Deliverables to the Department for each Program outlined above in accordance with the Milestone schedule.

Deliverables 7:

- The Grantee shall provide quarterly progress reports to the Department no later than January 15th, April 15th, July 15th, and October 15th for the October 1 to December 31, January 1 to March 30, April 1 to June 30, and July 1 to September 30 reporting periods, respectively. These reports shall be submitted via email (Word 6.0 or other suitable software as determined by the Department) on a standard form provided by the Department and shall contain a summary and percentage of all work completed by task during the reporting period and planned activities for the next quarter.
- The Grantee shall provide fiscal spending reports on the same schedule as the progress reports. The fiscal reports should list the spending for the quarter, itemized by the expense categories listed in Attachment B-Budget. All fiscal spending reports, including required M/WBE reporting on the Department's Payment Voucher Attachment Form, shall be provided to the Department's Contract Manager identified in the Notice to Proceed letter.

Task 8: Submit Draft and Final Project Reports.
The Grantee will submit the following Deliverables to the Department for each Program outlined above in accordance with the Milestone schedule.

Deliverables 8:

- Two paper copies of a draft final report shall be provided to the Department's Project Coordinator for review and comment at least two months prior to the milestone schedule end date. The report will include a summary of the entire project, including methods, results and conclusions as well as recommendations on actions that should be taken to further reduce water losses and comment on the effectiveness of the project.
- The Final Report must calculate the environmental results of the project and quantify the water savings in both gallons of water and dollar value per year.
- Upon receipt of comments on the draft report from the Department, the Grantee will address these comments in the final report. The draft final report and final report will contain all project deliverables.
- One camera ready copy (unbound) and three printed copies of the final report, and two CDs with electronic versions of the final report which are compatible with the Department's systems (Word or a searchable Adobe .pdf format) must be submitted to the Department's Project Coordinator by the project end date.

Appendix D

Indoor and Outdoor Water Conservation Brochures

"Indoor Water Conservation" Educational Brochure - a colorful 3.5" x 6.5 " folded eight panel brochure emphasizing indoor water use (low-flow toilets, showerheads, faucets, washing machines, etc.), water efficient fixtures and appliances for the home, ways to find and fix leaks, and simple water saving tips.

"Outdoor Water Conservation" Educational Brochure – a colorful 3.5" x 6.5" folded eight panel brochure emphasizing low water-use lawn and garden planting selection, water use needs, irrigation choices, and water conservation.

Ways To Save Water Everyday

FIND & FIX HOUSEHOLD LEAKS

There is a good chance you have at least one leak in your home that could be wasting hundreds of gallons of water a week, costing you money.

Leaky Toilets

The trickling sound you hear in the bathroom could be your toilet wasting 50 gallons of water a day - thousands each year. Because you can't always see or hear these leaks, here's a simple test:

TEST TO TRY AT HOME:

Put a few drops of blue food coloring in your toilet tank. Do not flush. If color appears in the bowl within 10 - 15 minutes, you have a leak. To repair it, the flush valve ("flapper") or the valve seat may need to be cleaned or replaced. Parts are inexpensive and easy to install.

Dripping Faucets & Showerheads

Worn-out washers – the cause of most dripping faucets and showerheads – cost pennies to replace and are easily installed.

Leaky Pipes

Check under sinks, behind your washing machine and around basement plumbing for suspicious looking wet areas. Leaks not only waste water – they could be damaging your walls, floors, and ceilings.

Because homeowners and businesses alike have taken

water conservation to heart, MWRA water is currently in good supply. The challenge lies in protecting our supplies over the long term. With good water use habits and efficient home plumbing and appliances you can help make that happen – and lower your water and energy costs.

For more information about how MWRA and your local water supplier bring you the water you need every day, or to get more detailed information on water efficient toilets, appliances or smart outdoor water use call the MWRA:

Water Efficiency: 617-242-SAVE

General Information: 617-242-6000, www.MWRA.com

WATER CONSERVATION KITS

Water Conservation Kits are offered free of charge. Just fill out the request form found on MWRA.com.

Simple Saving Tips

IN THE HOME

- Fix leaky faucets, pipes, toilets and save hundreds of gallons per week.
- Turn off the tap while you brush your teeth, shave, or do dishes.
- Don't flush the toilet needlessly.
- Run dishwashers and washing machines only when full or adjust the water level setting accordingly.

- Keep a jug of drinking water in your refrigerator to avoid running water until it is cold enough to drink.
- Don't fill the tub to the top when bathing and take shorter showers.

For tips on how to use water more efficiently outdoors, see our brochure - OUTDOORWATER CONSERVATION.

The Massachusetts Legislature created MWRA in 1985 to manage and modernize water and sewer services for 2.5 million people and 5,500 business in 61 communities. While the Boston Harbor Project and the Integrated Water Supply Improvement Program are the best known projects, MWRA also maintains over 400 miles of water pipes, aqueducts and tunnels and over 240 miles of sewers.

FOR MORE INFORMATION:
Massachusetts Water Resources Authority
Charlestown Navy Yard, Boston, MA 02129
617-242-6000, www.MWRA.com.

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INDOOR WATER CONSERVATION

A few gallons of water in the kitchen, a few dozen in the bathroom, a few hundred on the lawn - it adds up quickly.

With a family of four using 90,000 gallons of water a year, wasted water can add up too – unnecessarily increasing household water and energy costs. Here are some of the ways to make your home and your habits more water efficient.

Build in Water Savings

Make your old toilet a water saver

Here are some easy ways to make your older model more efficient:

INSTALL one of several new toilet retrofit products available at hardware stores. Some work only with certain toilets, so get a recommendation from your local plumber on the right one for you.

REDUCE the volume of each flush by placing a toilet dam or a water-filled plastic bottle weighted with gravel in the tank if you have not already installed a 1.6 gallon toilet. Be sure not to interfere with the flushing mechanism.
(Note: do not use bricks as they might disintegrate.)

Water efficient showerheads

Some showerheads may still use 3 - 7 gallons or more per minute. If you have not installed a showerhead which uses 2.5 gallons per minute or less, you are missing an excellent way to save water and energy without sacrificing the benefits of a satisfying shower.

Faucet aerators

Low-flow faucet aerators mix air with tap water to reduce the flow to 1.5 - 2.5 gallons per minute. Faucets without aerators may be using 3 - 7 gallons per minute.

Water & energy efficient appliances (Energy Star label)

HIGH EFFICIENCY WASHERS Unlike traditional machines, which must be filled to the top with water in order to immerse clothes sufficiently to clean them, front loading washers use about 25 gallons per load. The horizontal wash tub allows clothes to be lifted through a shallow pool of water at the bottom of the tub. Front loaders save energy too – 50% – or more by using less hot water and by extracting more water during the spin cycle, clothes need less time for drying. In addition to saving water, these new washers create less wear and tear on clothes, clean clothes better, and use less detergent. These machines save more water in one year than the average person drinks in a lifetime. To help defray the incremental cost of these new models, some gas and electric utilities offer incentives.

Installing all low flow toilets could cut your toilet water use in half.

Low flow toilets need only 1.6 gallons per flush, saving thousands of gallons each year, and unlike some earlier models, some low flow toilets available today receive high marks from consumers for overall performance. And, recent studies show that the number of flushes per household remains essentially the same in low-flow households, countering the argument that low-flow toilets require multiple flushes.

SIMPLE TEST FOR YOUR SHOWER: Hold a bucket underneath your showerhead for 20 seconds. If more than one gallon accumulates, you need a water efficient showerhead.

Dishwashers

Newer energy and water efficient dishwashers exceed minimum federal government standards. These newer models operate on 13 - 25% less energy and on as little as 6 gallons of water per load. Benefits to the consumer include: lower utility bills, improved washing systems that eliminate pre-rinsing, and less energy used to heat the water to clean the dishes.

When selecting new appliances, check the water and energy efficiency ratings in manufacturer's specifications or consumer magazines and look for the Energy Star label.

Organic matter will help your soil retain more moisture

Peat moss, composted leaves, kitchen vegetable scraps, and grass clippings will all improve soil structure and enhance moisture-retaining capabilities. Incorporate organic matter into your flower and vegetable beds, preferably 12"-18" deep.

Drip irrigation and soaker hoses – the best way to water your garden

Use a drip irrigation system or soaker hose in gardens that need the most water: vegetables, fruits, newly planted trees and shrubs, and some flower gardens. A soaker hose is a canvas or rubber hose with perforations. It is most effective when it lies on top or slightly below soil level and mulch is placed over the soil and hose. You can install the hose in the spring and leave it in place all season.

Drip irrigation can use 30%-70% less water than overhead sprinkler systems. In general, use the drip irrigation or soaker hose methods until the soil is moist 3-4 inches below the surface.

Use rain barrels

Place rain barrels or other large containers under downspouts to collect rain water to use for watering your garden. Use a lid, mesh fabric, or several drops of baby oil on the surface of the water to prevent mosquito breeding.

For a small garden

Use a hose to apply water very slowly at the base of each plant, not on leaves. Saucer-like basins around each plant help concentrate water where it is most needed – at the plant's roots. Watering by hand is easy when there are saucers to fill up.

Low water-use plants

There are many varieties of low water-use plants that can withstand dry summers, and actually thrive in drier soil. Remember: all newly planted trees, shrubs, and flowers initially need water to get established. But once established, drought tolerant plantings can survive without extra watering.

For tips on how to use water more efficiently indoors, see our brochure - INDOOR WATER CONSERVATION.

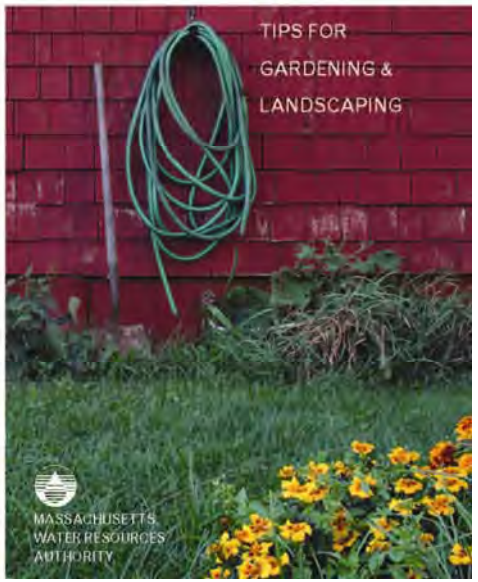
The Massachusetts Legislature created MWRA in 1985 to manage and modernize water and sewer services for 2.5 million people and 5,500 business in 61 communities. While the Boston Harbor Clean-Up and the Integrated Water Supply Improvement Program are the best known projects, MWRA also maintains over 400 miles of water pipes, aqueducts and tunnels and over 240 miles of sewers.

FOR MORE INFORMATION:
Massachusetts Water Resources Authority
Charlestown Navy Yard,
Boston, MA 02129
617-242-6000, www.MWRA.com.

low water-use plants

COMMON NAME	BOTANICAL NAME	HEIGHT
TREES		
Amur Maple	*Acer ginnala*	20-25'
Austrian Pine	*Pinus nigra*	50'
Japanese Black Pine	*Pinus thunbergii*	6-10'
Cornelian Cherry	*Cornus mas*	20-25'
London Plane	*Platanus x acerifolia*	50'
White Oak	*Quercus alba*	50'
SHRUBS		
Broom	*Cytisus scoparius*	5-6'
Flowering Quince	*Chaenomeles speciosa*	6-10'
Junipers	*Juniperus sp.*	2-9'
Cinquefoil	*Potentilla*	3-4'
Butterfly Bush	*Buddleia davidii*	6-10'
Rose-of-Sharon	*Hibiscus syriacus 'Diana'*	6-8'
Winterberry	*Ilex verticillata*	8-10'
Mugo Pine (dwarf)	*Pinus mugo*	3-4'
GROUND COVER		
Bearberry	*Arctostaphylos uva-ursi*	6-8"
Creeping Lilly-turf	*Liriope spicata*	6-8"
Violets	*Viola sp.*	6-8"
Snow-in-Summer	*Cerastium tomentosum*	6-8"
PERENNIALS		
New England Aster	*Aster Novae-angliae*	15-30"
Common Blanketflower	*Gaillardia aristata*	24-36"
Moonbeam	*Coreopsis verticillata*	24-36"
Purple Coneflower	*Echinacea purpurea*	24-36"
Lavender	*Lavendula 'Hidcote Blue'*	12-36"
Sedum (Acre, Red Carpet, Ruby Glow, Stoloniferum, Spectabile)	*Sedum sp.*	18-24"
Daylily	*Hemerocallis*	18-48"
Yarrow, 'The Pearl', 'Summer Pastels'	*Achillea sp.*	18-36"
ANNUALS/BIENNIALS		
Cosmos	*Cosmos sp.*	3'
Gazania	*Gazania*	6-18"
Marigold	*Dimorpotheca sp.*	4-6"
Portulaca	*Portulaca grandiflora*	8"
Strawflower	*Heliochrysum bracteatum*	3'
Sweet William	*Dianthus barbatus*	2'

OUTDOOR WATER CONSERVATION



Summer is an important time to save water

MWRA water supply is sufficient to meet normal community water demands. However, we tend to use more water in the summer, so there are opportunities to conserve. These tips will show you ways to use water more efficiently outdoors, make garden maintenance easier, and save money.

Water your lawn only as needed

Frequent light watering can actually weaken your lawn by encouraging shallow roots that are less tolerant of dry periods and more susceptible to insect damage.

Roots can hold plenty of moisture even after several days without rain. Before watering, look for signs that it's needed: patchy areas, a general change in color or footprints that remain in the grass long after being made.

Test your soil for dryness

Water only when the soil is dry to a depth of 1.5 inches. Make sure the water soaks down 3-4 inches. This encourages deep root growth.

Timing is critical

The best time to water your lawn is early morning (4-6 am). Watering mid-day will result in a high rate of evaporation and sun-burnt grass, and will leave grass vulnerable to disease from mildew and fungus.

Give it a rest

If your lawn "fades," don't panic. Grass naturally becomes dormant during hot, dry periods. It will revive quickly after a steady rainfall or in cooler weather.

- One inch of water per week (rain plus watering) should be plenty. Never water when it's windy, rainy or very hot. After heavy rains you may not need to water for 10-14 days.
- Raise the mower blade level to 2-3 inches or more. Longer grass retains more moisture because it shades the roots. It also encourages deeper rooting, requires less fertilizer and competes better against weeds.
- Never water faster than the soil can absorb it. Avoid puddling and runoff.
- Be sure your hose has a shut-off nozzle. A hose without a nozzle can spout 10 gallons or more per minute!
- Don't fertilize in the summer. New growth requires more water. Apply in early spring and/or fall.
- Aerate your soil in the spring and fall to aid water absorption and retention.

Prepare your new lawn properly

Grass needs at least 3-6 inches of very good topsoil. Rich loam mixed with peat moss or composted leaves will hold moisture and allow for good, deep root development. The kind of grass you grow matters. Lawns planted with fescue grasses do better than bluegrasses during periods of low rainfall and are slower to go dormant.

Automatic sprinklers

Studies have shown that automatic sprinkler systems often use 20-30% more water than hand-held hose watering. Make sure the timer or "controller" is set to water each landscape zone efficiently. Install a rain or soil moisture sensor that turns the system off when it rains or if moisture is present in the soil.

Features to look for when selecting an automatic sprinkler system

- At least 3 independent programs to allow for watering different parts of the yard on different days.
- Run times from 1 to 200 minutes.
- 3 start times per program.
- Odd, even, weekly and interval program capability.
- Rain shut-off device capability.

Tips for landscape, garden and flower care

The amount of water you use (and can save) outdoors depends on how you water as well as the size, type and location of your lawn, shrubs and gardens.

Plan and design your garden for efficient outdoor watering

Be aware of the various zones in your yard (hot/sunny, cool/shady, moist, dry, etc.) and plan your gardens and plantings accordingly. For example, if you have a hot, dry zone, select plants that can endure hot, dry conditions.

Stones or pebbles are good for shady areas, but give off too much heat when used near the house. Ground covers, such as ivy or pachysandra, also prevent evaporation around established shrubs and ornamental trees.

Mulch to keep roots cool and moist

Mulch can serve as ground cover that reduces evaporation from soil and reduces the number of weeds that would otherwise compete with the plant for available soil moisture. Mulching reduces water evaporation from soil, and hinders weed growth in a planting bed.

Cluster plants that require extra care

If you choose shrubs, flowers or vegetables that need lots of moisture, place them near each other. You'll save time and water by watering just one area of your yard.

Appendix E

Examples of MWRA's Community Outreach and Marketing Tools

MASSACHUSETTS WATER RESOURCES AUTHORITY

Water Conservation Fixture & Literature Request Form

INSTRUCTIONS: Free water conservation fixture kits and educational information brochures are available for residents, municipalities, housing authorities, housing managers, environmental groups, etc. located within the MWRA service area. To see if your city/town is located within the MWRA service area, check the list of communities below/on reverse side. For more information: mwra.com

Print this form, fill it out, and return to MWRA:
BY FAX: Attention Elaine Donahue, Project Manager – Fax Number 617-788-4888

By US Postal Mail: Elaine Donahue, Project Manager, MWRA
Charlestown Navy Yard
100 First Avenue
Boston, MA 02129

FOR INDIVIDUAL CUSTOMERS, HOMEOWNERS, & PRIVATE HOUSING MANAGERS

Requester's Name: _____ Daytime Phone #: _____

Street Address: _____ City/Town & Zip Code: _____

Installation Property Address: ___same as above; if different: _____
Number of Living Units/Apartments: _____
How Many? Bathrooms: _____ Toilets: _____ Showers: _____ Kitchens: _____

How did you learn about free MWRA water conservation materials?
_____ Local water department; _____ Water bill insert; _____ MWRA staff
_____ Media: (television, newspaper, newsletter, etc.); _____ Other, please specify: _____

SIGNATURE (required): I certify that the above information is true. I will install the fixtures provided in a timely manner. I give the MWRA permission to verify that the fixtures have been installed.

Signed: _____ Date: _____

FOR COMMUNITIES, HOUSING AUTHORITIES, OR ENVIRONMENTAL GROUPS

Community/Group Name: _____

Requester/Contact Person Name: _____ Daytime Phone #: _____

Address: _____

Quantity of **Indoor** Water Conservation Educational Brochures (Bill Insert Sized): _____
Quantity of **Outdoor** Water Conservation Educational Brochures (Bill Insert Sized): _____
Quantity of **Water Conservation Kits** (50 maximum per order): _____

Water Conservation Kits consist of:
- Low Flow Showerhead (2.5 gpm or less)
- Bathroom Faucet Aerator (1.5 gpm)
- Kitchen Faucet Aerator (2.2 gpm)
- Installation Instructions & Dye Tablets (to detect toilet leaks)

MASSACHUSETTS WATER RESOURCES AUTHORITY

Communities Eligible For Free Water Conservation Fixtures & Literature

Arlington
Ashland
Bedford
Belmont
Boston
Braintree
Brookline
Burlington
Cambridge
Canton
Chelsea
Chicopee
Clinton
Dedham
Everett
Framingham
Hingham Sewer District
Holbrook
Lancaster Sewer District
Leominster
Lexington
Lynn
Lynnfield Water District
Malden
Marblehead
Marlborough
Medford
Melrose
Milton
Nahant
Natick
Needham
Newton
Northborough
Norwood
Peabody
Quincy
Randolph
Reading
Revere
Saugus
Somerville
South Hadley Fire District #1
Southborough
Stoneham
Stoughton
Swampscott
Wakefield
Walpole
Waltham
Watertown
Wellesley
Weston
Westwood
Weymouth
Wilbraham
Wilmington
Winchester
Winthrop
Woburn
Worcester

WATER CONSERVATION INITIATIVES

To: Public Works Departments, Water Superintendents, Municipal Housing Authorities, Municipal Managers/Administrators, Municipal School Departments, Interested Stakeholders

From: Carl H. Leone, Senior Program Manager, Community Support Program

Subject: MWRA and Member Community Water Conservation Initiatives

---

The Massachusetts Water Resources Authority (MWRA), in partnership with its member communities, pursues water conservation initiatives that help to maintain average water demand below the regional water system's safe yield of 300 mgd. Current average annual water demand is less than 220 mgd, however, for the 20-year period 1969-1988 regional water use routinely exceeded 300 mgd. The local water conservation program includes distribution of water conservation education brochures and low-flow water fixtures (shower heads and faucet aerators), at no cost to regional customers. MWRA also continues to provide a task-order leak detection contract for municipal distribution systems. For calendar year 2008, MWRA is implementing two new water conservation projects: **Low-Flow Toilet Retrofit Rebate Project** for municipal buildings and a **Pilot Water Audit Project** for municipal water systems.

Low-Flow Toilet Retrofit Rebate Project: MWRA has received a $40,000 grant from the Massachusetts Department of Environmental Protection (MassDEP) to conduct a Low-Flow Toilet Retrofit Rebate project with member water communities during CY2008. Communities are encouraged to purchase/install low-flow (1.6 gallon per flush or less) toilets or toilet flush valves in municipal buildings to replace less efficient toilets that use a larger water volume per flush. For each toilet retrofit, the community may be eligible to receive a $100 rebate from MWRA. Member communities may utilize the rebates for low-flow toilet retrofits in municipal/publicly-owned buildings. These may include city/town halls, DPWs, schools, libraries, housing authorities, etc. Member water communities will apply to MWRA for the $100 rebates by submitting an information sheet, a copy of the purchase and/or installation receipt, and before/after photos to document the retrofit installation. Please see additional details on enclosed flyer.

Pilot Water Audit Project: MWRA has received a $40,000 grant from MassDEP to conduct a Pilot Water Audit Project. MWRA is currently looking for 2 or 3 member water communities to participate in the project during CY2008. The water audit will balance the volume of water purchased from MWRA (wholesale purchase) with the volume billed (retail sales) and account for the remainder of non-billed water volume. The project will help the community minimize its non-billed or unaccounted-for-water (UAW). A summary report will be prepared detailing the project results/lessons learned and will be shared with other MWRA communities. Please see additional details on enclosed flyer.

