

**New England Water Works Association
Massachusetts Water Works Association
Toolbox of BMPs for Water Resource Management**

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Introduction

Effective water resources management requires that a community understand its specific local circumstances, identify the specific challenges it faces with regard to system and demand management and apply the appropriate tools to address pertinent issues. The toolbox of potential best management practices presented here is designed to be used as a menu of choices by municipal officials and water managers; not all the BMPs will be appropriate to any particular system. One needs to recognize that municipal departments, districts and private utilities have different governing structures that impact the way decisions are made. The toolbox approach to successful water resource management provides community planners the flexibility to develop specific plans and priorities tailored to solve the particular problems facing the system.

To use the toolbox, planners should evaluate the status of their water systems: Is the community growing, losing population or stable? Is water demand changing, and if so, why? What is the age and condition of the infrastructure? What are the patterns of water use? What are the real and apparent water losses? Are current supplies adequate for expected demands? Can expected demands be managed so that they do not exceed current supply capacity? Utility managers and community leaders must also be aware of the regulatory framework and local and environmental conditions, as well as the ability of the community to invest in maintaining and improving its water system assets.

Communities should develop an integrated water resource plan; these tools provide the basis for developing such a plan. An integrated water resource plan generally looks at all of the community's water, wastewater and stormwater infrastructure and operating protocols in the context of the local demographic trends, environmental conditions and community's long term vision of itself. Such an integrated plan does not simply look at water supply and demand, but how wastewater and stormwater can affect the quality and quantity of the water supply. An integrated plan also looks at the larger picture of community growth and land use patterns and the regional environment. The plan will also take the long view of managing the system's assets, ensuring appropriate maintenance, rehabilitation and replacement of buried and above ground system components.

In addition to managing the water system for normal conditions, water system managers must be prepared to provide an adequate supply of safe water during extraordinary conditions. This type of contingency or emergency planning should encompass planning for supply disruptions from natural or human events (drought, flood, power failures, sabotage or contamination) and while it is to be expected that the types of tools necessary for these extraordinary events may overlap somewhat with the tools used to manage during normal conditions, some may only be applicable for the extreme events.

This document is organized into sections with tools a community can use to reduce water withdrawals, to minimize the environmental effects of local water withdrawals, to offset water withdrawals and to educate the public in water efficiency and environmental stewardship. There are three appendices which provide additional information on contingency planning tools and on tools to better account for the water that is used within the community.

NEWWA and MWWA recognize that the relative effectiveness of the tools may vary significantly based on their site specific use and locations; a very broad attempt has been made to categorize these tools within the toolbox. The effectiveness should be judged by each community based on their specific situation.

Better Accounting for all Water Use

In order to properly manage a community's water resources, the system manager must understand how water is used and where any losses occur. A water audit as described by AWWA Water Loss Control Committee can be used for this purpose. In looking at water losses or unaccounted for water use, water audits using the International Water Association (IWA) Water Audit Method (endorsed by the AWWA Water Loss Control Committee) differentiate between real losses (physical losses of water) and apparent losses (paper losses). Reductions in real losses will result in an immediate reduction in water withdrawals; reductions in apparent losses will not result in immediate reductions in withdrawals, but can improve the equity of retail rates, and may provide some impetus for use reductions in some circumstances.

The goal of the water loss reduction approach adopted by the International Water Association and AWWA¹ (see more detail in Appendix 2) is to identify and quantify each component of real and apparent losses; the approach essentially does away with the term "unaccounted for water use". All uses and losses are accounted for and quantified to allow the water system to then take appropriate action to reduce any of the real or apparent losses where such actions provide water system, societal or environmental benefits above their costs. One outcome of the audits will be the identification of real losses which may be able to be recovered through leak detection and repair, and system-specific unavoidable annual real losses (UARL). The IWA/AWWA water loss control approach recognizes that every water pipe has some level of leakage, which cannot be found and eliminated. Quantifying UARL as part of a systematic approach to managing losses allows a water system to determine how much potential there is for finding and recovering actual losses. There are several methods for calculating a system's UARL taking into account system specific pipe network data, including pipe materials, lengths and diameters, number of services, pressures and pipe age².

¹ *Applying Worldwide BMP's in Water Loss Control*, JAWWA August 2003

² AWWA Water Loss Control Committee, *Applying Worldwide BMP's in Water Loss Control*, JAWWA August 2003; AWWA standards C600, C603, C6005, C695 (each standard contains provisions testing and calculating for allowable leakage in new water main construction)

To assess the economic impact to the utility, the IWA/AWWA water loss control approach includes a cost accounting of water losses. The utility can then prioritize its goals to improve both system efficiency and economics, by such other measures as leak detection and metering improvements. The prioritization method can also account for adoption of improvements over time, for example altering the timing or frequency of billing in conjunction with meter system replacement when existing meters reach the end of their useful life. (Note that metering improvements and audits are only tools to better account for use (and potentially) to prioritize leak detection – they are not water savings technologies in their own right.)

