

# Salem Water Conservation Project

**Project Number:  
10-25/WCG**

**Year Project Conducted:  
2012**

*Prepared by:*



CITY OF SALEM, MASSACHUSETTS  
DEPARTMENT OF PLANNING AND COMMUNITY DEVELOPMENT

*Prepared for:*



MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION  
BUREAU OF RESOURCE PROTECTION

*and*



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY  
REGION 1 – NEW ENGLAND

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# FINAL REPORT

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY  
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EXECUTIVE OFFICE OF ENERGY & ENVIRONMENTAL AFFAIRS

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## PROJECT SUMMARY

The goal of this project is to promote water conservation and identify and reduce unaccounted for water loss from the City of Salem drinking water works and distribution system. The City of Salem's source of water supply derives from the Ipswich River Watershed.

The City determined that it would focus on replacing fixtures at three public facilities: the Bentley Elementary School, Salem Fire Department Headquarters, and at the Salem Public Library. Following the bidding process, the project came in nearly \$19,000 under budget (combined State Grant and City Funds). Below please find a summary of each task, the initial project scope, each approved change order, and the task deliverables:

### **Task 1: Municipal Toilet Retrofit Program**

#### *Initial Project Scope*

Purchase and install a total of **forty-two (42) low-flow toilets** using 1.6 gallons per flush (gpf) or less to replace those currently using 3.5 gpf or more at the Bentley Elementary School (32) and at the Salem Fire Department Headquarters (10). Also install **four (4) dual-flush toilets** using 1.6 or 1.1 gpf, depending upon flush mode, to replace those currently using 3.5 gpf or more at the Salem Public Library.

#### *Change Order #1*

O'Connell Plumbing (City's hired contractor) informed the City that all four (4) dual flush toilets to be installed at the Salem Public Library as specified in the bid were outfitted with push button flushing, which are not ADA approved. The City approved to change the initially specified dual-flush push button gravity tank toilets to dual-flush tip level toilets with pressure assist flushing. The change in toilet styles will insure that they all meet ADA requirement and greatly reduce clogging, due to the use of less water. Additionally, the wall hung toilet initially specified to be retrofitted was actually a floor mounted rear-outlet toilet. Change Order #1 did not increase the total amount of toilets installed it only changed one toilet type and all the toilet styles. The increase in cost for all the aforementioned changes totaled \$1,790.

#### *Change Order #2*

A portion of the surplus funds were used to install **three (3) more low-flow toilets** at Fire Headquarters and **four (4) more dual-flush toilets** at the Salem Public Library.

#### *Change Order #3*

No additional low-flow or dual-flush toilets were purchased in Change Order #3

#### *Deliverables:*

*Confirmation that **forty-five (45) low-flow toilets** using 1.6 gpf or less replaced those using 3.5 or more gpf at the Bentley Elementary School and at Fire Headquarters.*

- ◆ The City Project Manager performed a final inspection and took photo documentation on October 19, 2012 at Fire Headquarters to confirm the retrofit of thirteen (13) low-flow toilets and on October 23, 2012 at the Bentley School to confirm the retrofit of thirty-two (32) low-flow toilets (refer to Table 1).

*Confirmation that **eight (8) dual-flush toilets** using 1.6 or 0.9 gpf depending upon flush mode replacing those using 3.5 or more gpf have been purchased and installed.*

- ◆ The City Project Manager performed a final inspection and took photo documentation on October 22, 2012 at the Salem Public Library to confirm the retrofit of eight (8) dual-flush toilets (refer to Table 1).

*Listing of the make and model of old toilets with associated gpf, make and model of new low-flow or dual-flush toilets with associated gpf, installation locations, and quantify gallons of water saved per flush and the water savings per year as a result of the newly installed fixtures.*

- ◆ Refer to Attachment #1.

*Create educational sign decals to educate and promote water conservation via the use of low-flow or dual-flush toilets, to be reviewed and approved by MassDEP prior to fabrication and installation, and install them above each of the retrofitted toilets.*

- ◆ The City Project Manager submitted the revised draft educational sign decals for review and approval to MassDEP on September 24, 2012 and MassDEP approved them in writing on September 25, 2012. After the approved educational sign decals were fabricated, the City Project Manager installed them at each of the municipal locations (refer to Attachment #3).