For more detailed information on water audits, communities should review the Water Management Act Program Guidance Document and Forms for a Water Audit (available at www.mass.gov/dep/water/approvals/guidance.pdf) and the Water Resources Commission MA Water Conservation Standards - see the System Water Audits and Leak Detection section (available at www.mass.gov/envir/mwrc/pdf/Conservation_Standards.pdf).

Water Conservation Education Brochures: To assist communities and other interested stakeholders with their water conservation activities; MWRA provides bill stuffer sized water conservation educational brochures for local distribution (see enclosed samples). To receive bulk quantities of the brochures at no cost, please complete the enclosed order form (also available online at mwra.com). For more information, please contact Elaine Donahue at (617) 788-4824 or elaine.donahue@mwra.state.ma.us. The brochures include:

- **"Indoor Water Conservation" Bill Insert** - a colorful brochure emphasizing water efficient fixtures and appliances for the home - 3.5" x 6.5".
- **"Outdoor Water Conservation" Bill Insert** – a colorful brochure emphasizing lawn and garden conservation – 3.5" x 6.5".

Low-Flow Water Fixtures: MWRA provides water efficient retrofit kits (low-flow shower heads and faucet aerators) at no cost to member communities, individual customers, housing authorities, property managers, etc. within the service area. MWRA purchases these easy to install fixtures in bulk. To receive conservation kits, please complete the enclosed order form (also available online at mwra.com). Communities or large users may stockpile a reasonable quantity of water conservation kits. For more information, please contact Elaine Donahue, Project Manager at (617) 788-4824 or elaine.donahue@mwra.state.ma.us. The kits include:

- **A Low Flow Showerhead** – 2.5 gpm – plastic and chrome components
- **Two Faucet Aerators** – 1.5 gpm for bathroom, 2.2 gpm for kitchen
- **Dye Tablets** – to check for silent toilet leaks
- **Installation Instructions**

Water System Leak Detection Task-order Contract: To ensure member communities identify and repair leaks in locally-owned distribution systems, MWRA developed leak detection regulations (360 CMR 12.00) that went into effect in July 1991. Under these regulations, communities purchasing water from MWRA are required to complete a leak detection survey of their entire distribution system at least once every two years and repair leaks in a timely manner. Communities can accomplish the survey using their own contractor or municipal crews; or alternatively, using MWRA's task-order leak detection contract. MWRA's task-order contract provides high quality leak detection services at a reasonable cost that has been bid taking advantage of the large volume of work anticipated throughout the regional system. Leak detection services performed under the task-order contract are paid by MWRA, and the costs are billed to the community the following fiscal year. To request information or initiate a leak detection task-order project, please call John McLaughlin, Project Manager at (617) 788-4349 or email at john.mclaughlin@mwra.state.ma.us.

Please visit MWRA's website mwra.com to find information on residential, commercial and industrial water conservation, as well as, water supply system monthly status reports and monthly community water demand figures.

MWRA & Member Communities
Low-Flow Toilet Retrofit Rebate Project

MWRA has received a $40,000 grant from MassDEP to conduct a Low-Flow Toilet Retrofit Rebate project with member water communities during CY2008. Communities are encouraged to purchase/install low-flow (1.6 gallon per flush or less) toilets or toilet flush valves in municipal buildings to replace less efficient toilets that use a larger water volume per flush. For each toilet retrofit, the community may be eligible to receive a $100 rebate.

The $40,000 grant is based on a maximum of 400 toilet rebates. The 44 eligible member water communities (listed below) are each allocated nine (9) $100 rebates. Interested communities should contact MWRA by May 16, 2008 (see contact information below) to reserve rebates for their planned number/location of toilet retrofits. After May 16, 2008, previously allocated community rebates that are not yet reserved will be committed to other communities on a first come, first served basis.

Member communities may utilize the rebates for low-flow toilet retrofits in municipal/publicly-owned buildings. These may include city/town halls, DPWs, schools, libraries, housing authorities, etc. Member water communities will apply to MWRA for the $100 rebates by submitting an information sheet, a copy of the purchase and/or installation receipt, and before/after photos to document the retrofit installation. The deadline to apply for rebate funding is November 28, 2008. A summary report will be prepared detailing the project results/lessons learned and will be shared with member communities.

Eligible Communities

Arlington
Bedford
Belmont
Boston
Brookline
Canton
Chelsea
Chicopee
Dedham
Everett
Framingham
Lexington
Lynnfield WD
Malden
Marblehead
Marlborough
Medford
Melrose
Milton
Nahant
Needham
Newton
Northborough
Norwood
Peabody
Quincy
Reading
Revere
Saugus
Somerville
South Hadley FD #1
Southborough
Stoneham
Stoughton
Swampscott
Wakefield
Waltham
Watertown
Wellesley
Weston
Westwood
Wilbraham
Winchester
Winthrop
Woburn

Deadline to reserve allocated rebates is May 16, 2008

Interested communities should contact Elaine Donahue, Project Manager, MWRA Community Support Program at (617) 788-4824 or Elaine.Donahue@mwra.state.ma.us.

MWRA & Member Communities Pilot Water Audit Project

MWRA has received a $40,000 grant from MassDEP to conduct a Pilot Water Audit Project. MWRA is currently looking for 2 or 3 communities to participate in the project during CY2008. The water audit will balance the volume of water purchased from MWRA (wholesale purchase) with the volume billed (retail sales) and account for the remainder of non-billed water volume. The project will help the community minimize its non-billed or unaccounted-for-water (UAW). A summary report will be prepared detailing the project results/lessons learned and will be shared with other MWRA communities.

Communities should review the Water Management Act Program Guidance Document and Forms for a Water Audit (available at www.mass.gov/dep/water/approvals/guidance.pdf) and the Water Resources Commission MA Water Conservation Standards - see pages 10-12 System Water Audits and Leak Detection (available at www.mass.gov/envir/mwrc/pdf/Conservation_Standards.pdf)

Interested communities should contact MWRA by April 18, 2008 (see contact information below).

Higher Priority Communities (estimated unaccounted-for-water greater than 10%)

Boston	Marblehead	Quincy
Canton	Marlborough	Revere
Dedham/Westwood	Medford	Southborough
Everett	Melrose	Stoneham
Framingham	Northborough	Watertown
Lynnfield WD	Norwood	Wellesley
Malden	Peabody	

Lower Priority Communities (estimated unaccounted-for-water less than 10%)

Arlington	Nahant	Swampscott
Bedford	Needham	Wakefield
Belmont	Newton	Waltham
Brookline	Reading	Weston
Chelsea	Saugus	Wilbraham
Chicopee	Somerville	Winchester
Lexington	South Hadley FD # 1	Winthrop
Milton	Stoughton	Woburn

Sign-up deadline is April 18, 2008

Interested communities should contact Kristen Hall, Project Manager, MWRA Community Support Program at (617) 788-4831 or Kristen.Hall@mwra.state.ma.us.

Sample Letter to Communities Promoting Water Conservation

Dear xxxx:

The Authority is currently accepting requests for water conservation materials for local distribution during the spring and summer season. To assist communities and other interested stakeholders with their water conservation activities, MWRA makes available public information materials for distribution to customers.

The "Water Conservation Standards" by EOEA and WRC, July 2006, sets conservation standards for all communities. Water Management Act Registration renewals for MWRA, as well as all Water Management Act registrants, also requires registrants to maintain consistency with the state conservation standards. While these standards would be applied to MWRA as a system, each community should strive to meet the standards, which may be found on www.mass.gov/envir/mwrc/default.htm. Included in these standards is a public education component.

Enclosed for your review is a sample packet of materials. Outlined below is a description of these materials:

- **"Indoor Water Conservation" Bill Insert -** a colorful brochure emphasizing water efficient fixtures and appliances for the home - 3.5" x 6.5".
- **"Outdoor Water Conservation" Bill Insert** – a colorful brochure emphasizing lawn and garden conservation – 3.5" x 6.5".

If you wish to receive any of the aforementioned materials, please complete the attached form and fax to (617) 788-4888 as soon as possible. Orders are placed as needed so there may be a lag time between your request and when the literature is actually available. We will contact you to arrange for delivery. Please note that large quantities must be picked up. Feel free to contact Kathy Pouche, (617) 788-4365 with any questions.

The Authority also provides water efficient retrofit kits to local residents and property management companies within our service area. The MWRA will send out a maximum of 50 kits at a time. MWRA purchases these kits in bulk. Orders are placed as needed so there may be a lag time between your request and when the kits are actually available. Individual customers wishing to obtain a kit can complete a simple request form found online at www.mwra.com or call MWRA at (617) 242-SAVE (7283) to obtain the form. Communities may stockpile a reasonable quantity of water conservation kits for future distribution to retail customers and can request these kits along with the abovementioned literature. We recommend that you submit your request as soon as possible so an order may be placed that accommodates your needs. The kit includes:

- **A Low Flow Showerhead** – 2.5 gpm – plastic and chrome components
- **Two Faucet Aerators** – 1.5 gpm for bathroom, 2.2 gpm for kitchen – brass with chrome finish
- **Dye Tablets** – to check for silent toilet leaks
- **Installation Instructions**

In addition, MWRA's website, www.mwra.com, contains information on water conservation. The website features: indoor and outdoor residential water conservation tips, commercial and industrial water conservation suggestions, MWRA water supply system monthly status reports, and monthly community water demand figures.

Sincerely,

MWRA Community Support Program

Appendix F

Spreadsheet Used to Track the Distribution of Water Conservation Brochures and Low-Flow Fixtures for 2008

Distribution Summary

	Indoor Brochure	Outdoor Brochure	Total Brochures	Low-Flow Shower Head	Low-Flow Bathroom Aerator	Low-Flow Kitchen Aerator	Dye Tabs	Total Devices (w/o dye tabs)
Homeowners	416	416	832	720	868	528	866	2116
Multi-Units	7,442	2,734	10,176	2,326	2,382	2,252	2,775	6,960
DPW's	241,575	238,075	479,650	5,549	5,635	5,335	14,605	16,519
TOTALS	**249,433**	**241,225**	**490,658**	**8,595**	**8,885**	**8,115**	**18,246**	**25,595**

Appendix G

Low-Flow Toilet Retrofit Rebate Project

Reimbursement Request Form

MASSACHUSETTS WATER RESOURCES AUTHORITY

Low-Flow Toilet Retrofit Rebate Project
Reimbursement Request Form

Deadline to Apply for Rebate Funding is November 28, 2008

INSTRUCTIONS: Fill out this form, attach a copy of the purchase and/or installation receipt(s), enclose before/after photos to document the retrofit installation, and return by US postal mail to:

Elaine Donahue, Project Manager, MWRA Planning Dept.
Charlestown Navy Yard
100 First Avenue
Boston, MA 02129

YOUR INFORMATION:

Agency/Community:_____
Contact Person:_____
Telephone Number: (_____)_____
Installation Address*:_____
Manufacturer/Model Number:_____
Number of Rebates Being Requested: _____ Date of Installation_____

* For multiple installation addresses, please use Page 2.

Make Check Payable To:_____
Street Address: _____
City/Town, State and Zip Code: _____
Federal ID Number:_____

Rebate Requirements: Rebate requests must include before and after installation photos. A $100.00 rebate will be issued for each retrofit of a toilet or flush valve using greater than 1.6 gpf and replaced with a toilet or flush valve using 1.6 gpf or less (up to the number of rebates allowed per community).

Awardee certification: I certify that each of the toilets or flush valves for which I am requesting rebates have been purchased and installed for use at the above named address and meet the requirements of the MWRA Low-Flow Toilet Retrofit Rebate Project.

_____

Signature Title Date

Disclaimer: The MWRA may deny any application that does not meet program requirements. The MWRA does not provide any warranty, express or implied, as to any of the installed fixtures as to the quality of workmanship or the fitness or suitability of the fixtures for the particular place of installation. The MWRA reserves the right to terminate this program at any time.

Indemnification: The Awardee, at its expense, hereby releases and shall defend and shall indemnify and hold harmless the MWRA, its members, officers and employees, from and against any and all claims, causes of action, suits, losses, damages and expenses, including attorneys' fees, arising out of or resulting from any acts, errors or omissions, negligence, or breach of contractual duties which result in any loss to the Awardee and anyone employed by it (including Contractors, Subcontractors and/or Consultants and their employees) in work associated with this Low-Flow Toilet Retrofit Rebate Project. Such obligation shall not be construed to negate or abridge any release or obligation of indemnification running to the MWRA which would otherwise exist.

Please use this sheet for multiple installation addresses
(add more sheets if necessary).

Installation Information:

Installation Address:____
Unit Number:____________ Date of Installation:____________________
Manufacturer/Model Number:____________________________________

Installation Address:____
Unit Number:____________ Date of Installation:____________________
Manufacturer/Model Number:____________________________________

Installation Address:____
Unit Number:____________ Date of Installation:____________________
Manufacturer/Model Number:____________________________________

Installation Address:____
Unit Number:____________ Date of Installation:____________________
Manufacturer/Model Number:____________________________________

Installation Address:____
Unit Number:____________ Date of Installation:____________________
Manufacturer/Model Number:____________________________________

Installation Address:____
Unit Number:____________ Date of Installation:____________________
Manufacturer/Model Number:____________________________________

Installation Address:____
Unit Number:____________ Date of Installation:____________________
Manufacturer/Model Number:____________________________________

Installation Address:____
Unit Number:____________ Date of Installation:____________________
Manufacturer/Model Number:____________________________________

Appendix H

Low-Flow Toilet Retrofit Rebate
Installation Location Tracking Database

Massachusetts Water Resources Authority
Low-Flow Toilet Retrofit Rebate Project
Installation Location Tracking Database
Final as of December 31, 2008

Agency	Address of Retrofit	# of Retrofits
Canton Housing Authority Total retrofits - 12	Hagan Court - Units 1G, 1H, 6E, 7E, 8E, 9A, & two toilets in community room Rubin Court - Public Restrooms Concord Ave. - Units 15 & 17	8 2 2
City of Chelsea Total retrofits - 10	City Hall - 500 Broadway, Chelsea Senior Center - 10 Riley Way, Chelsea Fire Station - 883 Broadway, Chelsea E911 Center - 45 Washington Ave., Chelsea	2 6 1 1
Lexington Housing Authority Total retrofits - 47	One Countryside Village Unit #2A, 2B, 2C, 2E, 2F, 2G, 2H, 2I, 2J, 2L, 3A, 3B, 3C, 3E, 3F, 3I, 4A, 4B, 4C, 4D, 4E, 4J, 4L, 5A, 5C, 5D, 5E, 5F, 5G, 5I, 5K, 6C, 6E, 6F, 6H, 6I, 4I, 2K, 4F. 314 Bedford Street Unit #5, 6, 8, 9, 11, 108, 111. 16 Greeley Village 1st floor restroom	39 7 1
Marblehead Housing Authority Total retrofits - 15	Farrell Court - #2, 6, 9,12, 7, 17, 19, 26, 29, 31, 30, 58, 46, 50 & 14	15
City of Marlborough Total retrofits - 10	Assabet Valley High School - 85 Sawin St., Marlborough Kane Elementary School - 520 Farm Rd., Marlborough	4 6
Quincy Housing Authority Total retrofits - 100	80 Clay St. Units 815, 614, 1014, 1114, 214, 414, 714, 814, 914, 613, 620, 704, 610, 606, 519, 518, 517, 510, 906, 901, 817, 813, 803, 720, 708, 705, 619, 1113, 1109, 1106, 1018, 1007, 1005, 915, 912, 910, 1110, 1108, 1107, 1105, 1104, 1101, 1102, 1020, 1017, 1012, 509, 1011, 1009, 1006, 1004, 1003, 1002, 1001, 920, 919, 904, 903, 902, 819, 818, 812, 811, 810, 809, 808, 806, 913, 911, 907, 909, 807, 804, 802, 801, 719, 718, 717, 713, 712, 711, 710, 709, 707, 701, 702, 1119, 1118, 1117, 1115, 1112, 1111, 319, 309, 210, 209, 208, 207, 515, 1120.	100
City of Revere Total retrofits - 10	City Hall - 281 Broadway, Revere Public restrooms	10
Town of Saugus Total retrofits - 30	WayBright Elementary School - 25 Talbot St., Saugus LynnHurst Elementary School - 443 Walnut St., Saugus Oaklandvale Elementary School - 266 Main St., Saugus Belmonte Middle School - 25 Dow St., Saugus	10 3 15 2

Massachusetts Water Resources Authority
Low-Flow Toilet Retrofit Rebate Project
Installation Location Tracking Database
Final as of December 31, 2008

Agency	Address of Retrofit	# of Retrofits
Stoughton Housing Authority Total retrofits - 100	Rose Forte - 4 Capen St., Stoughton Unit #216, office restroom, 403, two public restrooms, 109, 101, 102, 103, 104, 108, 110, 111, 112, 113, 114, 117, 119, 122, 115, 121,404, 220, 219, 222, 221, 215, 105, 217, 218, 116, 209, 210, 211, 212, 213, 214, 201, 202, 203, 204, 205, 206, 207, 208, 301, 302, 303, 304, 305, 306, 308, 309, 321, 322, 320, 319, 307, 318, 312, 315, 317, 314, 313, 310, 311, 401, 402, 118, downstairs common room.	70
	Silva House - 44 Pleasant St., Stoughton Unit #19, 14, 12, common bathroom, 18, 3, 10, 2, 7, 8, 1, 4, 6, 9, 15, 16, 11, 17, 13.	19
	34 Lacivita Court Unit #72-2, 31, 29, 23, 25-1, 25-2, 27-1, 27-2, 35-2.	9
	178 Memorial Drive, Stoughton	1
	180 Memorial Drive, Stoughton	1
City of Woburn Total retrofits - 17	City Hall - 10 Common Street, Woburn Public restrooms	12
	Woburn Public Schools:	
	Wyman School - 679 Main St., Woburn	4
	Clapp School - 40 Hudson St., Woburn	1
	TOTAL	**351**

Appendix I

Somerville Water Audit Report

Appendix J

Quincy Water Audit Report

MASSACHUSETTS WATER RESOURCES AUTHORITY

SOMERVILLE PILOT WATER AUDIT

FINAL REPORT

MAY 2009

GREEN INTERNATIONAL AFFILIATES, INC.
CONSULTING ENGINEERS MEDFORD, MA

AND

CDM

Contents

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Section 1 City of Somerville Background Information

1.1 Location and History

The City of Somerville, MA is located just north of Boston in Middlesex County. It was established as a city in 1842, when it was separated from Charlestown. There are 4.2 sq. miles in Somerville. The topography varies, resulting in water service elevations from approximately sea level to 145 feet. Formerly known as a railroad and industrial community, the City of Somerville is now primarily a residential area. The current breakdown of land area by classification is presented in Table 1-1.

Table 1-1 Land Area Use by Zoning Classification

Zoning Classification Description	% of Total Area
Residential	64%
Business/Commercial	16%
Industrial	13%
Open Space	5%
University	2%

In 2007, the population of Somerville was 77,405 according to a city census, making it the most densely populated municipality in New England.

1.2 Water Supply System

Water is sold to the City of Somerville by the Massachusetts Water Resources Authority (MWRA), which provides water to 50 communities. The MWRA draws raw water from the Quabbin and Wachusett Reservoirs and the Ware River in central and western Massachusetts. The water is treated at the John J. Carroll Water Treatment Plant in Marlborough with ozone disinfection and the addition of chloramines. This water is then stored at a 115-million gallon, covered storage facility in Weston. Detailed information on the MWRA can be found at www.mwra.com. The City of Somerville has no water treatment or storage facility. It relies entirely upon the MWRA system. Water sold to Somerville is metered by the MWRA at seven locations, five of which serve the low pressure zone and two of which serve the high pressure zone of Somerville. Table 1-2 shows the location, size, and installation date of the seven MWRA meters.

Table 1-2 MWRA Meter Data

Meter No.	Pressure Zone	Location	Size	Venturi Size (in)	Install Date[1]
31	high	Boston Ave. at Dearborn Rd.	12-inch	8.22x4.8	1992
32	high	Broadway at Cedar St.	16-inch	16x5.75	1903
33	low	Broadway at Willow Ave.	6-inch	8.35x4.8	1992
35	low	Walnut St. at Pearl St.	16-inch	8.33x5.959	2003
37	low	Webster Avenue at Columbia St.	24-inch	8.33x5.957	2003
80	low	Alewife Brook Pkwy at Mystic Shops	12-inch	6.22x4.2	1992
91	low	Fellsway at Middlesex Ave.	20-inch	8.33x3.6	1992

1—Install date refers to meter installation date, not site installation date

The low pressure zone accounts for 66% of water consumption, while the high pressure zone accounts for 34%. Average daily flows for the Somerville meters are shown in Table 1-3.

Table 1-3 Average Annual MWRA Meter Flows for 2001-2007 in Million Gallons per Day (MGD)

Meter No.	2001	2002	2003	2004	2005	2006	2007
31	0.604	0.487	0.586	0.549	0.489	0.545	0.549
32	1.606	1.689	1.568	1.724	1.984	1.857	1.724
33	0.634	0.555	1.404	0.865	1.084	0.641	0.865
35	1.646	1.015	1.048	0.958	1.275	1.005	0.958
37	1.678	1.194	0.665	1.046	1.107	1.066	1.046
80	0.678	0.590	0.258	0.285	0.118	0.555	0.285
91	0.064	0.978	0.908	0.824	0.345	0.489	0.824
Total	**6.910**	**6.508**	**6.437**	**6.251**	**6.402**	**6.158**	**6.251**

Table 1-4 compares the size of each meter with the 2005-2007 average flow and the 2007 peak and minimum flow.

Table 1-4 MWRA Meter Size Compared with Average, Peak, and Minimum Flow in MGD

Meter No.	Meter Size (in)	2005-2007 Average Flow (MGD)	2007 Peak Flow (MGD)	2007 Minimum Flow (MGD)
31	8.22x4.8	0.53	1.1	0.0
32	16x5.75	1.86	3.2	0.8
33	8.35x4.8	0.86	2.3	0.0
35	8.33x5.959	1.08	1.8	0.0
37	8.33x5.957	1.07	1.7	0.5
80	6.22x4.2	0.32	0.4	0.4
91	8.33x3.6	0.55	2.5	0.3

During the night, meters 31, 33, and 35 go to zero flow. These meters are equipped with a check valve, so one can assume the zero flow reading is accurate, rather than the venturi meter not reading a flow outside of its reading range.