Reducing Water Withdrawals

Using water more efficiently and reducing waste can allow water withdrawals to be reduced while still accommodating all legitimate uses. In those places where a withdrawal does have a stream-flow-depleting impact, reducing withdrawal volumes has the potential for resulting in beneficial impacts on streamflow. Thus it is important to understand the local environmental situation when designing local programs. It is equally important to note that depending on the particulars of the water system's demand and supply system, some tools may be more implementable or more effective at achieving stream flow improvements. Tools may also differ in being long term vs. short term, seasonal vs. year round, or voluntary vs. mandatory. The tools selected by a community would be expected to be tailored to their situation – a community with a streamside well and primarily residential use will require different tools than a community with a large reservoir and extensive commercial development. Below are examples of some potentially effective tools for reducing water supply withdrawals.

1. Leak detection and repair.

Leaks may be detected through a water audit, audible leak detection, zone flow measurement and close monitoring of daily water use, especially minimum hourly flows. Use of this tool assumes that the leak will be repaired in a timely fashion in relation to the quantity of the leak.

- a. Audible leak detection surveys are the most commonly employed method for finding hidden distribution system leaks that never appear on the surface of the ground. Usually water system staff or a contracted leak detection firm will “listen” for leaks using sound intensifying equipment and correlators for pinpointing leak locations. The surveys typically follow a systematic pattern to cover the entire distribution system over some pre-determined period of time (one year, two years, three years, etc).
- b. The frequency with which to conduct leak detection surveys is subject to much debate. Leak detection equipment and/or contracted services are not inexpensive with correlators and sound intensifying equipment running up to \$30,000 (at current costs) and contracted services annually costing in the same range, depending on system size. Survey frequency should be based on the size and age of the distribution system, the number of visible leaks that typically occur during the year, overall water use trends and recent leak detection data.
- c. Water lost to leakage represents real losses and the cost of these losses can be measured in terms of production/treatment costs or, for systems purchasing water from others, the unit cost to buy water. By considering the cost to the utility of this lost water and the cost to find and repair hidden leaks, a water system can

develop a cost/benefit analysis to guide leak detection. Caution should be taken to consider all costs associated with this lost water which, in some communities, might include costs to develop new supplies or upgrade pumping/treatment capacity. Environmental costs should also be considered where withdrawals result in measurable effects.

- d. Water systems with a recent history of leak detection surveys can use that information to guide future survey frequency. If they found very few leaks in the recent past then it is probably not cost effective to do annual or biennial surveys unless a sudden, unexplained increase in water use or water loss is noted.
- e. Unaccounted for water (UAW) may serve as a very general gauge with which to base leak survey frequency. This “measure” may only be useful for a system comparing its UAW data to itself rather than to some arbitrary standard. A system that understands its own UAW calculation and that applies its calculation uniformly each year may have cause to consider more frequent leak surveys if an increasing trend in UAW is noted. However, that trend may be due to other factors like metering and other apparent losses (paper losses). The use of UAW as a measure of leakage is thus of questionable value. Water loss control using best management practices as espoused by AWWA’s Water Loss Control Committee is a more effective approach (see Page 2 in Appendix 2).
- f. It should be noted that leak detection technology has made major advances in recent years, a trend that is expected to continue. Devices now exist that can “listen” for leaks on a continuous basis. While this equipment is still undergoing scrutiny and refinement it does present some new options that may prove very useful at finding leaks as they occur.
- g. It must also be understood that finding and repairing distribution system leaks may not have a significant impact on reducing real water losses and UAW. As existing leaks are repaired new leaks develop. Extremely cold winters with deeper frost penetration often lead to many new leaks. Also, communities with significant underground work by other utilities (gas, electric, sewer, etc.) may be prone to more leakage as water mains and services are disturbed by adjacent excavations.

2. Distribution System Improvements

There are improvements to the water distribution system that will help to reduce water loss that are likely part of a water system’s Asset Management or Capital Improvement Program. These improvements can include:

- a. Water Main Replacement. While leak detection and repair can be used to locate certain types of water main leaks, it may not be able to resolve all leakage. In those cases, water main replacement is the next more advanced and preventative step to reducing water main leaks. Replacement of water mains with a frequent break or leak history should be prioritized to reduce system water loss. Once the obvious problem pipes are replaced, the only way to achieve additional leakage reductions may be replacement of older pipes without obvious problems even though this may not be cost effective.
- b. Water Main Looping. Some systems experience water quality degradation at dead ends in the water system and may utilize bleeders to improve water quality. In

some instances eliminating dead ends by looping water mains to provide better flow can eliminate the water quality problems and also eliminate water loss from the bleeders.