## **Task 2: Municipal Faucet and Urinal Retrofit Program**

### *Initial Project Scope*

Purchase and install **ten (10) low-flow urinals** using 1 gpf or less to replace those currently using 2.0 gpf or more at the Bentley Elementary School. Purchase and install **nineteen (19) metering faucets** at the Bentley School (15) and Fire Headquarters (4) **and two (2) battery-powered sensor faucets** (all ADA compliant) at the Bentley School outfitted with 0.5 gallons of water per minute (gpm) faucet aerators/flow restrictors on replacement faucets using up to 2.2 gpm or more.

### *Change Order #1*

The City was unable to retrofit the ten (10) low-flow urinals at the Bentley School (refer to the Difficulties Section of this report for more details) so on August 22, 2012 the City requested that the budgeted urinal funds totaling \$4,160 be reallocated to purchase and install **ten (10) more metering faucets** for the Bentley School. MassDEP approved the request in writing on August 23, 2012.

### *Change Order #2*

With a portion of the surplus funds the City purchased and installed **seventeen (17) more metering faucets** and **two (2) more manual faucets** with flow restricting aerators for Fire Headquarters and **two (2) more metering faucets** for the Salem Public Library.

### *Change Order #3*

**Two (2) metering faucets at the Fire Headquarters were returned and credited** to the City. With the remaining surplus funds the City purchased and installed **five (5) more metering faucets** for the Bentley School.

### *Deliverables:*

*Confirmation that **ten (10) low-flow urinals** were purchased and installed at the Bentley Elementary School replaced those using 2 gpf or more.*

- ◆ **No low-flow urinals were installed** as the Plumbing Contractor identified some issues that rendering the retrofit unfeasible (refer to Difficulties Section of this report for more details).

*Confirmation that **fifty-one (51) metering faucets** were purchased and installed at the Bentley School, Fire Headquarters, and Salem Public Library, **two (2) battery-powered sensor faucets** were purchased and installed at the Bentley School, and **two (2) manual faucets** outfitted with 0.5 gpm aerator/flow restrictors at Fire Headquarters replacing faucets using up to 2.2 gpm or more.*

- ◆ The City Project Manager performed a final inspection and took photo documentation on October 19, 2012 at Fire Headquarters to confirm the retrofit of **fifteen (15) metering faucets**, and **two (2) manual faucets** with aerator/flow restrictors, on October 22, 2012 at the Salem Public Library to confirm the retrofit of **six (6) metering faucets**, and October 30, 2012 at the Bentley School to retrofit **thirty (30) metering faucets** and **two (2) battery-powered sensor faucets** (refer to Table 1).

*Listing of the make and model of old faucets with associated gpm, make and model of new metering, manual, or sensor faucets with associated gpm, installation locations, and quantify gallons of water saved per minute and the water savings per year as a result of the newly installed fixtures.*

- ◆ Refer to Attachment 2.

### **Task 3: Reporting**

The City of Salem was required to submit the following deliverables to MassDEP pursuant to contract requirements:

*Deliverables:*

*The City shall provide quarterly progress reports to MassDEP in accordance with the project milestone schedule until the project is completed.*

- ◆ The City submitted all required quarterly reporting forms at the end of each quarter in accordance with the project milestone schedule, until the project was completed.

*The City shall provide fiscal spending reports and MBE/WBE reporting on the same schedule as the progress reports, pursuant to the approved project budget.*

- ◆ The City submitted all fiscal spending reports and MBE/WBE reporting forms at the end of each quarter, until the project was completed.

### **Task 4: Draft and Final Project Report**

The City of Salem was required to submit the following deliverables to MassDEP pursuant to contract requirements:

*Deliverables:*

*Two (2) hard copies of a draft final report and one (1) electronic version in word or pdf format sent via email to MassDEP for review and comment.*

- ◆ The City submitted two hard copies and emailed an electronic version of the draft final report to MassDEP for their review and comment on November 15, 2012.