Per MWRA guidelines, each of the MWRA meters is routinely calibrated and tested to ensure accuracy. The most recent meter calibrations and tests are shown in Table 1-5.

Table 1-5 MWRA Meter Calibration and Test Results

Meter No.	Last Calibrated	Last Tested	Pitot Flow (MGD)	Meter Flow (MGD)	% Difference
31	9/16/08	7/7/08	0.60	0.6	**0%**
32	6/18/08	7/10/08	1.49	1.61	**-8%**
33	9/8/08	N/A	N/A	N/A	**N/A**
35	9/16/08	7/7/08	0.77	0.73	**5%**
37	9/15/08	7/2/08	0.87	0.86	**1%**
80	9/17/08	1/2/07	0.42	0.40	**5%**
91	9/8/08	7/2/08	1.07	1.08	**-1%**
		Total	**5.22**	**5.28**	**-1%**

Meter #33 has no gauging point and cannot be tested. Of the remaining meters, every meter besides #32 was within MWRA's 5% difference guideline. In total, the 6 meters tested were within 1% of the metered flow.

The MWRA charges a standard wholesale rate for the volume of water supplied to all 50 communities it services. This rate is reassessed at the end of each fiscal year (July 1-June 30). Table 1-6 shows the wholesale rate for 2005-2008.

Table 1-6 Wholesale Water Rate from MWRA per Million Gallons (MG) of Water

Fiscal Year	Cost ($/MG)
2005	1,794.17
2006	2,168.56
2007	2,216.72
2008	2,398.88

In addition to servicing Somerville's water, MWRA fully services Somerville's wastewater needs. To calculate the annual wholesale sewer charge, MWRA meters the total wastewater flow and also utilizes additional rate parameters including total and sewered population. Sewer wholesale rates for FY05 to FY08 are shown in Table 1-7.

Table 1-7 Somerville's Wholesale Sewer Rates from MWRA per Million Gallons

Fiscal Year	Cost ($/MG)
2005	2,764.57
2006	2,827.81
2007	2,821.90
2008	2,963.84

The retail water and sewer rate structure is discussed in *1.7 Retail Water/Sewer Rate Structure*.

1.3 Water Distribution System

Construction of the City of Somerville water supply system began in 1868. Currently, the water distribution system consists of approximately 121 miles of pipe, ranging in diameter from 1-1/4-inch to 20-inch; however, the majority of piping is 12-inch in diameter or smaller. Table 1-8 shows the pipe size distribution of the system.

Table 1-8 Pipe Size Data

Diameter (in)	Length (mi)	Percent of Total
20	1.4	1%
18	0.2	0%
16	4.3	4%
14	1.9	1%
12	37.1	31%
10	17.0	14%
8	27.7	23%
6	28.7	24%
<4	2.7	2%
Total	**121.0**	**100%**

The majority of distribution piping is made of either cement-lined ductile iron or cast iron and was installed prior to 1950. Further, a total of approximately 68% of Somerville's distribution piping is not lined. Table 1-9 shows the pipe age distribution of the system.

Table 1-9 Pipe Age Data

Year of Installation	Length (mi)	Percent of Total
< 1900	47	39%
1901-1950	42	36%
1951-1973	3	3%
1974 – Present	17	20%
Unknown	12	2%
Total	**121**	**100%**

In addition to Somerville-owned water distribution piping, MWRA also has 4 miles of transmission mains located within the city. These mains range in diameter from 24-inch to 60-inch.

1.4 Water Meters

The Somerville Water Department currently serves approximately 13,900 individual service connections. These service connections can be categorized by the type of user that they supply: residential, commercial, institutional, or industrial. A breakdown of the number of meters by category is presented in Table 1-10.

Table 1-10 Number of Meters per Category

Type of Meter	Number of Meters
Residential	13,506
Commercial	249
Institutional	97
Industrial	4
Total	**13,856**

Somerville is in the process of replacing every meter in the city with new automatic meter reading (AMR) meters, which will be discussed further in *Section 2*.

1.5 Non-billed Water

Non-billed water is the difference between the total water use (water purchased from MWRA) and the total water sales (retail sales to water customers). It is a result of unmetered municipal usage (e.g. facilities, water main flushing, fire fighting), metering inaccuracies, accounting errors, leakage, etc. The percent of non-billed water has increased in recent years in the City of Somerville. Table 1-11 shows the annual non-billed water calculation.

Table 1-11 Water Usage and Non-Billed Water Consumption Reported by the City of Somerville

Year[1]	Total Water Use (MG)	Total Water Sales (MG)	Non-Billed Water (MG)	% Non-Billed
1993	2,864	2,559	305	**11%**
1994	2,895	2,549	346	**12%**
1995	2,432	2,176	255	**10%**
1996	2,432	2,189	243	**10%**
1997	2,500	2,225	275	**11%**
1998	2,368	2,084	284	**12%**
1999	2,394	2,095	299	**13%**
2000	2,433	2,153	280	**12%**
2001	2,522	2,169	353	**14%**
2002	2,376	2,126	250	**11%**
2003	2,350	1,904	446	**19%**
2004	2,288	1,968	320	**14%**
2005	2,337	1,915	422	**18%**
2006	2,247	1,804	443	**20%**
2007	2,330	1,814	517	**22%**

1—Calendar year, not fiscal year

In 1974, the City of Somerville had a non-billed value of 30%. That number was reduced to the 10-12% range in 1993-1998, but has increased to as high as 22% in 2007. While the total water use (water purchased from MWRA) has remained fairly steady over the last six years, the total water retail sales have been declining over the same period.

1.6 Leak Detection Surveys

The two most recent leak detection surveys for the City of Somerville were performed in 2005 and 2007 by Liston Utility Services and Heath Consultants Inc, respectively. The 2005 survey was completed on July 19, 2005 and identified a total of 12 leaks, which consisted of 2 main leaks, 8 service leaks, and 2 hydrant/valve leaks. Results of the 2005 survey are shown in Table 1-12.

Table 1-12 Leaks Identified by Liston Utility Services in 2005

Type	Location	Estimated Leakage (GPD)
Main	Opposite 90 School Street	**72,000**
Main	Opposite 22 Highland Avenue	**72,000**
Service	21 Franklin Avenue	**14,400**
Service	23 Fountain Avenue	**14,400**
Service	53 Bonair Street	**14,400**
Service	46-48 Moreland Street	**11,520**
Service	131 Summer Street	**21,600**
Service	23-25 Gorham Street	**14,400**
Service	43 Victoria Street	**14,400**
Service	5 Everett Avenue	**14,400**
Hydrant	Opposite 53 Sunset Road	**4,400**
Hydrant	Opposite 19 Curtis Avenue	**4,400**
	Total Leakage	**272,320**

The locations of these 12 leaks are shown in Figure 1-1.

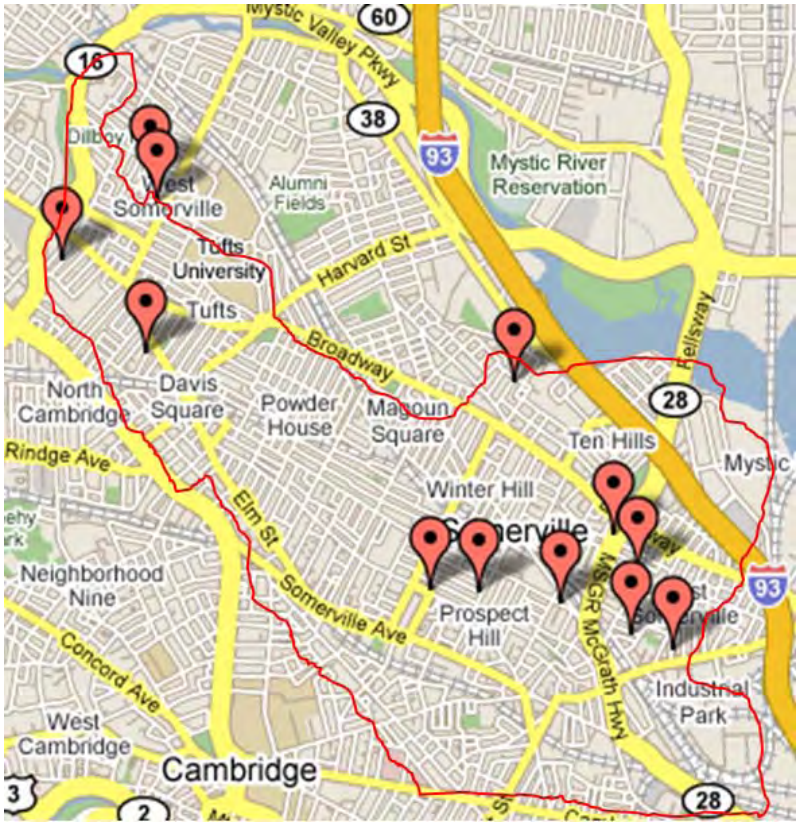

Figure 1-1. Location of the 12 leaks in the 2005 Leak Detection Survey. The outline shows the approximate city limits.

In addition to addressing the above leaks, Liston Utility Services recommended taking the following actions to reduce water loss:

1. Installation of a datalogging system at all the master metered sites, allowing the water superintendent to monitor the MWRA Master Meter and any Tank Level.

2. Investigate all compound and turbine meter accounts for unaccounted-for-water. Datalog these accounts and size them properly based upon the data results. Potentially investigate 2-in displacement meters as well.

Because the MWRA already gives access to master meter data via the web, the Datalogging system for master meters was not installed.

The 2007 survey was completed on June 29, 2007 and identified a total of 10 leaks. They consisted of 1 main leak, 3 service leaks, and 6 hydrant/valve leaks. Table 1-13 shows the 2007 survey results.

Table 1-13 Leaks Detected by Heath Consultants Inc in 2007

Type	Location	Estimated Leakage (GPD)
Main	120 Middlesex Avenue @ Cummings Street	**72,000**
Service	14 Wesley Street	**86,400**
Service	36 Warwick Street	**72,000**
Service	Dane St @ 460 Somerville Avenue	**28,800**
Hydrant	39 Whitman Street	**1,440**
Hydrant	171 Powderhouse Boulevard	**1,440**
Hydrant	201 Morrison Street	**1,440**
Hydrant	30 Gorham Street	**1,440**
Hydrant	34 Fairfax Street	**1,440**
Hydrant	46-48 Sunset Road	**1,440**
	Total Leakage	**267,840**

The locations of these 10 leaks are shown in Figure 1-2.

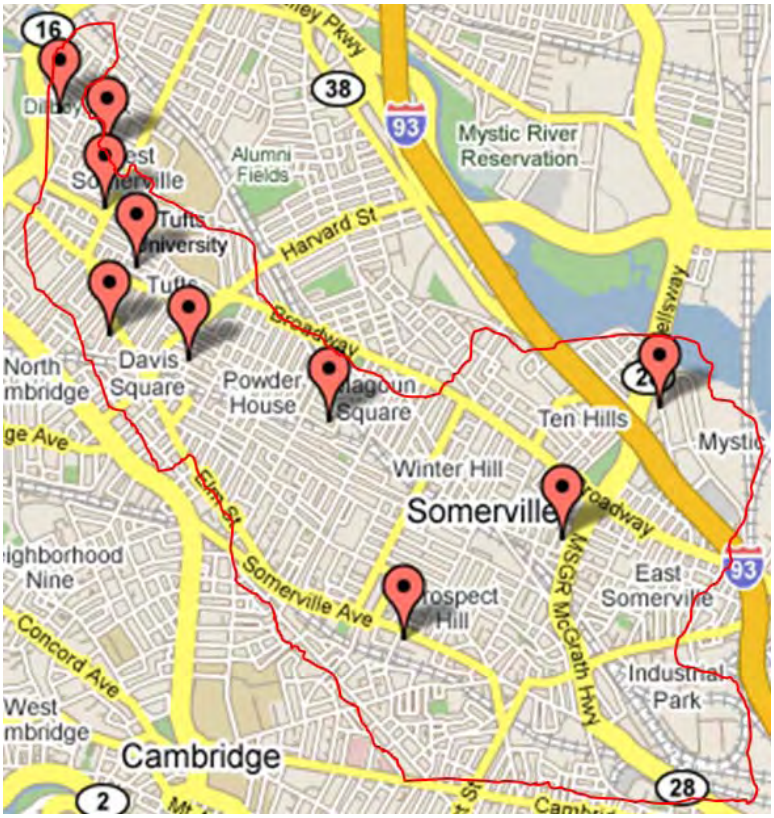

Figure 1-2. Location of the 10 leaks in the 2008 Leak Detection Survey. The outline shows the approximate city limits.

All of the leaks identified in both surveys have been repaired, according to the city water superintendent, Carol Antonelli. Additionally, in reviewing the location of the leaks in Figure 1-1 and Figure 1-2, it is clear that the leak detection surveys covered the entire city and there does not appear to be any one area of the city where leaks are more common.

1.7 Retail Water/Sewer Rate Structure

The retail water and sewer rates in the City of Somerville increase based upon usage. Additionally, rates are reassessed at the end of each fiscal year. Similar to the MWRA, the fiscal year for the City of Somerville is July 1st through June 30th. For example, the 2005 fiscal year is from July 1, 2004 to June 30, 2005. Table 1-14 shows the prorated water rates for 2005-2008.

Table 1-14 Retail Water Rate Structure by Fiscal Year

FY 2005			FY 2006	FY 2007	FY 2008
Usage (HCF)	Rate ($/HCF)	**Usage (HCF)**	Rate ($/HCF)	Rate ($/HCF)	Rate ($/HCF)
0-10	2.45	**0-13**	2.65	2.77	3.14
11-50	3.54	**14-67**	3.82	4	4.53
51-100	3.71	**68-133**	4.01	4.19	4.75
>100	3.85	**>133**	4.16	4.35	4.93

In the City of Somerville sewer usage is based upon the metered water usage. The city does not allow irrigation meters for water use that does not return to the sewer. Table 1-15 shows the prorated sewer rates for 2005-2008.

Table 1-15 Retail Sewer Rate Structure by Fiscal Year

FY 2005			FY 2006	FY 2007	FY 2008
Usage (HCF)	Rate ($/HCF)	**Usage (HCF)**	Rate ($/HCF)	Rate ($/HCF)	Rate ($/HCF)
0-10	4.55	**0-13**	4.91	5.35	5.39
11-50	5.81	**14-67**	6.27	6.83	6.88
51-100	6.09	**68-133**	6.58	7.17	7.22
>100	6.31	**>133**	6.81	7.42	7.47

Table 1-16 shows the prorated, combined water and sewer rates for 2005-2008.

Table 1-16 Retail Combined Water and Sewer Rate Structure by Fiscal Year

FY 2005			FY 2006	FY 2007	FY 2008
Usage (HCF)	Rate ($/HCF)	**Usage (HCF)**	Rate ($/HCF)	Rate ($/HCF)	Rate ($/HCF)
0-10	7.00	**0-13**	7.56	8.12	8.53
11-50	9.35	**14-67**	10.09	10.83	11.41
51-100	9.8	**68-133**	10.59	11.36	11.97
>100	10.16	**>133**	10.97	11.77	12.40

If an account had a billing period in February 1, 2006 of 150 HCF, it would be in the 2006 fiscal year rate structure. Therefore, the cost breakdown for both water and sewer would be billed as such: $98.28 (13 HCF X $7.56/HCF) + $544.86 (54 HCF X $10.09/HCF) + $698.94 (66 HCF X $10.59/HCF) + $186.49 (17 HCF X $10.97/HCF) = $1,528.57.

Lastly, rates are the same for all accounts, regardless of category.

Section 2 Review of Billing and Accounting Procedures

Water Department staff record meter readings using two types of remote readers. There are also some accounts (less than 10% of total meters) that are read by hand and recorded in meter books. At the end of the day, meter readers download electronic data collected that day into the software system as well as manually record all meter readings into meter books. The Water Department bills all users—independent of category—three times a year (every four months). Formerly the Water Department billed four times a year—or quarterly. Because of delays in obtaining meter readings, this billing frequency required too many bills to be estimated, so the billing frequency was decreased.

It takes approximately 4 to 6 weeks to manually read, conduct quality control checks and print invoices for all meters in a billing district. There are four billing districts, each of which contains about 4,000 meters. The bulk of the time is spent on quality control checking and converting electronic meter data into a format that is usable by the outside company that prints the bills. The first quality control check compiles a "skip" list of meters where: the remote readers may have missed a digit when reading the meter, the meter requiring a manual read was not accessible, or the meter reader missed a meter. Meters on this list are rechecked by staff until all inconsistencies have been resolved. Once all on the skip list have been verified, the Department completes a cross-check of consumption by comparing consumption for the current period with prior periods. If consumption has varied by plus or minus 10%, the Department immediately issues a letter notifying the customer of a meter reading out of range and proceeds to bill for the high reading.

Once all skips have been resolved and the consumption control check is completed for all meters in the district, the electronic files are forwarded to the City IT department to configure the files into a format that is usable by the outside printing company. Customers have 45 days from the date of the bill to remit payment. Late payments are charged 14- percent interest annually. Payments are sent to the Treasurer/Collector's office and deposited in the Water Enterprise Fund.

At the time of this report, Somerville is in the process of replacing all of the water meters in the city. The new automatic meter reading (AMR) meters are read by a fixed-network system of four data collection units (DCUs) in the city, which daily record the water meter reading in the Water Department accounting system—KP Electronic Systems Ltd. So far, 1,000 of the approximately 13,500 meters have been replaced with new meters. It is the hope of the Department that 70% of the meters in the city will be replaced during calendar year 2009. One of the many advantages of the new meters is that it allows the water department to instantly

determine if anyone has tampered with the meters or if there have been any leaks, because the system updates frequently and alerts the city to extreme readings.

Once this new metering system is in place, the Water Department anticipates billing users every other month.

Section 3 Water Sales

3.1 Background Information

The majority of water sales in the City of Somerville are to residential accounts. This is followed by industrial or commercial accounts, depending on the year. There are only two industrial accounts, the Central Steel Supply Company and the Angelica Corporation; however, the latter is the largest consumer in the city. Commercial accounts include restaurants, shops, laundromats, etc. The smallest category is the institutional accounts, which include schools, universities, hospitals, etc. Table 3-1 shows the breakdown of metered water sales by category.

Table 3-1 Customer Meter Records by Category in MG/yr (Calculated by CDM per Calendar Year)

Year	Residential	Commercial	Industrial	Institutional	Total
2005	1690.9	138.4	15.9	49.1	**1894.2**
2006	1472.8	168.5	144.2	58.9	**1844.4**
2007	1333.9	175.0	190.7	70.5	**1770.2**

The total water sales values in Table 3-1 are similar to the water sales values reported by the city in Table 1-11. A comparison of these two sets of data is shown in Table 3-2.

Table 3-2 Water Sales Comparison between City Records and CDM Calculations

Year	City Reported Water Meter Records (MG)	CDM Calculated Water Meter Records (MG)	Difference
2005	1,915	1,894	**1.1%**
2006	1,804	1,844	**-2.2%**
2007	1,814	1,770	**2.4%**
Total	5,533	5,509	**0.4%**

The discrepancy between City of Somerville water meter data and CDM water meter data is likely due to the way the two sets of data were calculated. CDM's method for calculating annual totals was to try to get the most representative calendar year usage data. The City of Somerville calculated their totals by summing all of the billing periods within a specific calendar year. For calculating fiscal years sums, the city prorates the accounts, but not when calculating calendar year sums. This would lead to discrepancies when meters were read around the end of the calendar year. For example, an individual account may have a billing period from 1/15/2007-1/15/2008 (all accounts operate on an approximate triannual billing rate). In this scenario, CDM's method would be to sum the entire billing period and attribute it the 2007 calendar year, whereas the City of Somerville would attribute the 1/15/2008 reading to the 2008 calendar year (and the period before 1/15/2007 would be attributed to 2007). While these methods are similar, they provide varying results.

Further, in some cases, the billing periods did not represent 12 months. Two examples of individual account records are shown in Table 3-3.

Table 3-3 Two Examples of Meter Data that Do Not Represent a 12-month Period

Billing Date	Usage (HCF)	Billing Date	Usage (HCF)	Billing Date	Usage (HCF)	Billing Date
12/15/2006	78	5/15/2006	81	9/15/2006	77	1/15/2007
4/15/2007	70	7/31/2007	200	10/31/2007	90	3/15/2008

In these instances, a correction factor was applied to calculate a representative 12 month period. In the first case, the billing periods represent 13 months. Therefore, the usage from 12/15/2006-5/15/2006 was multiplied by 4/5, which represents the approximate usage from 1/15/2006-5/15/2006. This corrected value was then added to the other billing periods to acquire the 12-month total. In the second case, the billing period represents 11 months. In this scenario, the first billing period (4/15/2007-7/31/2007) was multiplied by 4/3, which represents an approximate usage from 3/15/2007-7/31/2007. Similarly, this correction yielded a 12-month total.

These differences in method explain why the comparison of annual total data in Table 3-2 varies. However, it also explains why the total usage from 2005-2007 is nearly identical. Over a long enough data record, the data differences offset each other.

A graphical representation of the metered data from Table 3-1 is shown in Figure 3-1.