- c. Storage Tank Improvements. Some systems may need to overflow their storage tanks either due to system hydraulics or water quality concerns. Installation of altitude valves or tank mixing systems may help to alleviate these problems, thereby reducing water loss.
3. Rate and billing structures which encourage conservation, including:
- a. Descriptive bills with use history and use in gallons (perhaps even community per capita goals). Many utilities now show a monthly history of use. This provides customers with tangible evidence of changes in their use habits. Only by knowing or understanding how and when they use water will customers be able to modify wasteful habits. While many meters read in cubic feet, this is a meaningless number to most customers; gallons or thousands of gallons are far easier to relate to.
 - b. Full cost recovery. Water bills are a charge that is based on the cost of the service being provided and how much of that service is used; it is quite distinct from a tax. For customers to make the proper choice about how much of a service (water) they wish to use, they must understand the cost of that service. Hiding costs in general tax rates and deferring needed infrastructure improvements only mask the true cost and can lead to the under valuing of the service. Full cost recovery should include the recognition of all indirect costs such as employee benefits, administrative costs such as a portion of a superintendent's time devoted to water (including benefits and office expenses), professional development, capital, infrastructure and supply protection costs including debt and the systematic, planned replacement of assets needed to provide service. All costs related to all water supply activities should be recovered by rates, including the costs of maintaining and upgrading the system. If maintenance and capital costs are deferred, future generations will have to bear a disproportionate share of such costs.
 - c. Based on the specific circumstances of a community, quarterly, bi-monthly or in some cases monthly billing (automatic meter reading may facilitate this). While it is more expensive to read meters and bill more frequently, technological advances may reduce operating costs. More frequent water bills may have several advantages:
 1. They may provide a more frequent price signal or reminder of water use habits to the customer. A bill with a conservation rate that is issued at the end of the summer is a classic case of closing the barn door after the horse has escaped.
 2. More frequent bills are smaller than quarterly or semi-annual bills and thus may be easier for the customer to budget and pay.
 3. Many true conservation rates, especially those with seasonal components require frequent meter reading and billing. It is nearly impossible to adopt a seasonal rate if bills are only issued twice per year; and even

with staggered quarterly billing, it is difficult to determine a true summer or peak use period that is the same for all customers.

- d. Seasonal surcharges for increased use. Encouraging wise water use through prices typically involves the establishment of rates that charge for non-discretionary uses at higher rates. Production of seasonal water may have a higher per unit cost to the utility. The higher the cost of something, the less customers will tend to buy. Most measurable discretionary uses occur during peak demand periods in the summer and are associated with uses such as irrigation, car washing, pool filling, etc. Because of the seasonal nature of these uses, a seasonal rate structure that charges more for the discretionary uses can help reduce water demand. Seasonal rate structures can take many forms including:
 1. Higher rates for all uses during peak demand months
 2. Increasing block rates that set blocks or tiers based on normal or typical winter period use for residents
 3. Rates that compare each account's summer use to past winter month use and charge each customer for the excess over winter use at a higher rate.
 - e. Increasing block rate structures (if applied appropriately). Unless one is in a homogeneous, single family, residential community, an increasing block rate structure that is applied to all accounts will do little to encourage conservation. More often than not, such uniformly applied rate structures simply shift the cost of water to larger non-residential customers; and can actually reduce the charge to residents that use large volumes for non-essential uses. To achieve a real conservation signal, an increasing block rate structure must be individually designed and applied to unique types or classes of customers. Frequently this results in a residential, a commercial, and an industrial rate structure where the rate blocks or tiers and the rates are different for each customer class. Because there can be such large variations within classes (single family vs. multifamily within residential, or bank vs. restaurant within commercial), meter size is often used as the distinction between classes.
 - f. Second or deduct irrigation meters (where used appropriately). With increasing frequency, customers are looking to install a second meter for irrigation use in order to avoid paying sewer rates on water that is not returned to the sewers. Water used for irrigation is considered by many to be a non-essential use. It is often the most expensive water to provide, requiring larger pumps, pipes and storage to meet peak irrigation demands. As such, any water that is used by an irrigation meter should be priced at the highest rate to reflect its cost. If a community has an increasing block rate, the charge for an irrigation meter should not start again at the lowest rate step, but should at least pick up where use at the primary meter left off to avoid customers that install these second meters simply taking advantage of the lowest rate step(s) twice. There are other benefits to installation of a second meter including opportunities for backflow prevention, irrigation design and irrigation system management.
4. Indoor demand management programs for residential users including:
 - a. Water saving device giveaways or installation

- b. Incentives for high efficiency toilet installation and high efficiency clothes washers (rebates, etc)
 - c. Residential Water Audits
 - d. Encourage partnering with watershed association and other advocacy groups on incentives or rebates
5. Outdoor demand management for both residential and non-residential users including: (Some of the options listed below may require town department collaboration. Implementation of certain BMPs might not be under the purview of the water supplier; therefore, the appropriate town department should be consulted.)
- a. Education about actual irrigation needs in New England climate
 - b. Publication of irrigation daily needs index
 - c. Promote/require better irrigation controls to avoid over watering (i.e., rain sensors)
 - d. Water Conservation Bylaw
 - e. Landscape water audits
 - f. Encourage (via education, requirements, bylaws or rebates) climate based controllers and/or moisture sensors
 - g. Landscaping measures that promote/require:
 - 1. Organic soil content and minimum levels of topsoil to help soils to retain water
 - 2. Use of native or drought-tolerant plants
 - 3. Reduction of cleared areas
6. Irrigation alternatives including:
- a. Cisterns, rain barrels, etc. for storage and irrigation
 - b. Storm water capture and reuse from paved areas and roofs
 - c. Grey water capture and reuse for irrigation
 - d. Conversion of wet ponds for irrigation
 - e. Reclaimed water stored in ponds or in aquifers
7. Process and other indoor demand management for industrial/commercial and institutional uses including:
- a. Water audits or education on water saving opportunities
 - b. Facility improvements such as LEED³ accreditation
 - c. Grey water capture and reuse for toilet flushing
 - d. Where possible, consider recycling/reuse of cooling water
 - e. Replace water cooling with air cooling
 - f. Retrofit high water use fixtures
 - g. Separately meter process water to understand use
 - h. Develop & implement a water savings strategy
8. Land use pattern changes including:
- a. Low Impact Development (LID) measures
 - b. Higher density, with less private open space, less paved area per unit

³ LEED stands for Leadership in Energy and Environmental Design, a voluntary, consensus-based national standard for developing high-performance, sustainable buildings.