*Upon receipt of comments on the draft final report from MassDEP, the City will address these comments and submit the final report to MassDEP with all project deliverables.*

- ◆ The City received comments on the Draft Final Report from MassDEP on November 27, 2012. The City addressed all the comments and submitted the Final Report with all project deliverables to MassDEP on November 29, 2012.

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.

- ◆ Refer to Attachment 1 and Attachment 2. The water savings calculations in gallons saved per year was extrapolated from the Schneider Electric Investment Grade Audit (IGA) report prepared for the City of Salem on December 16, 2010. The dollar value calculations saved per year was derived from the City’s commercial water/sewer rate of \$11.78 per 100 cubic feet of water or \$0.0157 per gallon.

One (1) camera ready copy (unbound), three (3) printed copies of the final report, and two (2) CDs with electronic versions of the final report

- ◆ The City submitted one (1) unbound camera ready copy, three (3) bound printed copies, and two (2) CDs with electronic version of the Final Report on November 29, 2012.

## SUCSESSES

The City was able to install twice as many faucets and nearly 20% more toilets than initially budgeted, which in turn resulted in an estimated total savings of 613,625 gallons of water per year and \$9,170 saved per year just in the Salem Public Library, Fire Headquarters, and Bentley School. With this grant and the City’s allocation, the City was able to retrofit 100% of the toilets and faucets at the Salem Public Library and Fire Headquarters, and 90% of the toilets and 97% of the faucets at the Bentley School.

### Faucet Replacement Table

Number of Faucets Retro-fitted	Municipal Building	Existing Faucet Flow Rate (gallons per minute)	New Faucet Flow Rate (gallons per minute)	Daily Usage of New Faucets (minutes per unit)	Daily per Unit Savings (gallons)	Annual per Unit Savings (gallons)	Annual Program Savings (gallons)	Program Savings over five years (gallons)	Annual Program Savings (dollars)	Program Savings over five years (dollars)	% of Annual Production Cost
6	Library	2.2	0.5	7	11.9	4,129	24,775	123,875	\$371	\$1,855	<1%
17	Fire HQ	2.2	0.5	3.2	5.4	1,985	33,745	168,725	\$506	\$2,530	<1%
32	School	2.2	0.5	8.8	15	2,700	86,400	432,000	\$1,300	\$6,500	<1%
<b>GRAND TOTAL</b>				<b>6.3</b>	<b>10.8</b>	<b>2,938</b>	<b>\$144,920</b>	<b>724,600</b>	<b>\$2,177</b>	<b>\$10,885</b>	<b>&lt;1%</b>

### Quantification of Water Savings from Faucet Retrofits:

A total of fifty-five (55) faucets were replaced under this grant project, fifty-one (51) metering models using 0.5 gallons per minute, two (2) battery-powered sensor models using 0.5 gallons per minute, and two (2) manual faucets outfitted with 0.5 gallon per minute aerator/flow restrictors. All older faucets replaced used 2.2 gallons per minute. Each new faucet saves approximately 3,000 gallons of water per year. Total estimated annual water savings is 145,000 gallons a year.

#### Salem Public Library

Six (6) faucets with a flow rate of 0.5 gallons per minute were installed in the Salem Public Library, replacing 2.2 gallon per minute faucets. For purposes of this analysis, we estimated that each Library

occupant uses a faucet for 15 seconds per day, which is consistent with the figures in our 2010 Schneider Electric Investment Grade Audit (IGA). The project resulted in the replacement of 100% of the faucets with a total combined population of approximately 48 visitors and staff for 347 days per year. This equates to approximately 14,574 minutes of annual use for faucets which were retrofitted by the project. Savings is 1.7 gallons per minute, which equals approximately 24,775 gallons per year. The City of Salem uses 1.9 billion gallons of water a year, the annual percentage of water savings from this program is 0.0013%.