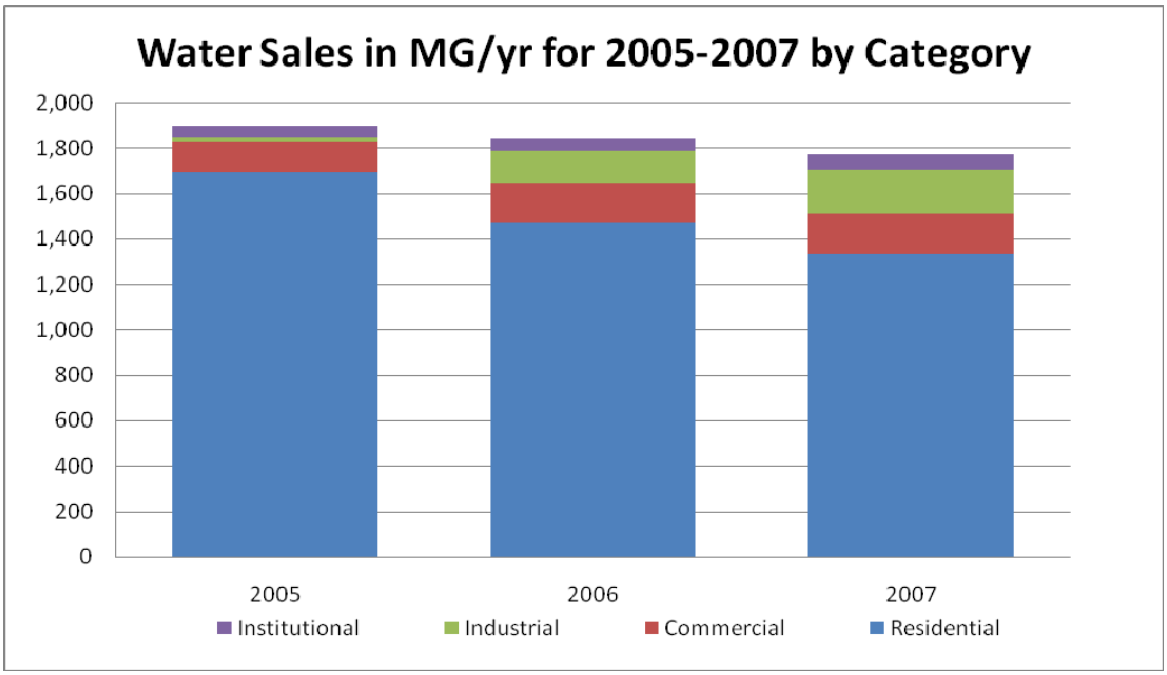

Figure 3-1. A graphical view of the categorical water sales from 2005-2007 in MG/yr from meter records.

Figure 3-1 will be discussed in more detail in Sections *3.2 Residential Accounts* and *3.3 Non-Residential Accounts*.

The largest water consumers have changed dramatically from 1974 to present, as a result of the City of Somerville's transition from an industrial to a residential community. In 1974, the top ten consumers were all commercial/industrial accounts, with the top consumer, the First National Stores, using 0.32 MGD. The largest 10 consumers in 2008 are displayed in Table 3-4.

Table 3-4 Largest 10 Water Consumers in 2008

Account Description	Water Use (MGD)
ANGELICA CORP (HIGH FLOW)	0.187
ROYAL HOSPITALITY SERVICE	0.167
ANGELICA CORP (LOW FLOW)	0.029
SOMERVILLE HOUSING AUTH	0.025
HOLIDAY INN	0.023
TENANTS ASSOC OFF 1D	0.021
TENANTS' ASSOC OFF 1D	0.019
TENANTS ASSOC OFF 1D	0.018
MWRA/FOD	0.017
TUFTS UNIVERSITY	0.015

Recently, the top ten consumers are a mixture of commercial, industrial, institutional, and residential accounts. Accompanying this shift, far less water is used by the top consumers, compared with the top consumers in the 1970's. The top seven consumers in 1973 accounted for a combined daily demand of 1.0 MGD; the top ten consumers in 2008 amounted to approximately half of that amount, with a combined daily total of approximately 0.521 MGD.

3.2 Residential Accounts

Residential water sales decreased for each of the years assessed, as show in Figure 3-1. Possible reasons for this decrease include: a reduction in active meters due to demolition of residential properties; a drop in city-wide population; increased conservation efforts; increases in water and sewer rates; increased accuracy of billing as a result of new meter installs; the city's on-going efforts to eliminate estimated bills, unbilled accounts and theft.

The Massachusetts Water Resources Commission's State Water Conservation Standards advise communities to have a Residential Gallons Per Capita Day (rgpcd) water consumption of no more than 65. Based on the census population data for 2007 (referenced in *1.1 Location and History*) and the residential water usage data for 2007 in Table 3-1, the rgpcd number in Somerville is 47.2, which meets the benchmark.

3.3 Non-Residential Accounts

While the total water sales have decreased in the 2005-2007 period, the water sales to non-residential users have increased.

The volume of water sold to commercial accounts has increased steadily from 2005-2007. The primary reason for this increase is due to the increased usage by Royal Hospitality Service Inc., which is a laundry service for local hospitals. The usage at this account was 0 MG, 33.0 MG, and 48.9 MG for 2005, 2006, and 2007, respectively. If this account is removed from the commercial accounts, then the annual usage from 2005-2007 does not change much: 138.4 MG, 135.6 MG, and 126.0 MG. Water sales to other commercial accounts are largely to laundromats, hotels and offices, whose sales have remained relatively constant. This is mostly due to the fact that there have not been many new accounts, nor have any accounts that haven't previously been billed started receiving bills recently.

Water sales to industrial accounts also increased dramatically from 2005 to 2006 and continued to increase in 2007. There are only two industrial users in the City of Somerville: the Central Steel Supply Company and the Angelica Corporation. In 2005, the Central Steel Supply Company had one metered account and the Angelica Corporation had two metered accounts, all three of which totaled 15.9 MG for the year. In 2006, the Central Steel Supply Company used the same amount of water; however, the Angelica Corporation—who manufactures textiles—

added another meter and increased their total usage from 15.6 MG/yr to 144.2 MG/yr. This increase in usage continued in 2007, with a total usage of 190.7 MG/yr. This one user accounts for the vast majority of the industrial use.

Also, there has been a steady increase in the water sales to institutional accounts. The amount of water sold was 49.1 MG, 58.9 MG, and 70.5 MG in 2005, 2006, and 2007, respectively. This is primarily due to accounts that were previously non-billed, now being billed for their water. A sample of accounts that had increased water usage from 2005-2007 is shown in Table 3-5.

Table 3-5 Sample of the Increased Usage in Institutional Accounts from 2005-2007 in 100 HCF/yr

	Usage (100 HCF/yr)		
Name of Account	**2005**	**2006**	**2007**
Accounts Payable Department	0	2,266	4,786
Cambridge Health Alliance	0	223	200
MWRA/FOD	0	5,817	7,367

It should be noted that many of the schools and churches in Somerville are still not metered, which reduces the total water sales to institutional accounts. However, the Water Department is currently in the process of installing meters in all of these unmetered accounts.

Section 4 Non-Billed Water Volume and Cost

Table 4-1 shows a comparison between the amount of water purchased (total water use, see Table 1-3) and the amount of water sold (see Table 3-1) in the City of Somerville for 2005-2007.

Table 4-1 Water Usage, Sales and Non-Billed Water

Year	Total Water Use (MG)	Total Water Sales (MG)	Non-Billed Water (MG)	CDM Calculated % Non-Billed	City of Somerville % Non-Billed
2005	2,337	1,894	**423**	**18%**	**18%**
2006	2,248	1,844	**404**	**18%**	**20%**
2007	2,282	1,770	**512**	**22%**	**22%**

Exactly how much this non-billed water volume is costing the City of Somerville depends on where this non-billed water is going. The minimum that the non-billed water would cost the city would be if the water was lost to leaks and to municipal uses where the water did not return to the sewer. Under this scenario, the amount that the non-billed water would cost the city would be based upon the wholesale water rate. If the non-billed water was used for municipal uses and did return to the sewer, then the cost to the city would be based upon both the wholesale water rate and the wholesale sewer rate. By including the wholesale sewer rate, the cost is increased by approximately 150%, as can be seen by comparing the wholesale water and sewer rates in Table 1-6 and Table 1-7. The maximum that the non-billed water would cost the city would be if the water was lost to meter inaccuracies and unmetered accounts. Under this scenario, the city would be paying MWRA the water and sewer wholesale rates for the non-billed water and they would also be losing revenue based upon the combined water and sewer retail rates. Therefore, the maximum amount that the non-billed water could cost the city is based upon the sum of the wholesale water rate, the wholesale sewer rate, and the combined retail water and sewer rate. The range of the amount that the non-billed water costs the city is presented in Table 4-2.

Table 4-2 Range of Costs of Non-billed Water for 2005-2007

Year	Non-Billed Water (MG)	Minimum/Wholesale Water Cost ($)	Wholesale Sewer Cost ($)	Retail W&S Cost ($)	Maximum Cost ($)
2005	423	838,117	1,182,788	5,040,507	7,061,412
2006	404	885,827	1,141,241	5,123,233	7,150,301
2007	512	1,181,594	1,481,149	6,900,028	9,562,771

The reason that the retail cost of non-billed water increases from 2005 to 2006 (despite the fact that the volume of non-billed water decreases) is that the water and sewer rates increased.

In order to create Table 4-2, calendar year wholesale and retail water and sewer rates were needed. The wholesale costs in Table 1-6 and Table 1-7 and the retail costs in Table 1-16 (both based on the fiscal year) were manipulated to achieve representative calendar year costs. For example, the 2005 fiscal year (July 1, 2004 – June 30, 2005) data was averaged with the 2006 fiscal year (July 1, 2005 – June 30, 2006) data to achieve a number that closely approximated the wholesale and retail cost of water in 2005. For calculating the wholesale cost, the calendar year costs were applied directly to the non-billed water volume to achieve annual costs of non-billed water. For the retail costs the prorated water/sewer retail rate structure had to be accounted for. To do this, the median usage (35-HCF) was determined from all billing periods for 2005-2007. This usage was used to determine a representative bill based upon the rate structure. These numbers were then applied to the non-billed water volume to achieve annual costs.

Section 5 Meter Adjustment Percentage Estimate

5.1 Meter Adjustment Percentages

Meters generally become more inaccurate with age. The degree of inaccuracy depends on a number of variables related to the meter: instantaneous flow, cumulative usage, and the manufacturer. Because there are so many factors, studies generally report varying inaccuracy numbers associated with meter age. Table 5-1 shows a summary of the decline in accuracy with age.

Table 5-1 Summary of Meter Accuracy Percentages with respect to Meter Age

Organization	WATER/Engineering & Management	Dept of Civil Eng. at WPI	AWWA	Journal AWWA	
Author	Attender	Westerling, Hart	Hill, Davis	Yee	
Meter Age (Years)				Brass Valve	Plastic Valve
New		97.4	100	100	100
5		95.1	99.0	99.7	98.3
10		92.7	98.1	99.3	96.8
15	99.4	90.4	97.2	99.0	95.1
20	99	88.1	96.3	98.8	93.5
25	95.8	85.8	95.4	98.5	
30	81.6	83.4	94.5	96.6	

A value of 100% indicates that a meter is reading perfectly. A value of 95% suggests that a meter is only reading 95% of the water through the meter. Generally in Table 5-1, the accuracy percentages from the various literary sources for newer meters agree, while the accuracy percentages for older meters do not agree. In order to achieve the most representative accuracy percentage values for each meter age listed in Table 5-1, outliers were removed and only brass valves were considered (i.e. the plastic valve column by Yee was not included). The remaining inaccuracy percentages were averaged. For example, to calculate the percent accuracy value for a 15-year old meter, both Westerling and Hart's value of 90.4% and Yee's plastic valve value of 95.1% were removed. The remaining 3 numbers were averaged to achieve a percent accuracy value of 98.5%. This method was used for every meter age in Table 5-1, except for 30-year old meters. In this case, two of the sources indicated a percent accuracy number in the low-80's, while the other two sources indicated a percent accuracy number in the mid-90's. To achieve a

representative value, all four of these values were averaged. The resulting accuracy percentage values are displayed in Table 5-2.

Table 5-2 Summarized Meter Accuracy Percentages with respect to Meter Age

Meter Age (years)	% Accurate
0	100
5	99.4
10	98.7
15	98.5
20	98.0
25	96.6
30	89.0

This summary suggests that there is a large drop-off in terms of accuracy in meters older than 25 years of age. This trend is supported by the fact that many organizations and regulatory authorities recommend replacing meters after 20 years of use.

5.2 Meter Age in Somerville

As mentioned in *Section 2*, Somerville is currently in the process of replacing all of the meters in the city with AMR meters. However, this installation program is not yet complete and some of the meters currently being used were installed as long ago as 1931. A summary of the age of meters in Somerville is presented in Table 5-3 below.

Table 5-3 Summary of Meter Installation Dates

Installation Date Range	# of Meters	%
Pre-1970	16	0.1
1970-1974	161	1.2
1975-1979	992	7.2
1980-1984	1,476	10.7
1985-1989	2,973	21.5
1990-1994	58	0.4
1995-1999	309	2.2
2000-2004	810	5.8
2005-8/28/2008	5,980	43.2
No Date	1,078	7.8
Total	13,853	100.0

The mean and median ages of meters in Somerville are 13 and 8.5 years old, respectively. Over 40% of the meters in Somerville were installed before 1990, making them at least 20 years old. Furthermore, 8% of the meters do not have an installation date on record. One can assume that

these meters were installed a long time ago, because it is more likely that Somerville would have accurate installation dates for recently installed meters. Additionally, approximately 8.5% of the meters in Somerville are 30 years old or older.

5.3 Application of a Percent Correction to Individual Meters

To understand how significantly the percent accuracy numbers in Table 5-2 affect the non-billed water values in Somerville, the percent accuracy numbers were applied to individual meters. In order to do this, Table 5-2 was modified to create Table 5-4 and achieve representative meter age ranges to apply the percent accuracy numbers.

Table 5-4 Meter Age Ranges for Percent Accuracy Values

Meter Age Range (years)	Meter Date Range	% Accurate
0-2.5	2/28/2006-8/28/2008	100
2.5-7.5	2/28/2001-2/28/2006	99.4
7.5-12.5	2/28/1996-2/28/2001	98.7
12.5-17.5	2/28/1991-2/28/1996	98.5
17.5-22.5	2/28/1986-2/28/1991	98.0
22.5-27.5	2/28/1981-2/28/1986	96.6
>27.5	<2/28/1981	89.0

To apply the age-correction percentage, the meters were sorted by category, then by age. Using the date ranges in Table 5-4, percent correction values were applied by multiplying the usage data by the reciprocal of the accuracy numbers. For example, if a meter was installed on 7/13/1983 and had a quarterly usage of 57 HCF for a certain period, the corrected usage was calculated as 59 HCF (57 HCF *1/0.966). In order to account for the fact that the installation date is not known for many of the meters, this method was only applied to the meters with known installation dates. The results were then extrapolated to the unknown meters. For example, a percent accuracy number was calculated for all of the commercial meters by applying the percent accuracy numbers in Table 5-4 to each individual meter with a known installation date. This one percent accuracy number for commercial meters was then applied to the total water use numbers for all commercial meters, yielding a meter age-corrected water usage number for all of the commercial meters.

These percent corrections affect certain meter categories (e.g. residential, commercial) more than others. A breakdown of the meter age by category is presented in Table 5-5.

Table 5-5 Meter Installation Dates by Category

	Residential		Commercial		Industrial		Institutional		All Accounts	
Year	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**%**
<1970	16	0.1							16	0.1
1970-1974	159	1.2	1	0.4			1	1	161	1.2
1975-1979	989	7.3	3	1.2					992	7.2
1980-1984	1,473	10.9	2	0.8			1	1	1,476	10.7
1985-1989	2,967	22.0	6	2.4					2,973	21.5
1990-1994	56	0.4	2	0.8					58	0.4
1995-1999	306	2.3	2	0.8			1	1	309	2.2
2000-2004	801	5.9	7	2.8			2	2	810	5.8
2005-8/28/2008	5,696	42.2	197	78.8	4	100	83	86	5,980	43.2
No Date	1,039	7.7	30	12			9	9	1,078	7.8
Total	13,502	100	250	100	4	100	97	100	13,853	100.0

The greatest distinction among categories is represented by the "2005-8/28/2008" row in Table 5-5: 42% of residential meters were installed during that period, whereas 79% of commercial, 100% of industrial, and 86% of institutional meters were installed in the same period. This means that the commercial, industrial, and institutional meters are relatively new compared with residential meters. Therefore, the residential meters are likely to see the greatest change after applying percent correction values. Table 5-6 shows the corrected residential sales and the percent difference.

Table 5-6 Residential Water Sales for 2005-2007: Metered and Meter Age-Corrected

Year	Metered Sales (MG/yr)	Meter Age-Corrected Sales (MG/yr)	% Difference
2005	1690.9	1717.0	1.54
2006	1472.8	1497.4	1.67
2007	1333.9	1357.4	1.76

For each year analyzed, the actual residential water sales are over 1.5% more than the metered sales. As noted previously, the age-corrected sales (1.12 times more) for meters installed before 2/28/1981 might be higher for residential meters because:

- This number is based upon the meter accuracy factor for meters at 30 years of age. Many of the residential meters were installed in the 1940's, 1950's, 1960's, and early 1970's, which would most likely result in an even lower accuracy percentage.
- Some literature suggests that meters as old as 30 years of age may only be reading 81.6% of the flow (see Table 5-1). This would result in a correction factor of 1.23X, which would nearly double the difference between the metered sales and the meter age-corrected sales for meters in that range, as compared to the 1.12X factor used.

For commercial, industrial and institutional accounts, there is not as much of a discrepancy between the metered sales and the meter age-corrected sales because the meters are newer. Table 5-7 shows the meter age-corrected commercial, industrial, and institutional sales and the % difference.

Table 5-7 Commercial, Industrial and Institutional Sales for 2005-2007: Metered and Meter Age-Corrected

	Commercial			Industrial			Institutional		
Year	Metered Sales (MG/yr)	Corrected Sales (MG/yr)	% Differ-ence	Metered Sales (MG/yr)	Corrected Sales (MG/yr)	% Differ-ence	Metered Sales (MG/yr)	Corrected Sales (MG/yr)	% Differ-ence
2005	138.4	138.7	0.25	15.9	16.0	0.58	49.1	49.2	0.30
2006	168.5	168.8	0.19	144.2	145.0	0.54	58.9	59.2	0.45
2007	175.0	175.3	0.17	190.7	191.7	0.52	70.5	70.7	0.26

Because residential accounts are the vast majority (see Table 5-5) in the City of Somerville, the total metered water sales increased by approximately 1.5% as a result of applying the percent correction factors in Table 5-4. Table 5-8 shows the total meter age-corrected water sales and the percent difference.

Table 5-8 Total Water Sales for 2005-2007: Metered and Meter Age-Corrected

Year	Metered Sales (MG/yr)	Meter Age-Corrected Sales (MG/yr)	Difference (MG/yr)	% Difference
2005	1894.2	1920.9	26.7	1.41
2006	1844.4	1870.4	26.0	1.41
2007	1770.2	1795.1	24.9	1.41

It should also be noted that the difference between meter age-corrected sales and metered sales may be even higher as a result of the fact that 43% of the total meters were replaced during the time period analyzed. Therefore, some meters may have been under-reading the sales, but were replaced recently so no correction factors were applied to the sales for the older meter.

Section 6 Non-billed Estimates

Many of the non-billed estimates presented in this section are only for one particular calendar year. However, the assumption is made that water required/lost for each of hydrant flushing, fire fighting, street/sewer cleaning, and water main breaks over a long period is approximately the same from year-to-year. Therefore, for the purpose of this report, when non-billed water data is only available for one year, it will be assumed that the water volume required/lost is similar for other years.

6.1 Unmetered Accounts

There are 42 accounts in the City of Somerville that are unmetered, which are largely comprised of non-profit institutional accounts, specifically churches. To account for these users, a usage will be estimated for each account based upon meter size. In order to do this, all meters in the City of Somerville were categorized by size. The average and median water sales were then determined for each billing period (approximately 4 months). The results of this analysis are shown in Table 6-1.

Table 6-1 Median and Average Water Sales per Billing Period for Each Meter Size

Meter Size (in)	Median Usage (100 CFU)	Average Usage (100 CFU)
5/8	34	40
3/4	18	47
1	57	121
1 ½	91	176
2	230	344
3	372	601
4	973	1,462

To ensure that the results presented in Table 6-1 accurately represent the hypothetical sales for the 42 unmetered accounts on record, the churches that had meter records were analyzed. There are five metered churches in Somerville: International Church, Pentacostal Church of God, Evangelical Haitain Church, Tabernaculo Church, and Trinity Church of God, all of which have 5/8-inch meters. The median and average meter records per billing period for these accounts are 35-100CFU and 47-100 HCU, respectively. These numbers are very comparable to the median and average data for 5/8-inch meters presented in Table 6-1. Given that 30 of the 42 unmetered accounts are churches and that the metered churches have hypothetical sales similar to the numbers presented in Table 6-1, Table 6-1 can confidently be used to estimate the water sales for all of the unmetered accounts. The reason that all of the unmetered accounts are not

estimated by comparing them to similar metered accounts is that there were not enough comparable matches for the same type of user with a corresponding meter size.

Based on the results in Table 6-1, the average usage data more accurately reflects the usage of the unmetered accounts. These averages were multiplied by 3 (the number of billing periods) and applied to each of the unmetered accounts to obtain a total value for unmetered (and non-billed) water sales. The results of this analysis are displayed in Table 6-2.

Table 6-2 Estimated Sales of Water to Unmetered Accounts by Analyzing Meter Size

Meter Size (in)	No. of Meters	Sales Per Meter (100 HCU)	Sales by All Meters (MG)
5/8	14	120	1.3
3/4	5	141	0.5
1	12	363	3.3
1 1/2	4	528	1.6
2	6	1,032	4.6
4	1	4,386	3.3
All	**42**	**6,570**	**14.6**

The unmetered services with 1-1/2-inch meters are St. Joseph's Covenant Church, the Boys & Girls Club, the Greek Orthodox Church, and the Somerville Home for the Aged. The unmetered services with 2-inch meters are St. Anne's School, the Roman Catholic Church of Boston, the Little Sisters of the Poor, the YMCA, St. Bendict's School, and St. Anthony's School. Finally, the unmetered service with a 4-inch meter is also for the Little Sisters of the Poor.

In calculating the consumption of the unmetered accounts, it was assumed that the usage was similar to users that have meters of the same size. It should be noted that this assumption may under-represent the actual consumption by each of these users.

6.2 Hydrant Testing/Flushing—City Estimate

Hydrants are flushed/tested by either the Fire Department, contractors, or the Water Department.