9. Rigorous enforcement and potential future changes to the plumbing code
10. Mandatory Restrictions (only under extraordinary circumstances; see Appendix 1)

Minimizing Adverse Effects of Local Water Withdrawals

Water withdrawals may cause localized or regional effects on water resources. A reservoir without releases to a stream can eliminate streamflow during certain seasons, whereas a reservoir with required releases may dampen the effects of dry weather. Wells far from a stream may have little discernable affect on the stream, while wells immediately adjacent to a stream may have some impact on the stream. The section above dealt with tools which would reduce the amount of water used by a water system, and hence withdrawn from its sources. This section focuses on tools which could have the benefit of reducing the impact of any given quantity of water on a particular local resource.

1. Shifting use of near-stream wells to wells further from the stream during low flows. Since wells closer to streams sometimes have a more direct and immediate impact on the stream, water suppliers that have multiple wells could potentially manage the use of these wells so that near-stream wells are utilized only during periods of high flow and wells more remote from sensitive streams could be used during periods of low flow.

In situations where all of a water supplier's wells are located near sensitive streams it may be advisable to look for additional water sources more distant from streams, if any aquifers are available, so that the supplier can rely less on near-stream wells during low flow periods. Water suppliers should be encouraged to augment their water supply wells to allow them to manage demand in this way, and regulatory structures should allow for the necessary flexibility in permitting and operations.

2. Using wells that are upgradient of large ponds or lakes. These wells sometimes have lower impacts on stream low flows, as the pond or lake dampens out flow variations. This principle can be applied in a manner similar to the previous "tool." Water suppliers may then be able to rely on wells upgradient of major ponds during low flow periods. If potential sources exist in locations upgradient of major ponds, the water suppliers should consider installing supplemental wells in these locations.
3. Conjunctive use of multiple supplies – Water management planning within a community should consider the conjunctive use of multiple supplies⁴, whether from groundwater and/or surface water sources. The end goal should be an operations plan based on such factors as safe yield, groundwater levels, reservoir levels, streamflow and drought conditions. Tools for development of such operations plans may include groundwater and/or hydrologic models to simulate conditions and develop operating

⁴ Conjunctive use is the use of two or more sources of water of differing characteristics, providing higher reliability, more yield or less impact than the individual sources operated independently. Yevjevich V. M. "Conjunctive Water Use", published in Water International Sept. 1979; pp.17-30. And Daniel Sheer et al "The computer as a negotiator", AWWA Journal of February 1989.

scenarios that minimize impacts to sensitive receptors such as streams, wetlands, ponds, and other water supply sources. Historical operations data and monitoring records may also be used to develop effective optimization scenarios that allow for effective use of multiple supplies. The benefits of this approach may not only allow for improvements to stream baseflow, but also provide for the opportunity to schedule and implement needed source supply rehabilitation.

4. Cooperative Resource Management – Recognizing that public drinking water supply is not the only user of water resources, there may be opportunities to reduce the impacts of withdrawals on water resources by understanding and cooperatively managing all withdrawals in an area. These may include withdrawals such as agricultural uses, golf courses, nurseries, and industrial uses as well as smaller private wells. Potentially, cooperative management in terms of timing, relative location and quantity could allow all users to achieve their needs, with a lower impact to the resource than uncoordinated withdrawals. This is particularly true if groundwater and surface water supplies can be cooperatively managed, especially if there is substantial storage available to dampen out seasonal or inter-annual variations in impacts to stream flows. The use of Decision Support Systems (i.e., an optimization scheme developed in consideration of priorities) may be of value in establishing such cooperative management schemes.
5. Modifications of the local public health department’s regulations on private well use and control may be considered.
6. Alternative Supplies – Desalination, regional water supplies or other sources outside your basin.
 - a. Desalination – Coastal Communities and those communities situated on tidal rivers could benefit greatly from the development of Desalination facilities. Augmenting with desalination can allow a community to better manage its sources of supply during peak demand periods and/or drought periods. During drought periods a community could reduce withdrawing water from the basin and meet demand with desalinated water which could help restore the aquifer and may provide relief for streamflow. Energy would be somewhat offset by turning off the energy demand for a community’s own supply and consideration could also be given to alternative sources of energy such as wind generation.
 - b. Regional Water Supplies –Communities in other basins could also benefit by purchasing water from other regional water suppliers during peak demand periods and/or drought periods. This would allow communities to relieve pumping stress on the basin aquifer achieve noticeable streamflow benefits.

Offsetting Water Withdrawals

1. Discharging appropriately treated wastewater close to streams or upgradient of sources provides more direct improvements to low flows than those farther from streams or

downstream. However, discharging treated wastewater upgradient of sources or anywhere with a potential to impact sources must only be considered on a case by case basis after thorough evaluation of travel time and other aquifer characteristics, pollutant attenuation factors, wastewater treatment effectiveness and potential contaminants (domestic or industrial/commercial sewage). Careful consideration should be given to treatments costs, monitoring costs, raw water contaminant concentration, public health and ecological concerns. Should treated wastewater be discharged in a water supply contributing area (watershed or wellhead) source water protection should not be compromised.