*Salem Fire Department Headquarters*

Seventeen (17) faucets with a flow rate of 0.5 GPM were installed in the Salem Fire Department Headquarters, replacing 2.2 gallons per minute faucets. For purposes of this analysis, we estimated that each Fireman uses a faucet for 15 seconds per day, which is consistent with the figures in our 2010 Schneider Electric Investment Grade Audit (IGA). The project resulted in the replacement of 100% of the faucets in Fire Headquarters with a total combined population of approximately 46 staff for 365 days per year. This equates to approximately 20,075 minutes of annual use for faucets which were retrofitted by the project. Savings is 1.7 gallons per minute, which equals approximately 33,745 gallons per year. The City of Salem uses 1.9 billion gallons of water a year, the annual percentage of water savings from this program is 0.002%.

*Bentley School*

Thirty-two (32) faucets with a flow rate of 0.5 GPM were installed in the Bentley School, replacing 2.2 gallon per minute faucets. For purposes of this analysis, we estimated that each school occupant uses a faucet for 15 seconds per day, which is consistent with the figures in our 2010 Schneider Electric Investment Grade Audit (IGA). The project resulted in the replacement of approximately 97% of the faucets with a total combined population of approximately 596 students and staff for 180 days per year. This equates to approximately 50,940 minutes of annual use for faucets which were retrofitted by the project. Savings is 1.7 gallons per minute, which equals approximately 86,400 gallons per year. The City of Salem uses 1.9 billion gallons of water a year, the annual percentage of water savings from this program is 0.005%.

**Toilet Replacement Table**

Number of Toilets Retro-fitted	Municipal Buildings	Existing Toilet Flow Rate (gallons per flush)	New Toilet Flow Rate (gallons per flush)	Daily Usage per New Toilet	Daily per Unit Savings (gallons)	Annual per Unit Savings (gallons)	Annual Program Savings (gallons)	Program Saving over five years (gallons)	Annual Program Savings (dollars)	Program Savings over five years (dollars)	% of Annual Production Costs
8	Library	3.5	1.1	21.3	51	17,700	141,600	708,000	\$2,100	\$10,500	<1%
13	Fire HQ	3.5	1.6	6.6	12.5	4,562	59,306	296,530	\$900	\$4,500	<1%
32	School	3.5	1.6	24.5	46.5	8,370	267,840	1,339,200	\$4,000	\$20,000	<1%
<b>GRAND TOTAL</b>				<b>17.5</b>	<b>110</b>	<b>10,210</b>	<b>468,746</b>	<b>2,343,730</b>	<b>\$7,000</b>	<b>\$35,000</b>	<b>&lt;1%</b>

### **Quantification of Water Savings from Toilet Retrofits:**

A total of fifty-three (53) toilets were replaced under this grant project, eight (8) dual-flush models using 1.1 or 1.6 gallons per flush and forty-five (45) low-flow models using 1.6 gallons per flush were installed. All older toilets replaced used 3.5 gallons per flush. Each new toilet saves approximately 10,000 gallons of water per year. Total estimated annual water savings is 468,750 gallons a year.

#### *Salem Public Library*

Eight (8) dual-flush toilets with a flow rate of 1.1 or 1.6 gallons per flush were installed in the Salem Public Library, replacing those toilets using 3.5 gallons per flush. For purposes of this analysis, we estimated that the total number of flushes per day is 170 flushes, or 21 flushes per toilet per day, which is consistent with the figures in our 2010 Schneider Electric Investment Grade Audit (IGA). The project resulted in the replacement of 100% of the toilets at the Library with a total combined population of approximately 700 visitors and staff for 347 days per year. This equates to approximately 175,000 gallons of annual use for toilets which were retrofitted by the project. Savings is 1.9 or 2.4 gallons per flush, which equals approximately between 112,000 and 141,600 gallons per year. The City of Salem uses 1.9 billion gallons of water a year, the annual percentage of water savings from this program is 0.007%.