The Fire Department performs regular flow tests to determine how much water is available for fire protection and to test the condition of and if there are closed valves in the water distribution system. They test approximately 1,525 hydrants per year and the Water Department approximates 250 gallons per hydrant flush. This equates to a total water volume loss of 381,250 gallons/yr.

Contractors perform hydrant testing to determine how much water is available for construction/development projects. The Water Department reports that there are approximately 30 flow tests of this kind per year, which require approximately 250 gallons per flush. This equates to a total volume of 7,500 gallons/yr of water loss.

Lastly, the Water Department is required to flush every city hydrant so that the increased flow flushes out rust and sediment deposits that invariably accumulate on the inside of distribution piping. All of the flushings in 2008 occurred between April 24th, 2008 and June 5th, 2008. A summary these flushings is presented in Table 6-3.

Table 6-3 Hydrant Flushing Data by the Water Department from April 24, 2008 to June 5, 2008

Date	# Hydrants	Time[1] (minutes)	Flow[1] (gpm)	Total Volume (gallons)	Volume/Hydrant (gallons)
24-Apr	16	45	50	36,000	2250
26-Apr	13	49	50	31,850	2450
1-May	7	42	50	14,700	2100
3-May	4	60	50	12,000	3000
7-May	13	65	50	42,250	3250
10-May	11	60	50	33,000	3000
15-May	14	55	50	38,500	2750
17-May	11	50	50	27,500	2500
22-May	26	50	50	65,000	2500
24-May	8	72	50	28,800	3600
25-May	4	54	50	10,800	2700
5-Jun	14	90	50	63,000	4500
				Total-403,400	**Average-2883**

1—Estimate from the Somerville Water Department

The sum of all three types of hydrant tests and flushings is 792,150 gallons/yr.

6.3 Fire Fighting—City Estimate

Another non-billed category of water usage is for fighting fires. In 2008, there were 26 fires in the City of Somerville, according to the Fire Department. The individual fires and an approximate estimate of the amount of water used to fight them are presented in Table 6-4.

Table 6-4 Water Usage for Fighting Fires in 2007

Date	Locations	Times	Time (min)	# Hydrants	Gallons[1]
1/1/2007	19-21 Vernon St	13:51-16:00	129	3	**18,000**
1/19/2007	1 Mossland St	20:46-21:46	60	2	**3,000**
3/3/2007	121 Temple St	06:27-09:45	198	8	**2,400**
3/25/2007	167 Highland Ave	01:45-02:22	37	2	**3,000**
3/29/2007	43 Foley St	12:04-12:59	55	2	**3,000**
4/2/2007	70R Innterelt Rd	12:04-12:59	55	1	**3,000**
4/14/2007	11 Lester Terrace	22:03-00:29	146	5	**20,000**
5/18/2007	13 Warwick St	18:30-19:22	52	2	**10,000**
5/25/2007	74 Jaquest St	10:47-12:38	111	5	**25,000**
6/13/2007	60 Winslow Ave	02:35-03:52	77	3	**25,000**
7/9/2007	26 Henderson St	22:14-01:15	181	4	**25,000**
7/12/2007	21 Pitma St	12:28-12:36	8	3	**15,000**
7/28/2007	20 Vernon St	07:12-09:51	159	4	**125,000**
8/3/2007	81 Walnut St	16:42-17:24	42	1	**1,000**
8/4/2007	1295 Broadway	18:04-20:07	123	4	**20,000**
8/18/2007	1 Watson St	12:18-13:09	51	1	**1,000**
9/1/2007	98 Central St	18:04-19:42	98	3	**15,000**
9/8/2007	51 Allen St	13:41-15:43	122	4	**75,000**
10/5/2007	21 Glenwood Rd	06:46-07:36	50	1	**1,000**
10/26/2007	238 Willow Ave	15:49-16:59	70	2	**10,000**
10/30/2007	338 Beacon St	15:28-16:26	58	1	**1,000**
11/2/2007	58 Oxford St	21:12-22:37	85	1	**1,000**
11/9/2007	90 Bartlett St	09:59-10:51	52	3	**15,000**
12/6/2007	11 Harvard Place	23:08-15:36	988	8	**1,440,000**
12/9/2007	350 Lowell St	02:44-04:46	122	1	**20,000**
12/24/2007	115 Pearl St	04:40-11:21	401	5	**100,000**
				Total	**1,977,400**

1—Estimate from the Somerville Water Department

6.4 Hydrant Testing/Flushing and Fire Fighting—CDM Estimates

Of the non-billed water estimates by the Somerville Water Department in sections 6.2-6.3, an area where there may be an even larger non-billed water volume is in the hydrant flow estimation. The Water Department estimated that the flow rate through a hydrant is 50 gpm; however, the actual flow through a hydrant is likely to be approximately 500 gpm. Further, the amount of water used to flush a hydrant is approximately 5,000 gallons, not 250 gallons. These new values can be applied to the following non-billed estimates: the fire hydrants flushed by the Fire Department, contractors, or the Water Department and the amount of water used for fighting fires.

- The Fire Department tests 1,525 hydrants in a year. If 5,000 gallons are used for each of these tests, then a total of 7.63 MG/yr of water would be flushed.
- There are approximately 30 flow tests performed by contractors. If 5,000 gallons are used for each of these tests, then a total of 150,000 gallons/yr would be flushed.
- For the Water Department flushings, if the flow column in Table 6-3 is changed (from 50 gpm to 500 gpm), then the total amount of water used is 4.03 MG/yr.
- Lastly, if one assumes that each hydrant used for fire fighting in Table 6-4 had a flow of 500 gpm, then the total amount of water used to fight fires would be 8.61 MG/yr.

This would increase the estimated amount of water used for hydrant testing/flushing and for firefighting from 2.4 MG/yr to 20.4 MG/yr.

6.5 Street and Sewer Cleaning

In the City of Somerville, street cleaning takes place between April 1st and November 30th, a period of 242 days. However, street cleaning is not performed every day by every street cleaner. The number of days and the amount of water that each street cleaner used in 2008 is presented in Table 6-5.

Table 6-5 Water Used in Street Cleaning

Days[1]	Street Cleaner ID	Tank Size (gallons)	# of fills[1]	Gallons Used per Day[1]	Total Gallons
140	#1	220	1	220	30,800
140	#2	220	1	220	30,800
140	#3	220	1	220	30,800
140	#4	220	1	220	30,800
24	WEEKEND TK	220	1	220	5,280
				Total	128,480

1—Estimate from the Somerville Water Department

Water is also used to clean the sewers. This cleaning is done year-round with vacuum trucks. A summary of the sewer cleaning water usage is shown in Table 6-6 below.

Table 6-6 Water Used in Sewer Cleaning

Weeks	Vac Truck ID	Tank Size (gallons)[1]	# of fills/week[1]	Gallons Used per Week	Total Gallons/year
52	#1	2,000	1	2,000	104,000
52	#2	2,000	0.25	500	26,000
				Total	**130,000**

1—Estimate from the Somerville Water Department

6.6 Traffic Islands and Parks

In the City of Somerville, there are traffic islands in the median between a few major roads (e.g. Broadway Ave). These islands have flowers and other greenery, which are watered regularly. Additionally, parks also use water for watering the lawns and flowers. As the city renovates parks and islands, it is required that meters are installed. In 2007, 24 of the 31 connections were metered. The consumption of these 24 meters was 3,699-100 CFU. If this is extrapolated to include all 31 meters, the total usage is 3.57 MG/yr.

6.7 Water Main Breaks

Another source of water loss is from breaks in the water main. Water mains break as a result of corrosion, age, and weather conditions. During summer months, the increased volume and pressure put stress on the water main. During winter months, the cold air, frost in the soil, and water temperatures can contribute to breaks. A list of all of the water main breaks in Somerville in 2008 is displayed in Table 6-7.

Table 6-7 Water Losses in 2008 from Water Main Breaks

Date	Location	Duration (mins)	GPM[1]	Water Lost (gallons)
1/5/2008	Somerville Housing	240	1,100	264,000
1/18/2008	155 Broadway	240	1,100	264,000
1/19/2008	689 Somerville Ave	240	1,100	264,000
1/24/2008	170 Highland Ave	240	1,100	264,000
1/24/2008	Mossland St	240	1,100	264,000
1/25/2008	2 Broadway	240	1,100	264,000
1/26/2008	Kennisington Ave	240	1,100	264,000
1/27/2008	787 Broadway	240	1,100	264,000
1/27/2008	Middlesex Ave & Cummings	1440	1,100	1,584,000
1/28/2008	Hawkins St	240	2,200	528,000
1/29/2008	9 Webster St	240	1,100	264,000
1/29/2008	33 Pearson	240	1,100	264,000
1/30/2008	399 Washington St	240	1,100	264,000
1/31/2008	Middlesex @ Rt 28	680	800	544,000
2/1/2008	145 Albion	240	1,100	264,000
2/2/2008	102 Curtis St	240	1,100	264,000
2/3/2008	54 Putnam St	240	1,100	264,000
2/10/2008	27 Fountain Ave	600	100	60,000
2/10/2008	Summer & Porter	240	1,100	264,000
2/15/2008	99 Albion St	240	1,100	264,000
2/16/2008	41 Lake St	240	1,100	264,000
2/24/2008	504 Broadway	240	1,100	264,000
2/24/2008	Foley St	4320	1,100	4,752,000
3/9/2008	429 Somerville Ave	240	1,100	264,000
3/10/2008	35 Hudson	240	1,100	264,000
3/30/2008	Chapel St	240	1,100	264,000
10/29/2008	Sturtevant, Mall Rd. Kensington	240	3,600	864,000
12/23/2008	Stop & Shop	2880	1,100	3,168,000
			Total	**17,044,000**

1—Estimate from the Somerville Water Department

6.8 Leakage

As discussed in *1.6 Leak Detection Surveys*, the two most recent leak detection surveys performed in the City of Somerville were completed on July 19, 2005 and June 29, 2007. It is assumed that every significant leak in the city was detected and repaired in each survey. Under these assumptions, there were 10 new leaks in the system between the first survey and the second survey. If it is further assumed that each of these leaks occurred approximately half-way between the first and second survey, then by halving the total daily volume of water loss from

the second survey (267,840 GPD), one can obtain a representative value of leakage in the City of Somerville (133,920 GPD) for any given period. This equates to an annual detectable leakage of approximately 48.9 MG/yr.

In addition to the leakage described above, there is a component of leakage that is "unavoidable", which are leaks that are too small to be detected or are uneconomical to repair. The International Water Association (IWA) described their approach towards calculating the Unavoidable Annual Real Losses (UARL) in the December 1999 issue of the IWA *AQUA* Magazine. The parameters used are presented in Table 6-8.

Table 6-8 Parameters for Calculating the Unavoidable Annual Real Losses (UARL) for a Water Distribution System

Infrastructure Component	Background (Undetectable) Losses	Reported Breaks	Unreported Breaks
Mains	8.5 gal/mi/hr	0.20 breaks/mi/year at 50 gpm for 3 days duration	0.01 breaks/mi/year at 25 gpm for 50 days duration
Service Lines (main to curb stop)	0.33 gals/service line/hr	2.25/1000 service line/year at 7 gpm for 8 days duration	0.75/1000 service line/year at 7 gpm for 100 days duration
Underground Pipes (curb stop to meter)	0.13 gal/service line/hr	1.51/1000 service line/year at 7 gpm for 9 days duration	0.50/100 service line/year at 7 gpm for 101 days duration

The IWA consolidated this information into a user-friendly chart shown in Figure 6-1.

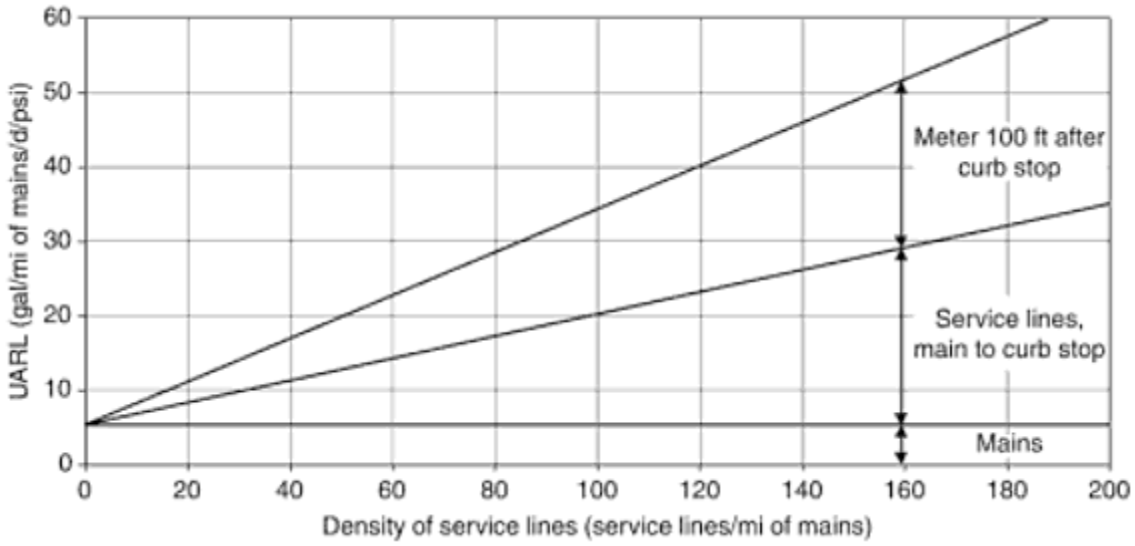

Figure 6-1. Chart displaying the Unavoidable Annual Real Losses (UARL) (gal/mile of mains/day/psi) of water compared with the density of service connections.

The density of service lines in the City of Somerville is: 13,856/(121 miles of Somerville main + 4 miles of MWRA main)=111 service lines per mile of main. It will be assumed that the distance of customer meters from the curb stop is approximately 20 ft (1/5th of the distance from the lower sloped line to the higher sloped line in Figure 6-1). Therefore, from Figure 6-1, the UARL number is approximately 27 gal/mi of mains/d/psi. It will further be assumed that the average operating pressure is 70 psi. The resulting unavoidable water loss is: 27 gal/mi of mains/d/psi*70psi*125 miles=86.2 MG/yr.

6.9 Summary of Non-Billed Water

A summary of all of the non-billed water estimates discussed in *Section 6* is shown in Table 6-9.

Table 6-9 Summary of Non-Billed Water Estimates from Section 6

Non-Billed Estimate	Water Volume (MG)
Unmetered Accounts	14.6
Fire Department Flushing	7.6
Water Department Flushing	4.0
Flow Tests	0.2
Fire Fighting	8.6
Street Cleaning	0.1
Sewer/Drain Cleaning	0.1
Traffic Islands & Parks	3.6
Main Breaks	17.0
Sub-Total w/out Leakage	**55.8**
Detectable Leakage	48.9
Unavoidable Leakage	86.2
Sub-Total Leakage Only	**135.1**
Total	**190.9**

Section 7 Summary of Findings

In this report the volume of water sold was analyzed from 2005-2007. This number was compared to the amount of water purchased (total water use) from the MWRA for the same years. A portion of Table 4-1 is shown below in Table 7-1.

Table 7-1 Summary of Water Purchased and Sold

Year	Total Water Use (MG)	Total Water Sales (MG)	Non-Billed Water (MG)
2005	2,337	1,894	423
2006	2,248	1,844	404
2007	2,282	1,770	512
3-year (rounded)	**2,290**	**1,840**	**450**

Because the volume of annual water sold varied significantly from the volume of water purchased, a number of different methods were undertaken to determine why such a deficit existed and to make corrections and adjustments where possible. These efforts are summarized in Table 7-2.

Table 7-2 Summary of Non-billed Estimates of Water Loss

	2005		2006		2007	
	MG	% of Non-billed	MG	% of Non-billed	MG	% of Non-billed
Non-Billed Volume	423		404		512	
Meter Age	26.7	6.3	26.0	6.4	24.9	4.9
Unmetered Accounts	14.6	3.5	14.6	3.6	14.6	2.9
Hydrant Flushing	11.8	2.8	11.8	2.9	11.8	2.3
Fire Fighting	8.6	2.0	8.6	2.1	8.6	1.7
Street Cleaning	0.1	0.0	0.1	0.0	0.1	0.0
Sewer/Drain Cleaning	0.1	0.0	0.1	0.0	0.1	0.0
Main Breaks	17.0	4.0	17.0	4.2	17.0	3.3
Traffic Islands & Parks	3.6	0.9	3.6	0.9	3.6	0.7
Sum of Non-Billed Estimates w/o leakage	**82.5**	**19.5**	**81.8**	**20.2**	**80.7**	**15.8**
Detectable Leakage	48.9	11.6	48.9	12.1	48.9	9.6
Unavoidable Leakage	86.2	30.4	86.2	21.3	86.2	16.8
Sum of Leakage	**135.1**	**31.9**	**135.1**	**33.4**	**135.1**	**26.4**
Total Non-Billed Estimates	**217.6**	**51.4**	**216.9**	**53.7**	**215.8**	**42.1**

Unaccounted-for-water is the difference between the non-billed water volume and the non-billed water volume estimates. However, per DEP guidelines and as defined in the Massachusetts Water Conservation Standards, both detectable and unavoidable leakage must be included within the unaccounted-for-water calculation. This calculation was performed for each year and the results are shown in Table 7-3.

Table 7-3 Unaccounted-for-water for 2005-2007

	2005	2006	2007	3-year (rounded)
Total Water Use (MG)	2,337	2,248	2,282	2,290
Non-Billed Water (MG)	423	404	512	450
Non-Billed Estimates w/o leakage (MG)	83	82	81	82
Unaccounted-for-Water (MG)	340	322	431	368
% Unaccounted-for-Water	15%	14%	19%	16%
Leakage Estimate (MG)	135	135	135	135
Leakage Estimate %	5.7%	6.0%	5.9%	5.9%

Unaccounted-for-water, which includes estimated leakage, may also be attributed to less accurate master meters, less accurate retail meters, accounting/meter reading errors, unauthorized connections, theft, and/or increased water loss for all non-billed estimates in *Section 5* and *Section 6*.

Section 8 Recommendations for Future Improvements

Of the efforts made to account for the non-billed volume of water, the five primary factors are meter age, unmetered accounts, leakage, main breaks, and hydrant use. For each of these different categories, Somerville is already in the process of lowering the water loss.

Meter Age: As discussed in *5.1 Meter Adjustment Percentages*, meters should be replaced after 20 years of use. In line with this recommendation, the City of Somerville is in the process of replacing every meter in the city, which would greatly reduce the percent of unaccounted-for-water.

Unmetered Accounts: Every consumer in a community's distribution system (including municipal buildings and parks) should be metered. It is up to the municipality as to whether all consumers should be billed, however, it is important that at least the water consumption is known so that cities and towns can better understand the unaccounted-for-water volumes. The City of Somerville is currently in the process of metering all users, including all public buildings and churches.

Leakage: All communities using MWRA water are required to perform leak detection and repair not less than every two years, as defined by Leak Detection Regulations 360 CMR 12.00. Formerly, the City of Somerville performed leak detection surveys every two years. However, in recent years, the city has started doing leak detection surveys every year. Further, they have been alternating between using digital correlation and sensors. By combining these two methods, the City of Somerville is ensuring that they are making every effort possible to detect and fix leaks in their distribution system. Any further leak detection efforts would be economically infeasible.

Main Breaks: If main breaks are occurring in a particular part of the town/city, then the water main in that area should be replaced. Given that main breaks in Somerville have been occurring throughout the water distribution system, replacing all the water mains is an impractical approach. However, the City of Somerville has made certain steps to ensure that the losses associated with particular breaks are as small as possible. For example, as part of the city's lead abatement program, many of the water main gates are being replaced. The new gates are now being used to control water loss during main breaks. In addition, over the past eight years Somerville has invested over $8.0 million in water main replacement and cleaning and lining projects through MWRA's Local Pipeline Assistance (interest-free loan) Program. The City has replaced over 7.5 miles of unlined cast iron water main and 1300 lead service connections, and cleaned and lined over 2.3 miles of previously unlined cast iron main.

Hydrant Use: Hydrant use includes water used for hydrant flushing and testing, fire fighting, and construction projects. For hydrant flushing and testing and for fire fighting, a log should be kept for the number of and the amount of time that each hydrant is on. For construction projects, the hydrants used should be equipped with meters to gauge the amount of water consumed. After the construction project is complete, the contractor should be billed for the amount of water used. The City of Somerville kept a record of all of these hydrant water volumes in 2008 and intends to continue this practice in future years.

In short, the City of Somerville is taking the necessary steps to reduce their unaccounted-for-water volume.

Appendix A DEP Forms 1-6

Somerville DEP Forms 1-6.xls

Additional supporting information for calculations, including voluminous spreadsheets containing billing and meter information, has been provided to MWRA and is available upon request.