2. There are a variety of stormwater controls which may be implemented to help keep water local. The objective of these efforts is to maximize the retention of stormwater within each river basin, with a focus on infiltrating stormwater following suitable treatment. Special consideration should be given to the degree of treatment when discharging within water supply source protection areas. There are a number of stormwater Best Management Practices (BMPs) available to help achieve these objectives, many of which are commonly referred to as Low Impact Development (LID) techniques⁵. They include such items as:
 - a. pervious pavement
 - b. pedestal sidewalks
 - c. parking groves
 - d. below pavement infiltration basins
 - e. parking lot planters/buffers
 - f. recharge basins
 - g. infiltration trenches
 - h. vegetative swales
 - i. rain gardens
 - j. tree box filters/stormwater planters
 - k. rooftop detention with infiltration gallery
 - l. stormwater wetlands

These and other LID measures will have the effect of reducing stormwater peaking times which can benefit streamflow and help recreate a more natural hydrological pattern. Use of extended detention structures such as swales, dry ponds, wet ponds, rooftop detention, and green roofs will provide similar benefits. The selection and appropriateness of LID BMPs are community specific, based on local soil type, geology and hydrology.

Communities can work to further the use of LID techniques in new municipal facilities, as well as incorporating BMPs such as rain gardens at existing facilities where appropriate. Consideration may also be given to the conversion of detention ponds to recharge basins. The most effective means of implementation is through the modification of local zoning regulations and stormwater recharge requirements. Specifically,

⁵ See the Town of Littleton's Low Impact Design/Best Management Practices Manual at:
http://www.littletonma.org/filestorage/53/1696/119/Low_Impact_Design_Best_Management_Practices_Manual.pdf

incorporation of a requirement for use of Low Impact Development approaches will provide changes to land use patterns, allowing for more groundwater recharge.

3. There may be potential of directing clean process water to aquifer areas for infiltration or direct pumping after suitable treatment. However, ensuring the quality of such discharges is of concern. Even further, special consideration should be given to the degree of treatment when discharging within water supply source protection areas.
4. Skimming off the high flows of streams to recharge aquifers or to fill offline reservoir storage may be viable in some basins.
5. Seasonal transfer of water to existing lakes or ponds with available storage capacity for later use during periods of high demand or periodic drought.
6. Reduction in infiltration/inflow to sewers particularly those where the treated discharge is downstream or out of basin.
7. A Water Bank can be established by a community for the purpose of maintaining or reducing demand while accommodating the needs of existing and/or future development. For example, for approval of a new connection, the developer could be required to first achieve a reduction in system water demand at least equal to the demand of the new connection.

Public Education and Awareness

Building public awareness of the limitations of local water supplies, and the consequences of overuse through public outreach is a key component of developing and implementing a drought or water shortage plan. A well-informed community will understand that overuse of water supplies will not only impact nearby ecosystems, but also threaten the availability of water for more essential purposes (such as drinking, or fire protection) and will respond more readily when asked to minimize non-essential water use. Public outreach should also appeal to the needs of different customer classes. For example, small business customers may require a different outreach strategy than residential customers with large landscapes.

A sequential, ongoing public outreach education program is the backbone of any water conservation program. The sequence of the program is important, with more general education (raising consciousness about the importance of water conservation) preceding outreach aimed at changing or regulating customer behavior. The following components should be considered:

1. Press: Local press is often the best venue for distributing information about water conservation. Water suppliers could cultivate relationships with editors and reporters, educating them so that they may in turn help educate the public. Consider sending them pre-written releases or columns; often this saves them time and allows you to get your message out directly to the public. Paid advertising and public service announcements have also proven an effective venue.

2. Information center: Water suppliers could set up easily-accessible areas, and on-line sources, where the public can pick up basic brochures, references, etc, on water conservation topics.
3. Newsletters: Regular newsletters are an invaluable means to provide ongoing outreach and education on conservation-related topics.
4. Website: Water suppliers should utilize their websites to post conservation related materials.
5. High user programs: Many water suppliers may be able to most efficiently and dramatically manage their demand by working directly with their highest users (residential and commercial.) Re-education may be needed to dispel some of the myths that perpetuate over-watering.
6. School education programs: Schools are an excellent venue to deliver local conservation ideas and values. Many elementary schools are looking for relevant curriculum that fits into the state science standards and links into the community.
7. Community displays: Local libraries, town halls and events are often excellent venues for displaying conservation related materials.
8. Demonstration garden/landscapes: Some utilities have sited drought-tolerant demonstration gardens on their grounds or in other public places. Plants could be labeled and “how to” information should be provided for reference.
9. Water bills: Water Bills could be used to show seasonal usage fluctuations, usage history, gallon-per-day, or comparisons to “average” use. Bill stuffers could contain conservation tips. Frequent billing (at least quarterly) better allows users to make connections between past use and amount charged.
10. Fact sheets or brochures on a variety of water conservation topics (e.g. indoor, outdoor, water-efficient appliances). When appropriate, materials should be provided in different languages.
11. Outdoor advertising (e.g., billboards, sandwich boards).
12. Broadcast programs on cable TV.
13. Conservation retrofit devices: Could be provided free, at-cost, or via rebates.
14. Conservation audit programs: Could be provided free or at-cost. Should include before and after surveys with published results.
15. Collaboration with community groups (such as service organizations, scouting groups and garden clubs): on conservation-related topics of mutual interest.
16. Award and recognition programs: For residents and businesses that have made gains in water conservation.
17. Collaboration of all water users: Commercial, residential, municipal, and those on private wells work together in the spirit of public good.
18. Providing speakers to community, business, youth and neighborhood groups.
19. Promote the importance of water conservation: Within all town government sectors.
20. Promote the importance of water conservation: To all developers/contractors working within the community.