#### *Salem Fire Department Headquarters*

Thirteen (13) low-flow toilets with a flow rate of 1.6 gallons per flush were installed in the Salem Fire Department Headquarters, replacing 3.5 gallon per flush toilets. For purposes of this analysis, we estimated that the total number of flushes per day is 86 flushes, or 6.6 flushes per toilet per day, which is consistent with the figures in our 2010 Schneider Electric Investment Grade Audit (IGA). The project resulted in the replacement of 100% of the toilets in Fire Headquarters with a total combined population of approximately 46 staff for 365 days per year. This equates to approximately 175,000 gallons of annual use for toilets which were retrofitted by the project. Savings is 2.4 gallons per flush, which equals approximately 59,000 gallons per year. The City of Salem uses 1.9 billion gallons of water a year, the annual percentage of water savings from this program is 0.003%.

#### *Bentley School*

Thirty-two (32) low-flow toilets with a flow rate of 1.6 gallons per flush were installed in the Bentley School, replacing 3.5 gallon per flush toilets. For purposes of this analysis, we estimated that the total number of flushes per day is 750 flushes, or 24.5 flushes per toilet per day, which is consistent with the figures in our 2010 Schneider Electric Investment Grade Audit (IGA). The project resulted in the replacement of 90% of the toilets at the Bentley School with a total combined population of approximately 600 students and staff for 180 days per year. This equates to approximately 175,000 gallons of annual use for toilets which were retrofitted by the project. Savings is 2.4 gallons per flush, which equals approximately 268,000 gallons per year. The City of Salem uses 1.9 billion gallons of water a year, the annual percentage of water savings from this program is 0.014%.

### **Educational Sign Decals**

By creating educational sign decals with information about the amount of water saved using the low-flow toilets and additional instructions to properly use the dual-flush toilets, the placement of these decals will inform the public how these new toilets use significantly less water per flush. The decals aim to inform and educate the public that the City has taken measures to conserve water in their municipal facilities. By significantly lowering the amount of water per flush, the City is showing the public how simple technology fixes can conserve large amounts of water per flush and per year. Additionally,

because the new metering faucets are all on an automatic timers, faucets cannot be left on which serves to limit the amount of water used per wash. By raising awareness of the new low-flow and dual-flush toilets and the new low-flow metering faucets, the public may be inspired to implement water conservation measures in their own home or business by replacing inefficient toilets, faucets, or other water fixtures.

Water conservation also provides energy conservation savings through the reduction in energy used to heat, pump, and treat water. Through water conservation and efficiency measures in municipal facilities, less of a burden is placed on the water supply, wastewater treatment plant, and distribution system, resulting in water taken from the environment. Other environmental benefits include increased water available to local streams, wetlands, and their natural inhabitants, and less wastewater generated, which ultimately requires less energy to be treated in wastewater treatment facilities. Water conservation and efficiency also helps to mitigate pollution from runoff of over-irrigation of agricultural and urban lands, additional dams and reservoirs, and additional water and wastewater treatment facilities, habitat degradation from surface water withdrawals, topsoil degradation, destruction of pollutant filtering wetlands, and increased energy needed to treat wastewater and byproducts from power plants. Because demand for fresh water continues to increase, and it is a finite resource, communities are developing water conservation measures to protect and sustain their water sources in order to continue providing affordable, clean, and safe water for the public.

## **DIFFICULTIES**

At the Bentley Elementary School, the Plumbing Contractor was unable to retrofit the urinals because the new low-flow wall hung urinals did not match the existing plumbing fittings or carriage holder. In order to replace the existing wall-hung urinals with the new low-flow urinals the Plumbing Contractor informed us that he would have to cut into the tiled wall, replace the carriage holders, rearrange the plumbing, and then rebuild and tile the wall. After speaking with the Public School Facilities Manager it was determined that it was not feasible to replace the urinals at that time. The City requested that the \$4,160 budgeted toward the low-flow wall hung urinals be reallocated to purchase and install ten (10) more low-flow metering faucets instead. DEP approved the request in writing on August 23, 2012.

When replacing the faucets at the Bentley Elementary School, the Plumbing Contractor had to replace four (4) shutoff valves (worked performed under Change Order #2) in the boy's gang bathroom in order to retrofit four (4) low-flow metering faucets.