FORM 1 - UNCORRECTED TOTAL WATER SUPPLY FROM SOURCES OF SUPPLY MASTER METER READINGS SOMERVILLE, MA

TOTAL ANNUAL AMOUNT **(in million gallons per year)**

YEAR	SOURCE 1	SOURCE 2	SOURCE 3	SOURCE 4	SOURCE 5	SOURCE 6	SOURCE 7	SOURCE 8	SOURCE 9	TOTAL	Comment
2005	178	724	396	465	404	43	126			2336	
2006	199	678	234	367	389	203	178			2248	
2007	200	629	316	350	382	104	301			2282	

TOTAL 6866

Avg. = Total divided by 3 = 2289 **Enter on Line 1 - Form 6 and Enter on Line 1 - Form 3**

FORM 2 - UNCORRECTED CUSTOMER METER RECORDS

TOTAL WATER SOLD
SOMERVILLE, MA

YEAR	RESIDENTIAL	INDUSTRIAL	COMMERCIAL	AGRICULTURAL	INSTITUTIONAL	OTHER	TOTAL
2005	1690.9	15.9	138.4		49.1		1894.3
2006	1472.8	144.2	168.5		59.9		1845.4
2007	1333.9	190.7	175.0		70.5		1770.1

Line a TOTAL 5509.8

Line b = Total divided by 3 = 1836.6

Enter on Line 4 - Form 6

CALCULATIONS

1	Total amount of water metered in system over the past three years (Line a _____)	5510
2	Average total amount of water metered over past 3 years (Line b = Line a/3 =_____)	1837
3	Estimate of total amount of water sold but not metered in past 3 years (Line c _____)	44
4	Average of the total amount of water sold but not metered over past 3 yrs. (Div. Line c by 3 = ___	15

Enter on Line 6 - Form 6

FORM 3 - PUMPING AND TREATMENT COSTS
SOMERVILLE, MA
Annual Costs for the past three (3) years

No.	Category	Year CY05 $	Year CY06 $	Year CY07 $	Total	Average = Total Divided by 3 $
1	Chemicals					
2	Fuel					
3	Electricity					
4	H2O Purchase					
5	Other	$4,628,469	$4,929,055	$5,266,400	$14,823,923	$4,941,308
				TOTALS	**Line a =**	

CALCULATIONS

Line 1	Average of the total amount of treated and pumped water supplied to the system over the past three years **Form Line a - Form 1**	**0**	
Line 2	If water is purchased, average of the amount purchased over the past three years **See Page 4**	**2289**	
Line 3	Total amount of water supplied from total of sources and total purchased **Add Lines 1 and 2**	**2289**	
Line 4	Average pumping and treating divided by the purchasing cost of water **Divide Totals - Line a (from above) by** Line 3	**$2,159**	**Enter on Line 15 Form 6**

FORM 4 - SOURCE METER ERROR ADJUSTMENTS TO THE TOTAL AMOUNT OF WATER SUPPLIED TO THE SYSTEM

Year 2005

No.	Meter Location	Meter Test Date	Calibration / Test	Meter Error % (+ or -)	times	Total Metered (gallons)		Adjustment in gallons (+ or -)
1	Boston Ave at Dearborn Rd				x	178.485	=	0.0
2	Broadway at Cedar St				x	724.16	=	0.0
3	Broadway at Willow Ave				x	395.66	=	0.0
4	Walnut St at Pearl St				x	465.375	=	0.0
5	Webster Ave at Columbia St				x	404.055	=	0.0
6	Alewife Brook Pkwy at Mystic Shops				x	43.07	=	0.0
7	Fellsway at Middlesex Ave				x	125.925	=	0.0
8					x		=	
9					x		=	
10					x		=	
11					x		=	
			AVERAGE PERCENT:		**TOTAL ADJUSTMENTS:**			0.0

Year 2006

No.	Meter Location	Meter Test Date	Calibration / Test	Meter Error % (+ or -)	times	Total Metered (gallons)		Adjustment in gallons (+ or -)
1	Boston Ave at Dearborn Rd				x	198.925	=	0.0
2	Broadway at Cedar St				x	677.805	=	0.0
3	Broadway at Willow Ave				x	233.965	=	0.0
4	Walnut St at Pearl St				x	366.825	=	0.0
5	Webster Ave at Columbia St				x	389.09	=	0.0
6	Alewife Brook Pkwy at Mystic Shops				x	202.575	=	0.0
7	Fellsway at Middlesex Ave				x	178.485	=	0.0
8					x		=	
9					x		=	
10					x		=	
11					x		=	
			AVERAGE PERCENT:		**TOTAL ADJUSTMENTS:**			0.0

Year 2007

No.	Meter Location	Meter Test Date	Calibration / Test	Meter Error % (+ or -)	times	Total Metered (gallons)		Adjustment in gallons (+ or -)
1	Boston Ave at Dearborn Rd				x	200.385	=	0.0
2	Broadway at Cedar St				x	629.26	=	0.0
3	Broadway at Willow Ave				x	315.725	=	0.0
4	Walnut St at Pearl St				x	349.67	=	0.0
5	Webster Ave at Columbia St				x	381.79	=	0.0
6	Alewife Brook Pkwy at Mystic Shops				x	104.025	=	0.0
7	Fellsway at Middlesex Ave				x	300.76	=	0.0
8					x		=	
9					x		=	
10					x		=	
11					x		=	
			AVERAGE PERCENT:	#DIV/0!	**TOTAL ADJUSTMENTS:**			0.0

CALCULATION

SOMERVILLE, MA

FORM 5 - DISTRIBUTION SYSTEM LARGE SERVICE METER ADJUSTMENTS

Year 2005

No.	Meter Location	Meter Test Date	Meter Size		Meter Error % (+ or -)		Total Metered (gallons)		Adjustment in gallons (+ or -)
1						x		=	
2						x		=	
3						x		=	
4						x		=	
5						x		=	
6						x		=	
7						x		=	
8						x		=	
9						x		=	
10						x		=	
11						x		=	
12						x		=	
			AVERAGE PERCENT:			TOTAL ADJUSTMENTS:			26.7

Year 2006

No.	Meter Location	Meter Test Date	Meter Size		Meter Error % (+ or -)		Total Metered (gallons)		Adjustment in gallons (+ or -)
1						x		=	
2						x		=	
3						x		=	
4						x		=	
5						x		=	
6						x		=	
7						x		=	
8						x		=	
9						x		=	
10						x		=	
11						x		=	
12						x		=	
			AVERAGE PERCENT:			TOTAL ADJUSTMENTS:			26.0

Year 2007

No.	Meter Location	Meter Test Date	Meter Size		Meter Error % (+ or -)		Total Metered (gallons)		Adjustment in gallons (+ or -)
1						x		=	
2						x		=	
3						x		=	
4						x		=	

FORM 6 - WATER AUDIT WORKSHEET SOMERVILLE, MA

Please place gallonage value in the Results in mgd column and perform calculations.

Line No.	DESCRIPTION	Description	FORM	LINE	(+ or -)	RESULTS
1	Uncorrected Total Water Pumped From Sources of Supply		1	Line 1		2289
2a	Adjustments toTotal Water Supply Master Meter Error		4	Line 2a		0.0
2b	Faulty valve controlling devices		Pg. 5	Line 2b		0
3	Corrected Total Water Supply **Add Lines 1, 2a and 2b)**	**Unadjusted Total (MG)**	**-**	Line 3		2289
4	Uncorrected Customer Meter Records Total Amount Sold		**2**	Line 4		1836
5a	Adjustments to Metered Water Sales - meter error		5	Line 5a		25.9
5b	Billing Procedure error		Pg. 6	Line 5b		0
6	Total Amount of Unmetered Water 'sold'		2	Line 6		15
7	CorrectedTtotal Quantity of WaterSold **Add Lines 4, 5a, 5b and 6**	**Adjusted Total (MG)**	**-**	Line 7		1877
8	Total amount of water not sold **Subtract Line 7 from Line 3**	**Unmetered (MG)**	**-**	Line 8		412
9	Total Unmetered Authorized Public Uses of Water **See Page 5**	**1-See Below**	Pg. 5	Line 9		24.2
10	Total Unmetered Miscellaneous Losses **See Page 5**	**2-See Below**	Pg. 5	Line 10		17
11	Total Identified Water Losses **Add Lines 9 and 10**	**Estimated (MG)**	**-**	Line 11		41.2
12	Total Unidentified Water Losses-**Subtract Line 11 from Line 8**	**UAW (MG)**	**-**	Line 12		371
13	Potential water system leakage in gpd per mile of watermain. **Divide Line 12 by 365 then divide by total system miles of watermain**	**Leakage(gpd)/mile**	**-**	Line 13		8394
14	Percentage of unaccounted for water that may be attributed to leakage **- Divide Line 12 by Line 3**	**UAW leakage %**	**-**	Line 14		**16.2%**
15	Pumping and treating cost per gallon of water **Line 4 on Form 3**	**$/MG**	**3**	Line 15		$2,159
16	Annual Expenditure Due to Unidentified Water Losses **Multipy Line 12 by 15**	**UAW Cost**				$800,424

1--Public Uses: Street Cleaning, Sewer Cleaning, Traffic Islands & Parks, Hydrant Testing/Flushing, Fire Fighting

2--Water Main Breaks

MASSACHUSETTS WATER RESOURCES AUTHORITY

QUINCY PILOT WATER AUDIT

FINAL REPORT

MAY 2009

GREEN INTERNATIONAL AFFILIATES, INC.
CONSULTING ENGINEERS MEDFORD, MA

AND

CDM

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Section 1 City of Quincy Background Information

1.1 Location and History

The city of Quincy is located southeast of Boston on the Neponset and Weymouth Fore Rivers. Quincy has a population of 91,622 according to the 2007 Quincy population census. There are about 17.0 sq miles of land area in Quincy. The city is primarily urban; however, 23% of the land area is within the uninhabited Blue Hills Reservation.

1.2 Water Supply System

Water is sold to the City of Quincy by the Massachusetts Water Resources Authority (MWRA), which provides water to 50 communities. The MWRA draws raw water from the Quabbin and Wachusett Reservoirs and the Ware River in central and western Massachusetts. The water is treated at the John J. Carroll Water Treatment Plant in Marlborough with ozone disinfection and the addition of chloramines. This water is then stored at a 115-million gallon, covered storage facility in Weston. Detailed information on the MWRA can be found at www.mwra.com. The City of Quincy has no water treatment facility. It relies entirely upon the MWRA system. Specifically, the Quincy distribution system is supplied by the MWRA Southern High (SH) service network, which supplies water to the southwestern sections of Boston and surrounding communities.

All water distributed to Quincy is metered by the MWRA at five locations, which are shown along with the meter size and installation date in Table 1-1.

Table 1-1 MWRA Meter Locations and Specifics

Meter No.	Location	Venturi Size (in)	Install Date
29	Adams St @ Beale St	24x8	1903
85	Beale St @ Summit Ave	16x8	1921
166	Furnace Brook Pkwy @ Copeland St	20x7.143	1957
199	West Squantum St @ Amsterdam	20x11.377	1975
334	Furnace Brook Pkwy @ Adams St	8.33x5.8	2004

Average daily flows for the Quincy master meters are shown in Table 1-2.

Table 1-2 Average Annual MWRA Meter Flows for 2001-2008 in MGD

Meter No.	2001	2002	2003	2004	2005	2006	2007	2008
29	0.971	1.037	1.103	1.183	1.300	1.645	1.864	1.710
85	3.126	3.137	3.331	3.640	3.136	2.751	2.808	2.535
166	2.748	2.622	2.771	1.140	1.690	2.208	2.245	2.049
199	2.574	2.548	2.578	2.697	2.847	2.490	2.540	2.634
334				0.915	1.127	0.771	0.845	0.685
Total	**9.419**	**9.344**	**9.783**	**9.575**	**10.10**	**9.865**	**10.30**	**9.613**

As shown in Table 1-1, master meter #334 was installed in 2004, which is why there isn't any data available from 2001-2003 in Table 1-2. Table 1-3 compares the size of each meter with the 2005-2007 average flow and the 2007 peak and minimum flow.

Table 1-3 MWRA Meter Size Compared with Average, Peak, and Minimum Flow

Meter No.	Meter Size (in)	2005-2007 Average Flow (MGD)	2007 Minimum Flow (MGD)	2007 Peak Flow (MGD)
29	24x8	1.603	1.0	2.5
85	16x8	2.898	1.7	3.7
166	20.x7.143	2.048	0.8	4.1
199	20x11.377	2.626	1.5	4.3
334	8.33x5.8	0.914	0.0	2.1

During the night and at mid-day, meter #334 goes to zero flow. This meter is equipped with a check valve, so one can assume the zero flow reading is accurate, rather than the venturi meter not reading a flow outside of its reading range.

Per MWRA guidelines, each of these meters is routinely calibrated and tested to ensure accuracy. The most recent meter calibrations and tests are shown in Table 1-4.

Table 1-4 MWRA Master Meter Calibration and Test Results

Meter No.	Last Calibrated	Last Tested	Pitot Flow	Meter Flow	% Difference
29	10/28/08	4/22/08	1.15	1.13	**2%**
85	8/20/08				
166	10/17/08	4/22/08	1.87	1.85	**1%**
199	10/31/08	4/22/08	2.67	2.55	**4%**
334	10/17/08	4/23/08	0.61	0.60	**2%**
		Total	**6.30**	**6.13**	**3%**

Meter #85 has no gauging point and cannot be tested. Of the remaining meters, every meter was within MWRA's 5% difference guideline. In total, the 4 meters tested were within 3% of the metered flow.

The MWRA charges a standard wholesale rate for the volume of water supplied to all 50 communities it services. This rate is reassessed at the end of each fiscal year (July 1-June 30). Table 1-5 shows the wholesale rate for FY05 to FY09.

Table 1-5 Wholesale Water Rate from MWRA per Million Gallons (MG) of Water

Fiscal Year	Cost ($/MG)
2005	1,794.17
2006	2,168.56
2007	2,216.72
2008	2,398.88
2009	2,514.49

In addition to servicing Quincy's water, MWRA fully services Quincy's wastewater needs. To calculate the annual wholesale sewer charge, MWRA meters the total wastewater flow and also utilizes additional rate parameters including total and sewered population. Sewer wholesale rates for FY05 to FY09 are shown in Table 1-6.

Table 1-6 Quincy's Wholesale Sewer Rates from MWRA per Million Gallons

Fiscal Year	Cost ($/MG)
2005	2,547.61
2006	2,603.20
2007	2,652.84
2008	2,788.28
2009	2,887.13

The retail water and sewer rate structure is discussed in *1.7 Retail Water/Sewer Rate Structure*.

1.3 Water Distribution System

Within the City of Quincy, the distribution system is divided into a main service system and four high service systems. The main service system supplies water to the majority of the city, while the four high service systems supply water to areas of high ground elevation: Penn's Hill, Pine Hill, Quarry Street, and Ricciuti Drive. There are two storage facilities used to maintain stable pressures and provide sufficient water for fire protection in these high service areas. These facilities are shown in Table 1-7.

Table 1-7 Water Distribution Storage Facilities

Storage Facility	Service System	Year Built	Capacity (MG)
Quarry Street Standpipe	Quarry Street	1976	1.0
Ricciuti Drive Elevated Tank	Ricciuti Drive	1974	1.0

The water distribution system consists of approximately 237 miles of piping, ranging in diameter from 4-inch to 20-inch water mains; however, the majority of piping is 12-inch in diameter or smaller. Table 1-8 shows the pipe size distribution of the system.

Table 1-8 Pipe Size Data

Diameter (in)	Length (mi)	Percent of Total
4	5.7	2%
6	96.8	41%
8	69.7	29%
10	18.2	8%
12	33.3	14%
16	9.8	4%
20	3.4	1%
Total	**236.9**	**100%**

1.4 Water Meters

The Quincy Water Department now serves approximately 21,900 individual service connections. A breakdown of the number of meters by size is presented below in Table 1-9.

Table 1-9 Number of Meters per Size

Meter Size (in)	No. of Meters
5/8	20,091
¾	587
1	219
1.5	223
2	327
3	95
4	67
6	9
8	3
10	2
Unknown	300
Total	**21,923**

1.5 Non-billed Water

Non-billed water is the difference between the total water use (water purchased from MWRA) and the total water sales (retail sales to water customers). It is a result of unmetered municipal

usage (e.g. facilities, water main flushing, fire fighting), metering inaccuracies, accounting errors, leakage, etc. The Quincy Water Department projects a non-billed percentage of approximately 18-19%.

1.6 Leak Detection Surveys

The City of Quincy performs leak detection in-house and with the help of private contractors. The most recent leak detection survey performed by a private contractor was completed on February 16, 2004 by Heath Consultants Inc. This survey found a total of 52 leaks: 13 main leaks, 14 service leaks, and 23 hydrant/valve leaks. Results of the 2004 survey are shown in Table 1-10.

Table 1-10 Leaks Identified by Heath Consultants Inc in 2004 (Continued on Next Page)

Type	Location	Estimated Leakage (GPD)
Service	1000 Southern Artery	**57,600**
Hydrant	91 Sheldon Rd	**1,440**
Hydrant	16 Farrell St	**1,440**
Service	26 Mt Ararat St	**7,200**
Service	Reardon St @ St Mary's Church	**21,600**
Main	1206 Furnace Brook Parkway	**5,760**
Hydrant	160 Suomi Rd	**1,440**
Main	220 West St	**8,640**
Service	63 Robertson St	**7,200**
Main	89 Robertson St	**28,800**
Service	74 Connell St	**4,320**
Service	26 Connell St	**2,880**
Service	84 White St	**4,320**
Service	Chestnut St @ Revere Rd	**2,880**
Hydrant	East Squantum St @ 58 Pole	**1,440**
Hydrant	15 Aberdeen Rd	**1,440**
Valve	29 Common St	**2,880**
Service	11 Atherton St	**5,760**
Main	Graham Ter @ Steward St	**36,000**
Hydrant	16 Sixth Ave	**1,440**
Hydrant	25 Mound St	**1,440**
Main	Curtis Ave @ 47 Baxter Ave	**20,160**
Hydrant	Follett St @ Beechwood St	**2,880**
Hydrant	Washington Ct @ 1 Lawn Ave	**1,440**
Main	155 Rock Island Rd	**28,800**
Hydrant	115 Intervale St	**1,440**
Hydrant	Faxon Rd	**4,320**
Hydrant	Hillside Ave @ Pine St	**1,440**
Hydrant	Newport Ave @ 14 Morgan Rd	**1,440**
Main	Quincy Shore Dr @ Sea St	**14,400**

Hydrant	88 Highland Ave	**1,440**
Hydrant	150 Fayette St	**7,200**
Hydrant	208 Wilson Ave	**1,440**
Hydrant	354 Elmwood Ave	**1,440**
Hydrant	Berkshire St @ Ardell St	**2,880**
Main	Lancaster St @ Grafton St	**57,600**
Main	Newcomb St @ Francis St	**14,400**
Service	80 Independence Ave	**17,280**
Main	38 Lunt St	**21,600**
Service	1200 Crown Colony	**14,400**
Main	Billings Rd @ Ap	**1,440**
Hydrant	11 Burgess St	**1,440**
Hydrant	231 Beach St	**1,440**
Hydrant	Calumet St @ Vassell St	**1,440**
Service	59 Cheriton St	**20,160**
Service	18 W Elm Ave	**10,080**
Service	86 Darrow St	**8,640**
Main	40 Stoughton St	**24,480**
Main	E Squantum St @ Victory Rd	**17,280**
Service	39 Milton Rd	**7,200**
Hydrant	Samoset Ave @ Virginia Rd	**1,440**
Hydrant	148 Squanto Rd	**1,440**
	Total Leakage	**518,400**

The locations of these 52 leaks are shown in Figure 1-1.

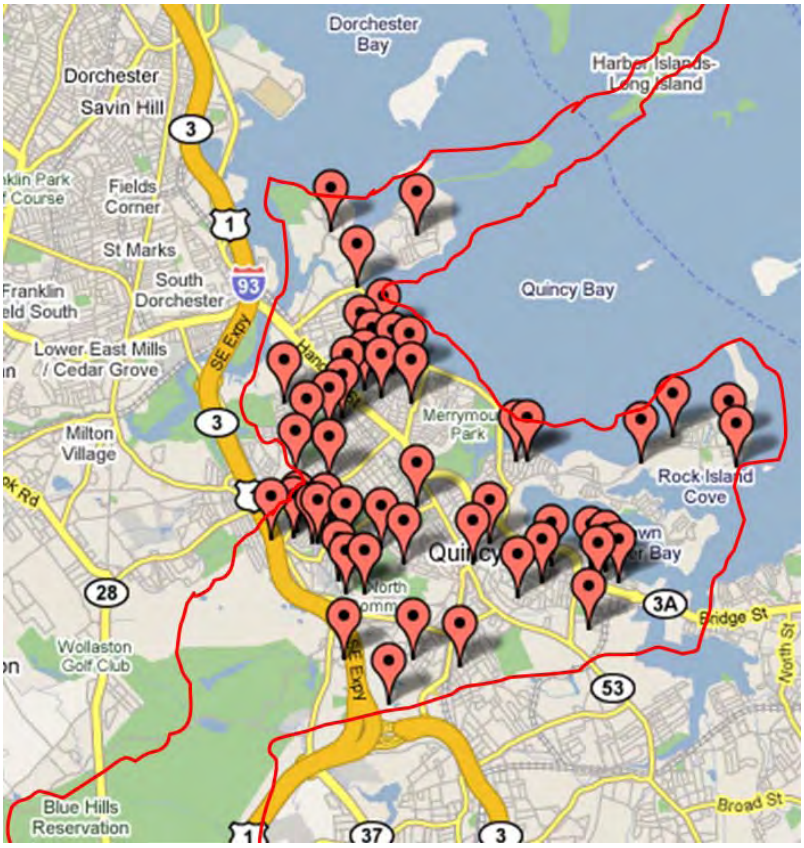

Figure 1-1. Location of the 52 leaks in the 2004 Leak Detection Survey. The outline shows the approximate city limits.

The most recent leak detection efforts performed in-house by the City of Quincy were completed in the summer of 2007 and totaled 34 leaks. Results of this survey are shown in Table 1-11.

Table 1-11 Leaks Detected by the City of Quincy in 2007

Leak Detection Type	Number	Estimated Leakage (GPD)
Main	14	243,400
Service	14	79,300
Hydrant/Valves	6	14,300
	Total Leakage	**337,000**

The in-house surveys are done with leak noise correlators and listening devices. The entire city is covered approximately every 2 years. Additionally, the Quincy Water Department intends to continue to hire private contractors to perform leak detection and plans on having such a survey completed in 2009.

1.7 Retail Water/Sewer Rate Structure

The retail water and sewer rates in the City of Quincy are a fixed rate independent of the degree of usage. These rates are reassessed at the end of each fiscal year and sometimes even more frequently than that. Similar to the MWRA, the fiscal year for the City of Quincy is July 1st through June 30th. For example, the 2005 fiscal year is from July 1, 2004 to June 30, 2005. Table 1-12 shows the retail water rates for FY05 to FY09.

Table 1-12 Retail Water Rates for 2005-2009

Fiscal Year	Rate ($/HCF)
2005	2.93
2006	3.26
2007	3.46
2008	4.26
2009	4.31

For the 2007 fiscal year, the water retail rate was reassessed mid-year.

In 2005, the City of Quincy offered a 25% discount for water for elderly and/or low income residents. Additionally, in 2007, metered accounts were charged a minimum bill of $13.80.

In the City of Quincy sewer usage is based upon the metered water usage. Also, the city does not allow irrigation meters for water use that does not return to the sewer. Table 1-13 shows the sewer rates for FY05 to FY09.