Effective communication needs to capture the recipient’s attention. Studies have shown that boring, inconspicuous flyers and pamphlets are often ignored by the public. Information that is vivid, concrete and personal is more likely to be noticed and acted on. Other ways to ensure successful public outreach efforts include:

1. Have an organization or individual that is credible with target audience deliver the message.
2. Communication, especially if it includes instructions for a desired behavior, needs to be clear and specific.
3. Make it easy for people to remember what to do, and how and when to do it.
4. Provide feedback to customers on their water conservation efforts.
5. Partner with other organizations

The preceding outreach/education activities are recommended prior to, and accompanying the implementation of outdoor water use restrictions. It has been shown that conducting comprehensive public outreach and education is critical to successful implementation of any conservation-based restrictions.

Toolbox of Best Management Practices

Tool Category	Tool	Effectiveness				Responsibility	
		Residential	UAW	Reduced Withdrawals	Streamflow	PWS	Others
Better Accounting for All Water Use	Meter Inaccuracies		■			✓	
	Unmetered Uses		■			✓	
	Data Management		■			✓	
	Unauthorized Uses		■	■		✓	
Reducing Water Withdrawals	Leak Detection and Repair		■	■	○	✓	
	Distribution System Improvements		■	■	○	✓	
	Rate and Billing Structures	■		■	□	✓	✓
	Residential Indoor Demand Management	■		■	□	✓	✓
	Outdoor Demand Management	■		■	○	✓	✓
	Irrigation Alternatives	■		■	○		✓
	Non-Residential Indoor Demand Management			■	□	✓	✓
	Land Use Pattern Changes	■		■	□		✓
	Rigorous Enforcement/Additional Plumbing Code Changes	■		■	□		✓
	Mandatory Restrictions	■		■	○	✓	✓
Minimizing Adverse Effects of Local Water Withdrawals	Shifting Use of Near-Stream Wells during Low Flow Periods				■	✓	✓
	Using Wells Upgradient of Ponds & Lakes				■	✓	
	Conjunctive Use of Multiple Supplies Within a Community				■	✓	
	Cooperative Resource Management				■	✓	✓
	Private Well Use and Control				□		✓
	Alternative Supplies-- Desalination Alternative Supplies-- Regional ⁶			■ □	■ □	✓ ✓	✓ ✓
Offsetting Water Withdrawals	Local Wastewater Discharges				■		✓
	Stormwater Controls ⁷				■		✓
	Process Water Infiltration				■		✓
	High Flow or Flood Skimming				■	✓	✓
	Seasonal Transfer to Lakes or Ponds				■	✓	✓
	Reduction in Inflow/Infiltration to Sewers				■		✓
	Water Bank	□	□	□			✓
Public Education & Awareness	■		■	□	✓	✓	
Contingency Plan for Supply Management	■		■	□	✓	✓	

Legend:

UAW – Unaccounted For Water

PWS – Public Water Supplier

Others – May include local officials such as police, building inspectors, planning boards; state officials; or federal officials.

■ - Significant

□ - Marginal

○ - Can't be determined without local information

⁶ Depends on the basin you are examining.

⁷ Assumes highest recharge requirement of 1.25 inches for A soil, 1 inch for B soil. Only medium results gained from adopting Stormwater Policy community wide.

Appendix 1: Contingency Planning for Supply Management

Every water system needs to concern itself with a worse case scenario of water supply shortage. What happens if available supplies are insufficient to meet system demands? Such circumstances can be brought about by drought (a prolonged period of less than normal rainfall), demand exceeding system capacity, loss of supply to contamination, loss of access to supply due to treatment, pumping, storage or transmission failures and limited supply availability due to regulatory or environmental constraints. Each water system should address this issue in two ways:

1. Manage the water system to minimize vulnerability to factors that can lead to supply shortages.
2. Prepare contingency plans to identify appropriate response actions should a shortage be imminent.

Water systems need to manage their supplies from source to tap. Systems must understand the water supply needs of the community along with demand trends. They also must know the system's ability to supply, treat and convey water and where the weak links in the system may exist. Systems should not be operated at or near their limits as to do so leaves little room for the unexpected. Well managed water systems have:

- ◆ adequate reserve supplies
- ◆ reserve pumping and treatment capacity⁸
- ◆ redundant transmission and distribution systems
- ◆ storage that is readily available to meet fire flow
- ◆ demand that does not stress the supply system

Water systems that lack all or some of these features need to assess their weaknesses and take appropriate action. To address supply vulnerabilities, managers must take a holistic view of their water systems and select a course of action that considers costs, effectiveness, public acceptance and long range planning. For instance, a supply vulnerability may exist in that pumping rates are near maximum capacity for extended periods during the summer. The “knee jerk” response may be to install larger pumps. However, this could be a very costly alternative especially where larger pumps may dictate larger water mains. Another approach may be to enhance demand management through greater conservation efforts and reduce flows so that the pumps operate at a more sustainable level. There are also costs associated with this option. The decision making process must then weigh the costs and benefits of each approach and decide what is best for the community.