When replacing the toilets at the Bentley Elementary School, the Plumbing Contractor had to replace one (1) broken carrier drain (work performed under Change Order #2) in the girl's gang bathroom in order to retrofit one (1) of the low-flow wall hung toilets.

At the Salem Public Library we also ran into a problem with respect to one of the initially specified dual-flush toilets. Our Plumbing Contractor informed us that the wall hung dual-flush toilet does not have a carriage holder which suspends the toilet off the floor, instead it is a toilet that sits on the floor but the plumbing extends out the back of the toilet into the wall. Furthermore the plumbing connects to another similar toilet on the other side of the wall, which we were not intending to change, however in order to retrofit one we had to retrofit both. The City requested to use surplus funds to purchase two floor-mounted rear outlet dual-flush toilets to resolve the matter. DEP approved request in writing on August 23, 2012.

## **LESSONS LEARNED**

The single greatest challenge for the City was the change in project management. The former City Energy and Sustainability Manager stepped down in July 2012 and the Director of Planning and Community Development delegated a Staff Planner to take over the project and complete the construction, grant compliance, and close out phase.

Project timelines established under the grant were attainable. The Plumbing Contractor was able to install most of the budgeted fixtures within the allotted grant timeframe, however in order to expend the surplus funds to purchase additional eligible water conserving fixtures the City was granted an extension of time to October 31, 2012. The City asked for another extension of time on October 23, 2012 in order to fully expend the remaining surplus funds and complete the grant close out requirements. On October 24, 2012 MassDEP granted another time extension to December 31, 2012.

Throughout this project MassDEP was very responsive and flexible. They approved two grant deadline extensions to permit the City to expend all the surplus funds on eligible fixtures, which in turn resulted in the installation of nearly twice as many fixtures as initially budgeted.

The Project did encounter site constraints as detailed in the previous section. The lesson learned from those site constraints encountered is that unforeseen plumbing issues will likely occur and future project should include a monetary contingency to account for them.

The project went smoothly because we contracted with a very qualified Plumbing Contractor who understood the scope of work and worked well with City Staff. With the cooperation and professional expertise from our hired Plumbing Contractor we were able to work through unforeseen circumstances and resolve matters in a logical, timely, and cost effective manner. To that end, if any advice were to be given, we would suggest that other communities do their due-diligence before they award a project to a low-bidder.

## **RECOMMENDATIONS**

The savings from the water conservation measures implemented in the three facilities demonstrate the significant and immediate impacts that fixture replacements can have on water consumption. Because of this savings impact, the City of Salem and other municipalities would benefit greatly from an expanded DEP sponsored program which would give the City a more comprehensive and expanded City-wide water conservation program. Future DEP funding would allow the City to replace old and inefficient toilets, urinals, and faucets in all the schools, municipal buildings and publicly owned properties. These measures would help the City realize a more thorough approach to water conservation. An important first step to this water conservation plan would be to develop a water use inventory for the City including a comprehensive facility survey to target problem buildings. By finding out how much total water the City uses, an economic analysis can be developed to show the benefit of deploying water conservation and efficiency measures in the City.

Additionally, a recommended component for a future water conservation program would be funding for outreach and education, and water conserving measures for private homes and businesses. Because the City and the public both draw water from the same supply, the community can benefit from public outreach projects where water conservation measures can be implemented in private homes and businesses. Some outreach projects include making retrofit kits containing low flow faucet aerators, high efficiency showerheads, leak detection tablets, and replacement valves for residences and business free

or at a small cost, promoting water-efficient landscape practices that include using native plants, landscape renovation to reduce water use, and more efficient irrigation systems, and water-use audits offered by the City to provide users with info about how water is used and where conservation methods could be deployed. Because residents and businesses of a municipality represent the majority of usage in any community, efforts that successfully accomplish water conservation will result in a major impact in water usage, lowering the burden on wastewater treatment plants and resulting in the environmental benefits listed above.

Through the success of this DEP water conservation grant and using the lessons learned from the project, an expanded program to implement water conservation measures across the whole City of Salem would help to realize the potential for environmental, economic, and social benefits that water savings can have.