Table 1-13 Retail Sewer Rates for 2005-2009

Fiscal Year	Rate ($/HCF)
2005	6.93
2006	7.97
2007	8.61
2008	9.84
2009	9.94

Table 1-14 shows the combined water and sewer rates for FY05 to FY09.

Table 1-14 Retail Combined Water and Sewer Rates for 2005-2009

Fiscal Year	Rate ($/HCF)
2005	9.86
2006	11.23
2007	12.07
2008	14.10
2009	14.25

Lastly, rates are the same for all accounts, regardless of category.

Section 2 Review of Billing and Accounting Procedures

Water Department staff record meter readings using several different methods:

- The large meters (meters that are 1-1/2-inch or larger) are equipped with radio chips for remote readings. In order to read these chips, a sensor needs to be within a particular distance of the meter (approximately 1 mile). Every month a car—with the remote reading sensor—is driven around the city to each meter location to download the readings. This takes one day. There are approximately 774 meters of this kind, which service the commercial/industrial accounts. There are also approximately 130 radio chips of this kind in domestic meters.

- The remaining meters are read by physically reading the meters from one of two kinds of outdoor sensors: copper pins or touchpad boxes. The older meters have copper pins, which connect to the indoor meter. A hand-held apparatus is physically connected to this copper pin, which records the meter reading through a radio frequency. Newer meters have outdoor touchpad boxes. These meters are read with the same apparatus as the copper pins; however, it is a different connection on the apparatus. There are 6 reading routes for these remaining meters, 2 of which are read every month, resulting in quarterly readings on these smaller meters (less than 1-1/2-inch). These readings are performed every day.

- There are also several hundred meters that are read by hand and recorded in meter books.

The day after readings are taken, quality control measures are implemented. There are two scenarios that result in a visit by a Water Inspector:

- If the water sales have increased/decreased by 75-80%

- If there is a 0 bill

Repairs are done daily, so if the Water Inspector determines that there is a faulty meter or leak, the problem is addressed immediately. In the event that a meter cannot be read, the bill is estimated based on the 4 prior billing periods.

Five days before the bill date, the head of the billing department spools all of the bills and the IT group does the printing. Bills are then mailed through a mailing company. Users have 30 days to pay, from the date of the bill, and the Quincy Water Department ensures that the 30th day

from the date of the bill is a weekday, so that users have the longest amount of time to pay. Late bills are charged 14% interest, which begins to accrue the day after the bills are due. Payments are made to a warehouse associated with the Water Department or they can be sent to the Collector's office.

The City of Quincy is looking into the possibility of installing new automatic remote reading (AMR) meters, but they would like to try a pilot program before implementing any city-wide changes.

Section 3 Water Sales

3.1 Background Information

The accounts in the Quincy meter sales system do not have a description (e.g. Quincy High School). Therefore, it is not possible to definitively determine water sales on a category basis (e.g. residential, commercial, industrial, institutional). For the purpose of this report, it will be assumed that all meters ¾-inch in diameter or smaller are residential meters. On the other hand, all meters larger than ¾-inch in diameter will be categorized as commercial/industrial meters. Institutional accounts will not be distinguished, as the meter size associated with these accounts is not easily divisible. Water sales totals for 2006-2008 were calculated two distinct ways: from individual meter records and from billing records. These two sets of data were summed by category and are presented in Table 3-1.

Table 3-1 Water Sales Totals by Category in MG/yr

	Residential		Commercial/Industrial		Totals		
Year	Billing Records	Meter Records	Billing Records	Meter Records	Billing Records	Meter Records	% Difference
2006	1,904	2,036	765	925	2,668	2,961	**-11**
2007	1,758	1,794	868	808	2,626	2,603	**1**
2008	1,633	1,830	1,191	961	2,823	2,791	**1**

The metered water sales totals are similar to the values calculated from the billing records provided by the Quincy Water Department, as shown in Table 3-1. For the purpose of this report, the billing records values will be used, which include municipal uses (e.g. schools, parks, lawns, etc.). The discrepancy that does exist between the water sales data is likely due to duplicate data sets, estimated bills, and the difference in time between when meters are read and when bills are sent out. CDM deleted any identical meter records that could be found from the data set, however, the possibility remains that some duplicate meter records still exist, which would increase the sum of the metered water sales. Also, as described in *Section 2*, there is a lag period from when a meter is read until the bill is processed, which would differentiate the meter and billing annual totals. For example, a meter that was read on 12/15/2007 would be on the 2007 meter record total, but would appear on the 2008 billing record total.

A graphical representation of the billing record data shown in Table 3-1 is shown in Figure 3-1.

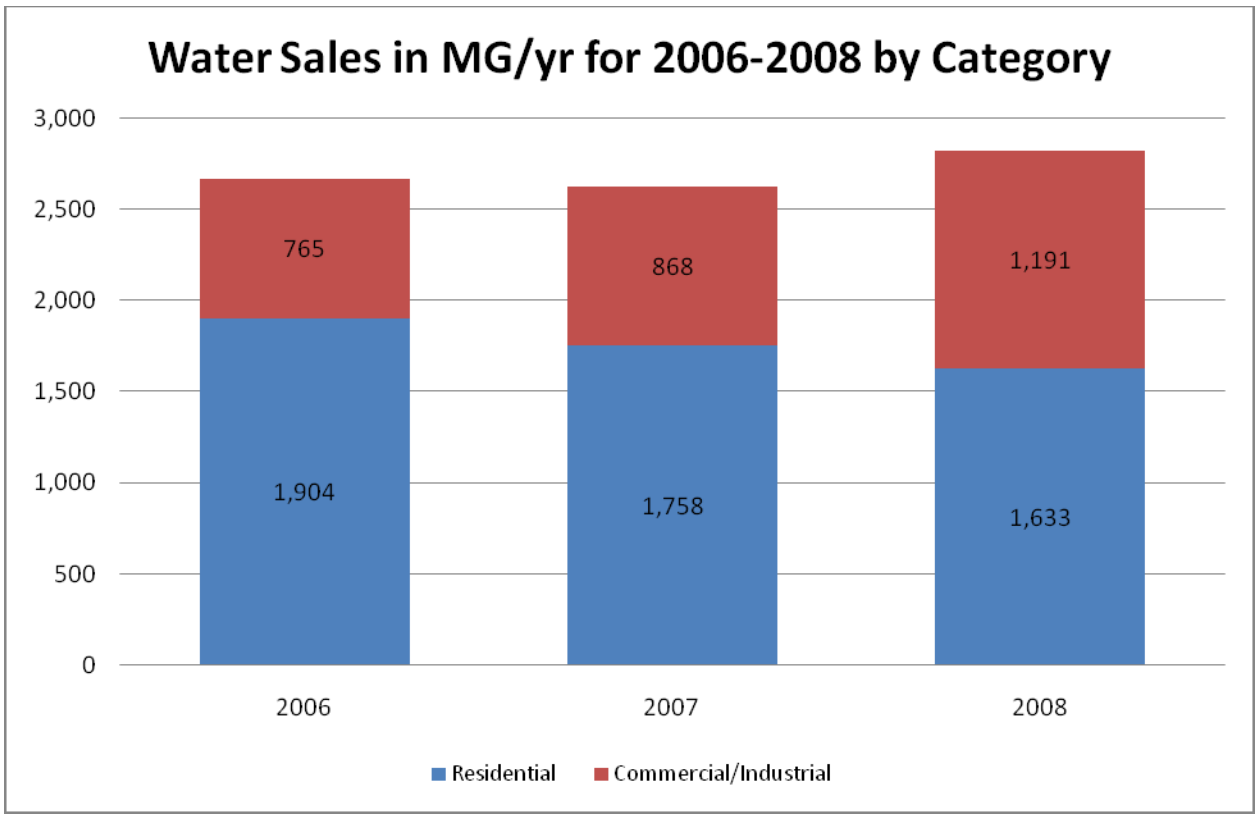

Figure 3-1. A graphical view of the categorical water sales from 2006-2008 in MG/yr from billing records.

Figure 3-1 will be discussed in more detail in Sections *3.2 Residential Water Accounts* and *3.3 Non-Residential Accounts*.

The largest 10 consumers in 2008 are displayed in Table 3-2.

Table 3-2 Largest 10 Water Consumers in 2008

Account Description	Address	Water Sales (MG/yr)
Park/Lawn	Wharf St	113
Park/Lawn	Moon Island	63
Loading Docks on Harbor	760 Washington St	60
Amrcon A Modern (Construction)	147 Sea Avenue	28
Park/Lawn	31 Tilden Common Dr	23
Park/Lawn	1 Bridge St	20
Mass Military Research Center	97 East Howard St	19
Blue Cross Blue Shield	1 Enterprise Dr	16
Marriott Quincy Hotel	1,000 Marriott Dr	14
Quincy Housing Authority	80 Clay St	10

3.2 Residential Accounts

As seen in Figure 3-1, the residential water sales displayed a discernable downward trend from year to year: the annual water sales (using billing records) decreased from 1,904 MG in 2006 to 1,758 MG in 2007, and 1,633 MG in 2008. This reduction of 14 percent residential water use resembles the behavior seen in the total MWRA water sales, which has been decreasing in recent years. Possible reasons for the varying sales include: increases in water and sewer rates, increased conservation efforts, a reduction in active meters due to demolition of residential properties, unbilled accounts, and theft.

The Massachusetts Water Resources Commission's State Water Conservation Standards advise communities to have a Residential Gallons Per Capita Day (rgpcd) water consumption of no more than 65. Based on the census population data for 2007 (referenced in *1.1 Location and History*) and the residential water usage data for 2007 in Table 3-1, the rgpcd number in Quincy is 53.6, which meets the benchmark. For the Water Audit, Quincy's residential water use was estimated based on meter size, which may be inaccurate. Future efforts by Quincy to categorize water accounts into residential, commercial, industrial, institutional, municipal, etc. would help to better quantify residential per capita use.

3.3 Non-Residential Accounts

Non-residential water sales (using billing records) follow the opposite behavior as the residential and total water sales; however, the highest total sales were in 2008. Over the 3-year span, the sales increased from 765 MG in 2006 to 868 MG in 2007, and 1,191 MG in 2008; an overall increase of 56 percent.

Section 4 Non-Billed Water Volume and Cost

Table 4-1 shows a comparison between the amount of water purchased (total water use, see Table 1-2) and the amount of water billed (see Table 3-1) in the City of Quincy for 2006-2008.

Table 4-1 Water Usage and Non-Billed Water Consumption

	Water Purchased (MG)	Water Billed (MG)	Water Non-Billed (MG)	% Non-Billed
2006	3,601	2,668	933	26%
2007	3,760	2,626	1,134	30%
2008	3,509	2,823	686	20%

Exactly how much this non-billed water volume is costing the City of Quincy depends on where this non-billed water is going. The minimum that the non-billed water would cost the city would be if the water was lost to leaks and to municipal uses where the water did not return to the sewer. Under this scenario, the amount that the non-billed water would cost the city would be based upon the wholesale water rate. If the non-billed water was used for municipal uses and did return to the sewer, then the cost to the city would be based upon the sum of the wholesale water rate and the wholesale sewer rate. By including the wholesale sewer rate, the cost is increased by approximately 120%, as can be seen by comparing the wholesale water and sewer rates in Table 1-5 and Table 1-6. The maximum that the non-billed water would cost the city would be if the water was lost to meter inaccuracies and unmetered accounts. Under this scenario, the city would be paying MWRA the wholesale water and sewer rates for the non-billed water and they would also be losing revenue based upon the combined water and sewer retail rates. Therefore, the maximum amount that the non-billed water could cost the city is based upon the sum of the wholesale water rate, the wholesale sewer rate, and the combined retail water and sewer rate. The range of the amount that the non-billed water costs the city is presented in Table 4-2.

Table 4-2 Range of Costs of Non-billed Water for 2006-2008

Year	Non-Billed Water (MG)	Minimum/Whole-sale Water Cost ($)	Wholesale Sewer Cost ($)	Retail W&S Cost ($)	Maximum Cost ($)
2006	933	2,045,733	2,451,943	14,529,408	19,027,084
2007	1,134	2,617,045	3,085,115	19,834,768	25,536,928
2008	686	1,685,286	1,946,666	12,998,329	16,630,281

In order to create Table 4-2, calendar year wholesale and retail water and sewer rates were needed. The wholesale costs in Table 1-5 and Table 1-6 and the retail costs in Table 1-14 (both

based on the fiscal year) were manipulated to achieve representative calendar year costs. For example, the 2006 fiscal year (July 1, 2005 – June 30, 2006) data was averaged with the 2007 fiscal year (July 1, 2006 – June 30, 2007) data to achieve a number that closely approximated the wholesale and retail cost of water in 2006. These numbers were then applied to the non-billed water volume to achieve annual costs.

Section 5 Meter Adjustment Percentage Estimate

5.1 Meter Adjustment Percentages

Meters generally become more inaccurate with age. The degree of inaccuracy depends on a number of variables related to the meter: instantaneous flow, cumulative usage, and the manufacturer. Because there are so many factors, studies generally report varying inaccuracy numbers associated with meter age. Table 5-1 shows a summary of the decline in accuracy with age.

Table 5-1 Summary of Meter Accuracy Percentages with Respect to Meter Age

Organization	WATER/Engineering & Management	Dept of Civil Eng. at WPI	AWWA	Journal AWWA	
Author	Attender	Westerling, Hart	Hill, Davis	Yee	
Meter Age				Brass Valve	Plastic Valve
0		97.4	100	100	100
5		95.1	99.0	99.7	98.3
10		92.7	98.1	99.3	96.8
15	99.4	90.4	97.2	99.0	95.1
20	99	88.1	96.3	98.8	93.5
25	95.8	85.8	95.4	98.5	
30	81.6	83.4	94.5	96.6	

A value of 100% indicates that a meter is reading perfectly. A value of 95% suggests that a meter is only reading 95% of the water through the meter. Generally in Table 5-1, the accuracy percentages from the various literary sources for newer meters agree, while the accuracy percentages for older meters do not agree. In order to achieve the most representative accuracy percentage values for each meter age listed in Table 5-1, outliers were removed and only brass valves were considered (i.e. the plastic valve column by Yee was not included). The remaining inaccuracy percentages were averaged. For example, to calculate the percent accuracy value for a 15-year old meter, both Westerling and Hart's value of 90.4% and Yee's plastic valve value of 95.1% were removed. The remaining 3 numbers were averaged to achieve a percent accuracy value of 98.5%. This method was used for every meter age in Table 5-1, except for 30-year old meters. In this case, two of the sources indicated a percent accuracy number in the low-80's, while the other two sources indicated a percent accuracy number in the mid-90's. To achieve a

representative value, all four of these values were averaged. The resulting accuracy percentage values are displayed in Table 5-2.

Table 5-2 Individual Meter Accuracy Percentages with Respect to Meter Age

Meter Age (years)	% Accurate
0	100
5	99.4
10	98.7
15	98.5
20	98.0
25	96.6
30	89.0

This summary suggests that there is a large drop-off in terms of accuracy in meters older than 25 years of age. This trend is supported by the fact that many organizations and regulatory authorities recommend replacing meters after 20 years of use.

5.2 Meter Age in Quincy

A summary of the age of meters in Quincy is presented in Table 5-3 below.

Table 5-3 Summary of Meter Installation Dates

Install Date Range	Frequency	%
pre-1970	11,501	52.5
1970-1974	0	0.0
1975-1979	5	0.0
1980-1984	4	0.0
1985-1989	223	1.0
1990-1994	114	0.5
1995-1999	4,093	18.7
2000-2004	2,721	12.4
2005-12/8/2008	3,252	14.8
No Date	10	0.0
Total	21,923	100

All of the meters listed as "pre-1970" in Table 5-3 have an installation date of 12/31/1967, which indicates that the date of those installations was sometime before 12/31/1967, when the Water Department started keeping track of meter installation dates. This represents the majority of the meters in the City of Quincy, or 52.5%. Of the remaining meters, most were installed in the past 15 years.

5.3 Application of a Percent Correction to Individual Meters

To understand how significantly the percent accuracy numbers in Table 5-2 affect the non-billed water values in Quincy, the percent accuracy numbers were applied to individual meters. In order to do this, Table 5-2 was modified to create Table 5-4 and achieve representative meter age ranges to apply the percent accuracy numbers.

Table 5-4 Meter Age Ranges for Percent Inaccuracy Values

Meter Age Range (years)	Meter Date Range	% Accurate
0-2.5	7/1/2006-1/1/2009	100
2.5-7.5	7/1/2001-7/1/2006	99.4
7.5-12.5	7/1/1996-7/1/2001	98.7
12.5-17.5	7/1/1991-7/1/1996	98.5
17.5-22.5	7/1/1986-7/1/1991	98.0
22.5-27.5	7/1/1981-7/1/1986	96.6
>27.5	<7/1/1981	89.0

To apply the age-correction percentage, the meters were sorted by category, then by age. Using the date ranges in Table 5-4, percent correction values were applied by multiplying the usage data by the reciprocal of the accuracy numbers. For example, if a meter was installed on 7/13/1983 and had a quarterly usage of 57 HCF for a certain period, the age-corrected usage was calculated as 59 HCF (57 HCF *1/0.966). As a result of the vast discrepancy of meter age in Quincy (approximately half of the meters being >30 years old and half of the meters installed in the past 15 years), some meter readings will be significantly adjusted, while others will only be moderately adjusted.

These percent corrections affect certain meter categories (e.g. residential, commercial) more than others. A breakdown of the meter age by category is presented in Table 5-5.

Table 5-5 Meter Installation Dates by Category

	Residential		Commercial/Industrial		All Accounts	
Install Date Range	**Frequency**	**%**	**Frequency**	**%**	**Frequency**	**%**
<1970	11,107	53.7	394	31.6	11,501	52.5
1970-1974	0	0.0	0	0.0	0	0.0
1975-1979	5	0.0	0	0.0	5	0.0
1980-1984	4	0.0	0	0.0	4	0.0
1985-1989	221	1.1	2	0.2	223	1.0
1990-1994	107	0.5	7	0.6	114	0.5
1995-1999	4,004	19.4	89	7.1	4,093	18.7
2000-2004	2,696	13.0	25	2.0	2,721	12.4
2005-12/8/2008	2,527	12.2	725	58.2	3,252	14.8
No Date	7	0.0	3	0.2	10	0.0
Total	20,678	100	1245	100	21,923	100

Based on the information in Table 5-5, the residential meters are older than the commercial/industrial meters: 54% of the residential meters were installed prior to 1970, compared with 32% of commercial/industrial meters. Additionally, 58% of the commercial/industrial meters were installed in the previous 4 years, compared with only 12%of the residential meters. As a result of this discrepancy, the meter age-corrected sales are going to more heavily impact the residential accounts compared to the commercial/industrial accounts. Table 5-6 shows the corrected residential sales and the percent difference.

Table 5-6 Residential Water Sales for 2006-2008: Metered and Meter Age-Corrected

Year	Metered Sales (MG/yr)	Corrected Sales (MG/yr)	% Difference
2006	2,036	2,160	6.1
2007	1,794	1,904	6.2
2008	1,830	1,943	6.2

For each year analyzed, the meter age-corrected residential water sales are over 6% more than the metered sales; however, the adjustment could be even more significant. As noted previously, the age-correction factor (1.12X=1/0.89) for meters installed before 7/1/1981 could be significantly higher for residential meters because:

- This number is based upon the meter accuracy factor for meters at 30 years of age. Many of the residential meters could have been installed as much as 80 years ago, which would most likely result in an even lower accuracy percentage.

- Some literature suggests that meters as old as 30 years of age may only be reading 81.6% of the flow (see Table 5-1). This would result in a correction factor of 1.23X, which would nearly double the difference between the metered sales and the meter age-corrected sales for meters in that range, as compared to the 1.12X factor used.

For commercial/industrial accounts, there is not as much of a discrepancy between the metered sales and the age-corrected sales because the meters are newer. Table 5-7 shows the age-corrected commercial/industrial sales and the percent difference.

Table 5-7 Commercial/Industrial Sales for 2006-2008: Metered and Meter Age-Corrected

Year	Metered Sales (MG/yr)	Corrected Sales (MG/yr)	% Difference
2006	925	938	1.4
2007	808	819	1.4
2008	961	973	1.2

As seen in Table 5-7, the commercial/industrial accounts only increased 1.2-1.4%.

Because residential accounts are the majority (see Table 5-5) in the City of Quincy, the total metered water sales increased by approximately 4.5% as a result of applying the percent correction factors in Table 5-4. Table 5-8 shows the total age-corrected water sales and the percent difference.

Table 5-8 Total Water Sales for 2006-2008: Metered and Meter Age-Corrected

Year	Metered Sales (MG/yr)	Meter Age-Corrected Sales (MG/yr)	Difference (MG/yr)	% Difference
2006	2,960.6	3,097.6	137.0	4.6
2007	2,602.8	2,723.8	121.0	4.6
2008	2,791.1	2,916.1	125.0	4.5

Section 6 Non-billed Estimates

Water use for Traffic Islands and Parks is included in the meter records and is included in the total water meter records numbers in Table 3-1.

6.1 Unmetered Accounts

According to the Quincy Water Department, there are very few accounts in the City of Quincy that are unmetered. For the unmetered residential accounts, sales are estimated based upon the total household occupancy from the current census information. For these estimations, it is assumed that 1,000 cubic feet (7,480 gallons) are used per quarter per person. Based upon the RGPCD number of 53.6 calculated in *3.2 Residential Accounts*, the average resident in Quincy would use approximately 4,900 gallons per quarter. This indicates that the estimated bills may actually be higher than the actual consumption. However, it is also possible that the actual consumption would be higher than the estimated bills because the census data per household may be outdated or incorrect, the households may have leaks, etc.

Additionally, there are less than 3 municipal buildings that are unmetered. Because there are so few unmetered accounts that are not already estimated, no further estimates will be made in this report.

6.2 Hydrant Testing/Flushing

Hydrants are flushed/tested for three different reasons: to determine if there is adequate flow and pressure for fire fighting, to determine the flow and pressure for new construction projects, and to flush out rust and sediment deposits.