In another example, a community may rely totally on water conservation to meet its supply needs. It may offer retrofits of low flow fixtures, maximize water loss control, ban outdoor water use and implement every known aspect of green development. While these efforts go forward the community may pass up opportunities to secure lands for future water supplies. Such an approach may work very well for the short and mid-term but in the long term this community may reach the limits of water conservation and find it needs new supplies. At that

⁸ For instance, MassDEP's Guidelines for Public Water Systems, Chapter 7.3 states: “With any pump out of service, the remaining pump or pumps shall be capable of providing the maximum daily pumping demand of the system.”

point of realization it may be too late to augment existing sources as there may no longer be suitable lands for new sources available. The point is that addressing supply vulnerabilities needs to be done with an encompassing view of the problem. In most cases a combination of supply side and demand side management is needed. These approaches are not mutually exclusive.

Solutions to supply shortages also must consider the nature and duration of the shortage. An appropriate plan to address a shortage that only manifests itself during peak use days in the summer may not be suitable for addressing long-range source water limitations. Management strategies must be tailored to the specific issue as there are no “magic bullets” that cover all potential supply shortage scenarios.

While water systems should strive to address vulnerabilities they must also recognize that there will always be circumstances that cannot be eliminated which can lead to supply shortages. It is the obligation of every water system manager to be prepared to respond to potential water supply shortages resulting from prolonged periods of below normal rainfall or other factors through creation of system specific supply contingency plans. While often termed “drought management plans,” these tools are appropriate for responding to all manner of water supply shortages. Supply contingency plans should incorporate a system specific trigger mechanism, based on operational, supply or environmental measures that will determine when to implement response protocol. The response protocol should be designed to reduce water demand to sustainable levels appropriate for the supply situation.

Triggers and response protocol are often tiered with increasingly stringent responses needed as the supply situation worsens and triggers to dictate when different responses are needed. Typically, responses to initial triggers are advisory only and intended to alert consumers of below normal supplies or potential supply-limiting emergencies and a general need to be more aware of water use. Subsequent triggers may require reductions in so-called non-essential water uses followed by elimination of non-essential uses, then reductions in less essential water uses and finally, under the most severe circumstances, limiting water use to that needed for public health and safety. Identification of triggers, the level of use reduction needed and definitions of non-essential and less essential uses are system specific and must be developed to best meet the needs of the community.

Trigger mechanisms may include:

- ◆ Reservoir storage
- ◆ Pumping rates
- ◆ Storage tank levels
- ◆ Groundwater levels
- ◆ Drought Indices (e.g. Palmer Index)
- ◆ Precipitation
- ◆ Streamflow conditions (streamflow conditions are influenced by many factors and must be used cautiously as contingency plan triggers. They should only be used in conjunction with other triggers and when there is a clear understanding of the cause of the streamflow condition.)

Response protocol may include: (these are examples only and in no particular order)

- ◆ Enhanced public outreach and education
- ◆ Outdoor turf watering restrictions
- ◆ Limitations on street cleaning
- ◆ Restrictions on restaurants serving water unless requested
- ◆ Shutting down ornamental fountains
- ◆ Moratorium on new water connections
- ◆ Limiting vehicle washing
- ◆ Activation of emergency supplies and interconnections
- ◆ Fines for non-compliance
- ◆ Enhanced leak repair
- ◆ Limitations on water system flushing
- ◆ Increase minimum temperatures in facilities using evaporative cooling systems
- ◆ Enhance distribution of conservation devices (showerheads, high efficiency toilets, etc)
- ◆ Moratorium on bulk water sales
- ◆ Water shutoffs for non-compliance
- ◆ User specific limitations (generally for large commercial, industrial, institutional users who should be encouraged to develop their own contingency plans)

A supply contingency plan is really a component of an emergency response plan. Why it may need to be implemented can vary but the goal in all cases is to reduce demand to assure a sustainable supply for essential water needs of the community.

An excellent source of information on supply contingency planning is the AWWA Drought Management Handbook.

Appendix 2: Reducing Apparent Water Losses

This appendix focuses on tools to reduce apparent losses. While reducing apparent losses provides no immediate environmental or cost benefit, a better understanding of all water use will allow better priority setting for all other actions a water system undertakes.

In looking at water losses or unaccounted for water use, water audits using the International Water Association (IWA) Water Audit Method (endorsed by the AWWA Water Loss Control Committee) differentiate between real losses (physical losses of water) and apparent losses (paper losses). The goal of the water loss reduction approach adopted by the International Water Association and AWWA⁹ is to identify and quantify each component of real and apparent losses; the approach refines the term “unaccounted for use” by dividing it into a number of more specific sub categories which are measured and managed separately. Reductions in real losses result in an immediate reduction in water withdrawals; reductions in apparent losses do not result in immediate reductions in withdrawals, but can improve the equity of retail rates, and may provide some impetus for use reductions in some circumstances.