The Quincy Fire Department tests approximately 2,400 hydrants per year. If it is estimated that each hydrant is tested for 5 minutes at a flow rate of 800 gpm, a total water volume of 9.6 MG/yr is used for hydrant flushing.

6.3 Fire Fighting

Another non-billed category of water usage is for fighting fires. The Quincy Fire Department does not record the amount of water used for fire fighting. For these scenarios, the American Water Works Association (AWWA) uses a standard that 1% of total water usage (water purchased from the MWRA) is used for fire fighting. Using the water purchased numbers from Table 4-1, the amount of water used for firefighting from 2006-2008 was 36.0 MG, 37.6 MG, and 35.1 MG for 2006, 2007, and 2008, respectively.

6.4 Street and Sewer/Drain Cleaning

In the City of Quincy, street cleaning water usage is tracked by the Quincy Public Works highway division 4, which reports that trucks use approximately 500 gallons of water per fill and that the total water consumption for 2008 was 1.08 MG.

Water is also used to clean the sewers and storm drains. This cleaning is done year-round with vacuum trucks. A summary of the sewer cleaning water usage is shown in Table 6-1 below.

Table 6-1 Water Used in Sewer and Storm Drain Cleaning

Days[1]	Type of Cleaning	Tank Size (gallons)[1]	# of fills/day[1]	Total MG/year
265	Sewer	1,500	4	1.59
240	Storm Water Drain	2,500	2	1.20
			Total	**2.79**

1—Estimate from the Quincy Water Department

6.5 Water Main Breaks

Another source of water loss is from water main breaks. Water mains break as a result of corrosion, age, and weather conditions. During summer months, increased volume and pressure put stress on the water main. During winter months, cold air, frost in the soil, and water temperatures can contribute to breaks. Based upon documented work reports from the Quincy Water Department, in 2008 there were approximately 55 major main breaks with an average size of 8 inch and an average time to shutdown of 1 hour. The City of Quincy further estimates that the average flow through an 8 inch main, under the operating pressures in the distribution system, is 3,000 gpm. Therefore, the total volume of water loss is calculated as (55 breaks/yr)X(3,000gpm)X(60 minutes)/(1,000,000 Gal/MG)=9.90 MG/yr. Water main break numbers from 2008 were used to estimate the volume of water loss associated with this area. There isn't documented data for previous years, so it is assumed that previous years had similar amounts.

6.6 Leakage

As discussed in *1.6 Leak Detection Surveys*, the two most recent leak detection surveys performed in the City of Quincy were completed on February 16, 2004 and at the end of the summer of 2007 (assumed to be August 31, 2004). If one assumes that the surveys were completed perfectly—that every leak in the city was detected in each survey—then there were 34 new leaks (the number of leaks found in the second survey) in the system between the first survey and the second survey. If it is further assumed that each of these leaks occurred approximately half-way between the first and second survey, then by halving the daily volume of water loss from the second survey (337,000 GPD), one can obtain a representative value of leakage in the City of

Quincy (168,500 GPD) for any given period. This equates to an annual "detectable" leakage of approximately 61.5 MG/yr.

In addition to the leakage described above, there is a component of leakage that is "unavoidable", which is made up of leaks that are too small to be detected or are uneconomical to repair. The International Water Association (IWA) described their approach towards calculating the Unavoidable Annual Real Losses in the December 1999 issue of the IWA AQUA Magazine. The parameters used are presented in Table 6-2.

Table 6-2 Parameters for Calculating the Unavoidable Annual Real Losses (UARL) for a Water Distribution System

Infrastructure Component	Background (Undetectable) Losses	Reported Breaks	Unreported Breaks
Mains	8.5 gal/mi/hr	0.20 breaks/mi/year at 50 gpm for 3 days duration	0.01 breaks/mi/year at 25 gpm for 50 days duration
Service Lines (main to curb stop)	0.33 gals/service line/hr	2.25/1000 service line/year at 7 gpm for 8 days duration	0.75/1000 service line/year at 7 gpm for 100 days duration
Underground Pipes (curb stop to meter)	0.13 gal/service line/hr	1.51/1000 service line/year at 7 gpm for 9 days duration	0.50/100 service line/year at 7 gpm for 101 days duration

The IWA consolidated this information into a user-friendly chart shown in Figure 6-1.

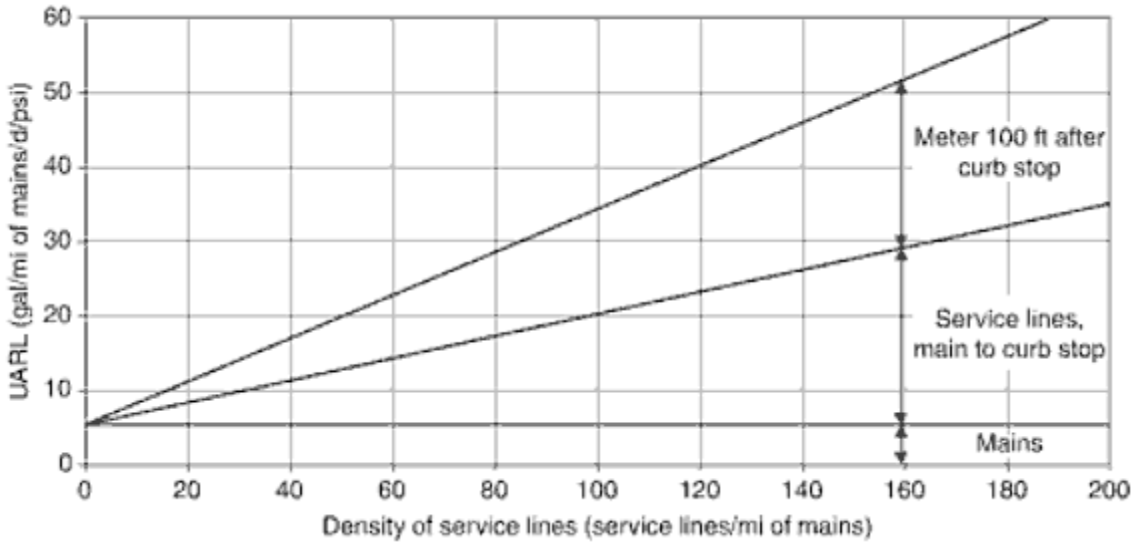

Figure 6-1. Unavoidable annual real losses (gal/mile of mains/day/psi) vs. density of service connections.

The density of service lines in the City of Quincy is: 21,923 service lines/237 miles of water mains=92.5 service lines per mile of mains. It will be assumed that the distance of customer meters from the curb stop is approximately 20 ft (1/5th of the distance from the lower sloped line to the higher sloped line in Figure 6-1). Therefore, from Figure 6-1, the UARL number is approximately 22 gal/mi of mains/d/psi. It will further be assumed that the average operating pressure is 70 psi. The resulting unavoidable water loss is: 22 gal/mi of mains/d/psi*70psi*237 miles=133.2 MG/yr.

6.7 Summary of Non-Billed Water

A summary of all of the non-billed water estimates discussed in *Section 6* is shown in Table 6-3.

Table 6-3 Summary of Non-Billed Water Estimates from Section 6

Non-Billed Estimate	Water Volume (MG)
Unmetered Accounts	0
Fire Department Flushing	9.6
Fire Fighting	36.2
Street Cleaning	1.1
Sewer/Drain Cleaning	2.8
Main Breaks	9.9
Sub-Total w/out Leakage	**59.6**
Detectable Leakage	61.5
Unavoidable Leakage	133.2
Sub-Total Leakage Only	**194.7**
Total	**254.3**

Section 7 Summary of Findings

In this report the volume of water sold was analyzed from 2006-2008. This number was compared to the amount of water purchased (total water use) from the MWRA for the same years. A portion of Table 4-1 is shown below in Table 7-1.

Table 7-1 Summary of Water Sold and Purchased

Year	Total Water Use (MG)	Total Water Sales (MG)	Non-Billed Water (MG)
2006	3,601	2,668	**933**
2007	3,760	2,626	**1,134**
2008	3,509	2,823	**686**
3-year (rounded)	**3,620**	**2,710**	**910**

Because the annual volume of water sold varied significantly from the volume of water purchased, a number of different methods were undertaken to determine why such a deficit existed and to make corrections and adjustments where possible. These efforts are summarized in Table 7-2.

Table 7-2 Summary of Non-billed Estimates of Water Loss

	2006		2007		2008	
	MG	% of Non-billed	MG	% of Non-billed	MG	% of Non-billed
Non-Billed Volume	933		1,134		686	
Meter Age	137.0	14.7	121.0	10.7	125.0	18.2
Hydrant Flushing	9.6	1.0	9.6	0.8	9.6	1.4
Fire Fighting	36.0	3.9	37.6	3.3	35.1	5.1
Street Cleaning	1.1	0.1	1.1	0.1	1.1	0.2
Sewer/Drain Cleaning	2.8	0.3	2.8	0.2	2.8	0.4
Main Breaks	9.9	1.1	9.9	0.9	9.9	1.4
Sum of Non-Billed Estimates w/o leakage	**196.4**	**21.1**	**182.0**	**16.0**	**183.5**	**26.7**
Detectable Leakage	61.5	6.6	61.5	5.4	61.5	9.0
Unavoidable Leakage	133.2	14.3	133.2	11.7	133.2	19.4
Sum of Leakage	**194.7**	**20.9**	**194.7**	**17.2**	**194.7**	**28.4**
Total Non-Billed Estimates	**391.1**	**41.9**	**376.7**	**33.2**	**378.2**	**55.1**

Unaccounted-for-water is the difference between the non-billed water volume and the non-billed water volume estimates. However, per DEP guidelines and as defined in the Massachusetts Water Conservation Standards, both detectable and unavoidable leakage must be included within the unaccounted-for-water calculation. This calculation was performed for each year and the results are shown in Table 7-3.

Table 7-3 Unaccounted-for water for 2006-2008

	2006	2007	2008	3-year (rounded)
Total Water Use (MG)	3,601	3,760	3,509	3,620
Non-Billed Water (MG)	933	1,134	686	910
Non-Billed Estimates w/o leakage (MG)	196	182	184	185
Unaccounted-for-Water (MG)	737	952	502	725
% Unaccounted-for-Water	20%	25%	14%	20%
Leakage Estimate (MG)	195	195	195	195
Leakage Estimate %	5.4%	5.2%	5.6%	5.4%

Unaccounted-for-water, which includes estimated leakage, may also be attributed to less accurate retail meters, less accurate master meters, accounting/meter reading errors, unauthorized connections, theft, estimated bills and/or increased water loss for all non-billed estimates in *Section 5* and *Section 6*.

Section 8 Recommendations for Future Improvements

Of the efforts made to account for the non-billed volume of water, the five primary factors are meter age, unmetered accounts, leakage, main breaks, and hydrant use.

Meter Age: As discussed in *5.1 Meter Adjustment Percentages*, meters should be replaced after 20 years of use. By comparison, over half of the meters in Quincy were installed over 40 years ago. All meters older than 20 years should be replaced, at which point one could expect a vast decrease in the unaccounted-for-water values.

Unmetered Accounts: Every consumer in a community's distribution system (including municipal buildings and parks) should be metered. It is up to the municipality as to whether all consumers should be billed, however, it is important that at least the water consumption is known so that cities and towns can better understand the unaccounted-for-water volumes. According to the Water Department, there are very few unmetered accounts in Quincy. When a meter reading cannot be read, a Water Inspector visits the site. In doing this, Quincy ensures that the volume of unmetered water sales is kept to a minimum.

Leakage: All communities using MWRA water are required to perform leak detection and repair not less than every two years, as defined by Leak Detection Regulations 360 CMR 12.00. As referenced in *1.6 Leak Detection Surveys*, city-wide leak detection is performed in-house every two years. However, the in-house surveys may not be finding all of the leaks in the system. Once the leak detection performed by the private contractor is completed in 2009 (the last private leak detection survey was completed in 2004), the Quincy Water Department will have a better idea as to how to proceed with leak detection. If the 2009 survey finds an expected amount of leaks, then the Water Department can confidently continue to perform in-house surveys. However, if the private contractor finds a substantial amount of leaks, then the Water Department will have to either upgrade their current in-house procedures or more regularly hire private contractors.

Main Breaks: If main breaks are occurring in a particular part of the town/city, then the water main in that area should be replaced. In 2008 in Quincy, there were 55 main breaks distributed over the 237 miles of distribution piping. This number is reasonable; however, it could be reduced by installing additional gates throughout the water distribution system, so that leaks could be closed off as soon as possible. In addition, repairing, lining, or replacing sections of water main in the distribution system are important upgrades. Over the past eight years, Quincy has invested over $13 million to replace old unlined cast iron water mains with 16.8 miles of new cement lined ductile iron mains.

Hydrant Use: Hydrant use includes water used for hydrant flushing and testing, fire fighting, and construction projects. For hydrant flushing and testing and for fire fighting, a log should be kept for the number of and the amount of time that each hydrant is on. For construction projects, the hydrants used should be equipped with meters to gauge the amount of water consumed. After the construction project is complete, the contractor should be billed for the amount of water used. The City of Quincy currently does not keep a formal log of all of these water uses. By doing so in the future, the Water Department would be able to better understand where non-billed water is being used.

Appendix A DEP Forms 1-6

Quincy DEP Forms 1-6.xls

Additional supporting information for calculations, including voluminous spreadsheets containing billing and meter information, has been provided to MWRA and is available upon request.

FORM 1 - UNCORRECTED TOTAL WATER SUPPLY FROM SOURCES OF SUPPLY MASTER METER READINGS QUINCY, MA

TOTAL ANNUAL AMOUNT **(in million gallons per year)**

YEAR	SOURCE 1	SOURCE 2	SOURCE 3	SOURCE 4	SOURCE 5	SOURCE 6	SOURCE 7	SOURCE 8	SOURCE 9	TOTAL	Comment
2006	600	1004	806	909	281					3600	
2007	680	1025	819	927	308					3759	
2008	624	925	748	961	250					3508	

TOTAL 10867

Avg. = Total divided by 3 = 3622 **Enter on Line 1 - Form 6 and Enter on Line 1 - Form 3**

FORM 2 - UNCORRECTED CUSTOMER METER RECORDS

TOTAL WATER SOLD
QUINCY, MA

YEAR	RESIDENTIAL	INDUSTRIAL	COMMERCIAL	AGRICULTURAL	INSTITUTIONAL	OTHER	TOTAL
2006	1904	See Note 1	765				2668
2007	1758	See Note 1	868				2626
2008	1633	See Note 1	1191				2823

Line a TOTAL 8117

Line b = Total divided by 3 = 2705.7

Enter on Line 4 - Form 6

CALCULATIONS

1	Total amount of water metered in system over the past three years (Line a _____)	8117
2	Average total amount of water metered over past 3 years (Line b = Line a/3 =_____)	2706
3	Estimate of total amount of water sold but not metered in past 3 years (Line c _____)	0
4	Average of the total amount of water sold but not metered over past 3 yrs. (Div. Line c by 3 = ___	0

Enter on Line 6 - Form 6

Note 1--Industrial meter records are included in commercial records

FORM 3 - PUMPING AND TREATMENT COSTS
QUINCY, MA
Annual Costs for the past three (3) years

No.	Category	Year CY06 $	Year CY07 $	Year CY08 $	Total	Average = Total Divided by 3 $
1	Chemicals					
2	Fuel					
3	Electricity					
4	H2O Purchase					
5	Other	$7,893,504	$8,675,020	$8,618,069	$25,186,593	$8,395,531
				TOTALS	**Line a =**	

CALCULATIONS

Line 1	Average of the total amount of treated and pumped water supplied to the system over the past three years **Form Line a - Form 1**	**0**	
Line 2	If water is purchased, average of the amount purchased over the past three years **See Page 4**	**3622**	
Line 3	Total amount of water supplied from total of sources and total purchased **Add Lines 1 and 2**	**3622**	
Line 4	Average pumping and treating divided by the purchasing cost of water **Divide Totals - Line a (from above) by** Line 3	**$2,318**	**Enter on Line 15 Form 6**

FORM 4 - SOURCE METER ERROR ADJUSTMENTS TO THE TOTAL AMOUNT OF WATER SUPPLIED TO THE SYSTEM

Year 2006

No.	Meter Location	Meter Test Date	Calibration / Test	Meter Error % (+ or -)	times	Total Metered (gallons)		Adjustment in gallons (+ or -)
1	Adams St @ Beale St				x	600.425	=	0.0
2	Beale St @ Summit Ave				x	1004.115	=	0.0
3	Furnace Brook Pkwy @ Copeland St				x	805.92	=	0.0
4	West Squantum St @ Amsterdam				x	908.85	=	0.0
5	Furnace Brook Pkwy @ Adams St				x	281.415	=	0.0
6					x		=	0.0
7					x		=	0.0
8					x		=	
9					x		=	
10					x		=	
11					x		=	
			AVERAGE PERCENT:		**TOTAL ADJUSTMENTS:**			0.0

Year 2007

No.	Meter Location	Meter Test Date	Calibration / Test	Meter Error % (+ or -)	times	Total Metered (gallons)		Adjustment in gallons (+ or -)
1	Adams St @ Beale St				x	680.36	=	0.0
2	Beale St @ Summit Ave				x	1024.92	=	0.0
3	Furnace Brook Pkwy @ Copeland St				x	819.425	=	0.0
4	West Squantum St @ Amsterdam				x	927.1	=	0.0
5	Furnace Brook Pkwy @ Adams St				x	308.425	=	0.0
6					x		=	0.0
7					x		=	0.0
8					x		=	
9					x		=	
10					x		=	
11					x		=	
			AVERAGE PERCENT:		**TOTAL ADJUSTMENTS:**			0.0

Year 2008

No.	Meter Location	Meter Test Date	Calibration / Test	Meter Error % (+ or -)	times	Total Metered (gallons)		Adjustment in gallons (+ or -)
1	Adams St @ Beale St				x	624.15	=	0.0
2	Beale St @ Summit Ave				x	925.275	=	0.0
3	Furnace Brook Pkwy @ Copeland St				x	747.885	=	0.0
4	West Squantum St @ Amsterdam				x	961.41	=	0.0
5	Furnace Brook Pkwy @ Adams St				x	250.025	=	0.0
6					x		=	0.0
7					x		=	0.0
8					x		=	
9					x		=	
10					x		=	
11					x		=	
			AVERAGE PERCENT:	#DIV/0!	**TOTAL ADJUSTMENTS:**			0.0

CALCULATION

QUINCY, MA

FORM 5 - DISTRIBUTION SYSTEM LARGE SERVICE METER ADJUSTMENTS

Year 2005

No.	Meter Location	Meter Test Date	Meter Size		Meter Error % (+ or -)		Total Metered (gallons)		Adjustment in gallons (+ or -)
1						x		=	
2						x		=	
3						x		=	
4						x		=	
5						x		=	
6						x		=	
7						x		=	
8						x		=	
9						x		=	
10						x		=	
11						x		=	
12						x		=	
			AVERAGE PERCENT:			TOTAL ADJUSTMENTS:			137

Year 2006

No.	Meter Location	Meter Test Date	Meter Size		Meter Error % (+ or -)		Total Metered (gallons)		Adjustment in gallons (+ or -)
1						x		=	
2						x		=	
3						x		=	
4						x		=	
5						x		=	
6						x		=	
7						x		=	
8						x		=	
9						x		=	
10						x		=	
11						x		=	
12						x		=	
			AVERAGE PERCENT:			TOTAL ADJUSTMENTS:			121.0

Year 2007

No.	Meter Location	Meter Test Date	Meter Size		Meter Error % (+ or -)		Total Metered (gallons)		Adjustment in gallons (+ or -)
1						x		=	
2						x		=	
3						x		=	
4						x		=	

FORM 6 - WATER AUDIT WORKSHEET QUINCY, MA

Please place gallonage value in the Results in mgd column and perform calculations.

Line No.	DESCRIPTION	Description	FORM	LINE	(+ or -)	RESULTS
1	Uncorrected Total Water Pumped From Sources of Supply		1	Line 1		3622
2a	Adjustments toTotal Water Supply Master Meter Error		4	Line 2a		0.0
2b	Faulty valve controlling devices		Pg. 5	Line 2b		0
3	Corrected Total Water Supply **Add Lines 1, 2a and 2b)**	**Unadjusted Total (MG)**	**-**	Line 3		3622
4	Uncorrected Customer Meter Records Total Amount Sold		**2**	Line 4		2706
5a	Adjustments to Metered Water Sales - meter error		5	Line 5a		127.7
5b	Billing Procedure error		Pg. 6	Line 5b		0
6	Total Amount of Unmetered Water 'sold'		2	Line 6		0
7	CorrectedTtotal Quantity of WaterSold **Add Lines 4, 5a, 5b and 6**	**Adjusted Total (MG)**	**-**	Line 7		2834
8	Total amount of water not sold **Subtract Line 7 from Line 3**	**Unmetered (MG)**	**-**	Line 8		788
9	Total Unmetered Authorized Public Uses of Water **See Page 5**	**1-See Below**	Pg. 5	Line 9		49.7
10	Total Unmetered Miscellaneous Losses **See Page 5**	**2-See Below**	Pg. 5	Line 10		9.9
11	Total Identified Water Losses **Add Lines 9 and 10**	**Estimated (MG)**	**-**	Line 11		59.6
12	Total Unidentified Water Losses-**Subtract Line 11 from Line 8**	**UAW (MG)**	**-**	Line 12		729
13	Potential water system leakage in gpd per mile of watermain. **Divide Line 12 by 365 then divide by total system miles of watermain**	**Leakage(gpd)/mile**	**-**	Line 13		8424
14	Percentage of unaccounted for water that may be attributed to leakage **- Divide Line 12 by Line 3**	**UAW leakage %**	**-**	Line 14		**20.1%**
15	Pumping and treating cost per gallon of water **Line 4 on Form 3**	**$/MG**	**3**	Line 15		$2,318
16	Annual Expenditure Due to Unidentified Water Losses **Multipy Line 12 by 15**	**UAW Cost**				$1,689,127

1--Public Uses: Street Cleaning, Sewer Cleaning, Hydrant Testing/Flushing, Fire Fighting

2--Water Main Breaks