Apparent losses are made up of:

- ◆ Meter inaccuracies (either source or retail due to meter condition or incorrect sizing)
- ◆ Unmetered “retail” uses (such as municipal buildings, recreational fields, fire fighting, street cleaning)
- ◆ Unmetered “system” uses (such as water main or hydrant flushing, tank draining, bleeders)
- ◆ Data management errors (meter data incorrectly input into or handled by the accounting system, or metered but “no charge” accounts not input into accounting system)
- ◆ Unauthorized use (meter tampering, illegal taps into mains)

The IWA and AWWA water loss reduction report recognizes that there are not yet fully accepted standard BMPs for reducing apparent losses, but indicates that the system manager should “determine where the greatest amounts of apparent loss are believed to exist” and undertake “those interventions needed to reduce the overall apparent losses to the appropriate economic level.” Water systems should strive to account for and report on as much water use as reasonable, either through improvements in metering or appropriate forms of estimation.

Meter inaccuracies:

Supply or source master meters should be regularly calibrated. Systems should evaluate their calibration records to see if there is a regular pattern of drift in calibration. If this is the case, estimates of the quantity of water “missed” between calibrations can be made to improve the systems overall accounting of uses and losses, reported as “accounted for” apparent losses, and adjustments to calibration schedules considered if needed.

Systems should understand the level of under-registration of each class of their retail meters. Meters typically gradually allow increasing amounts of flow to pass through them without registering as they age. This is particularly true for very low flow rates (as caused by a slow leak or drip.) Periodically testing a representative sample of meters of a given age, size and model

⁹ *Applying Worldwide BMP's in Water Loss Control*, JAWWA August 2003

can provide an estimate of under-registration which can be applied to the entire class of similar meters. This will both allow for improved accounting and reporting of water use, and by tracking the trends in accuracy provide the information needed to determine when that class of meters may need to be replaced.

An issue noted in a paper by Sullivan and Speranza¹⁰ is that large commercial meters are frequently improperly sized for actual current use. This can result in substantial flows being below the lower end ability of the meter to accurately register. This may occur when meters are sized for fire flow rates required by the sprinkler system or when the use of the building changes and thus water use patterns change (for example when a building is changed from an industrial use to a commercial use). The paper demonstrates that resizing meters and installing fire flow bypasses, if needed, is a cost effective way to better and more accurately meter flows in commercial and industrial buildings. While meter ownership and financial responsibility arrangements vary from system to system, developing and reporting an estimate of the size of this potential apparent loss is the first step in any program to eliminate it and fully charge those users.

Unmetered Uses:

Historically, many community water systems provided free water to the community itself, for schools, cemeteries, athletic fields and other municipal facilities. This is no longer considered appropriate water policy: AWWA recommends that all water distributed be metered at the point of use even if no charge is levied for the use of the water.

Water systems should move toward metering any municipal facilities which are still unmetered. It may be appropriate to prioritize such an effort by estimating and reporting on current uses and metering the largest ones first or those where the potential for actual use reduction may be highest.

Some uses, such as construction use and street cleaning where the use is taken from hydrants, can be metered with portable meters (these can also include appropriate backflow prevention devices). Water systems can issue these meters as part of a hydrant use permitting program, and should consider seeking the authority to issue fines for any unpermitted uses. Alternatively, street cleaning use can also be accurately estimated by maintaining logs of how many times the street sweeper tank is filled and how large the tank is.

Uses such as fire fighting, main and hydrant flushing and bleeders, tank overflows and draining may not be easily metered, but can be estimated by maintaining logs of duration and flow rates for each type of use, or volumes drained.

Data Management Errors:

Periodic audits of accounting systems and cross checks against other municipal records should be undertaken to ensure that data management systems are correctly capturing data for meter readings and that every use is registered. While full cost recovery policies do require that all municipal uses be accounted for and cross charges made, at a minimum systems should require

¹⁰ Sullivan, Jr., John P. and Speranza, Elisa M., Proper Meter Sizing for Increased Accountability and Revenues, AWWA Annual Conference, Philadelphia, PA, 1991

that even if current municipal policy is not to charge other departments for water and sewer use, that those departments receive regular informational invoices stating what their use was and how much the water would have cost at the regular billing rates. Those uses should be recorded and reported along with all other metered uses.

Unauthorized Uses:

Water use records should be periodically reviewed to look for any evidence of unexplainable changes in use patterns. Providing notice to a customer of unexpected increases may help the user find an unnoticed leak, and be perceived as good customer service. Noticing and investigating downward changes can alert the system to meter failures or bypasses. Water system and building department personnel should all be alert for evidence of bypasses, unmetered entry points, and unpermitted and unmetered taps into mains, and have a defined process for reported any suspected water theft. When detected, retroactive estimates of water losses may be possible, and along with any appropriate criminal proceedings, the system should recover lost revenue and report on the use.

Unavoidable real leakage:

The IWA/AWWA water loss control approach recognizes that every water pipe has some level of leakage, which cannot be found and eliminated. Quantifying UARL as part of a systematic approach to managing losses allows a water system to determine how much potential there is for finding and recovering actual losses. There are several methods for calculating a system's UARL taking into account system specific pipe network data, including pipe materials, lengths and diameters, number of services, pressures and pipe age. See *Applying Worldwide BMP's in Water Loss Control*, JAWWA August 2003; AWWA standards for allowable leakage in new water main construction (Appendix 3).

Appendix 3: *Applying Worldwide BMP's in Water Loss Control*