ONCE IS NOT ENOUGH

A GUIDE TO WATER REUSE IN MASSACHUSETTS

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A GUIDE TO WATER REUSE IN MASSACHUSETTS

Throughout Massachusetts, we are realizing that water is an increasingly limited resource. Water supplies cannot be continuously expanded to accommodate new development because of the challenges associated with stressed river basins, expensive water treatment, and increasingly strict permitting standards. The state, especially within the 495/MetroWest Corridor, must take a more deliberate and sustainable approach to water resources if we are to expand economic development and maintain our high quality of life. One important strategy to reduce demand is the reclamation of treated wastewater for nonpotable uses such as landscaping, industrial processes, and toilet flushing.

While commonly associated with arid regions, water reuse has a place in all climates. This report describes different forms of water reuse and highlights case studies demonstrating that water reuse is a practical and beneficial strategy in Massachusetts. As described in the Recommendations section, there is still more work to be done: Public education is vital and pilot projects are needed to demonstrate the feasibility of water reuse. Meanwhile, regulators and stakeholders are collaboratively reviewing the Massachusetts Interim Guidelines on Reclaimed Water in order to revise these standards where necessary to enable more appropriate uses of reclaimed water while also protecting human and environmental health. As the title states, "once is not enough" when it comes to water use, and we hope this report will encourage more widespread use of reclaimed water.

George Preble, P.E.
Co-Chair of the 495/MetroWest Corridor Partnership Water and Sewer Committee

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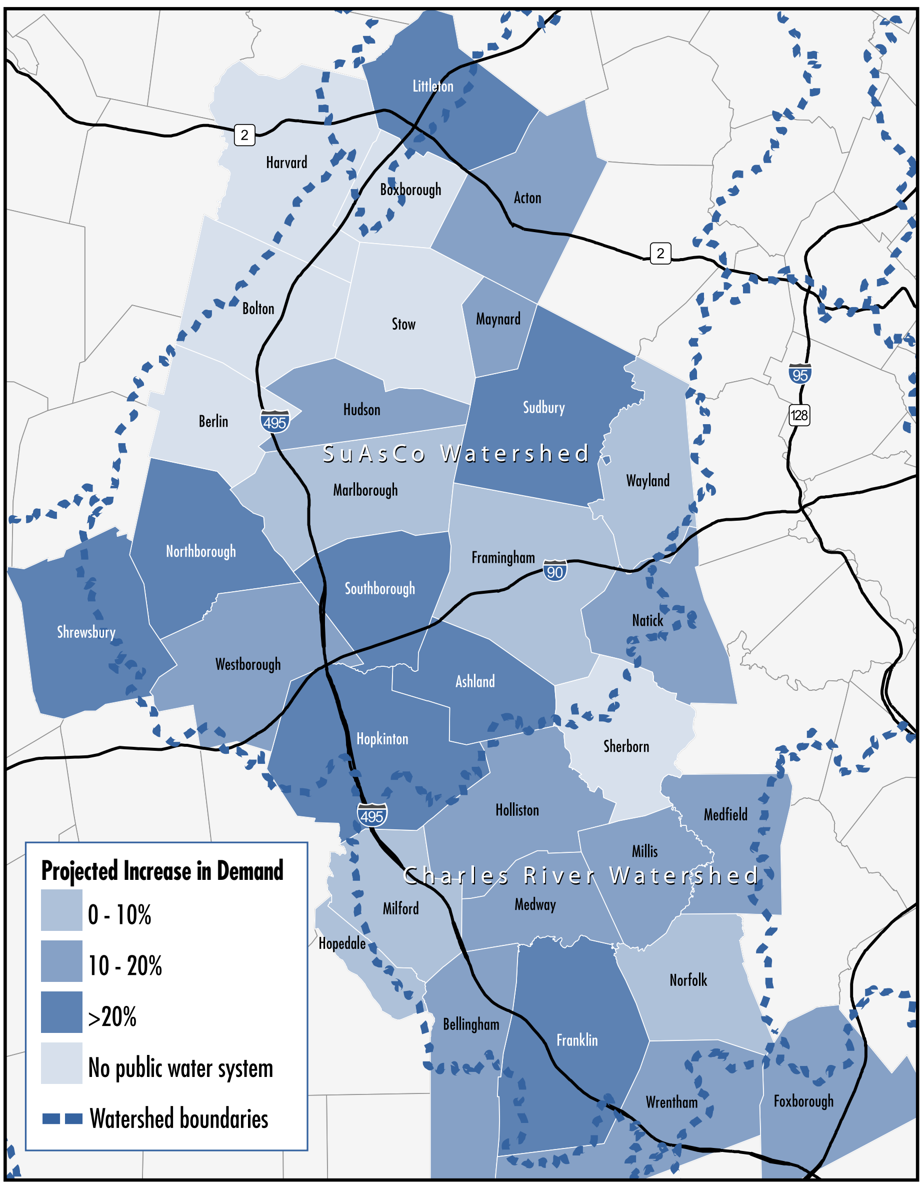
AN INTRODUCTION TO WATER REUSE

Water is a limited resource around the world and right here in Massachusetts. Many communities that rely on groundwater or surface water for their public water supplies are finding that current demand is approaching the limits of their resources. Many of the region's aquifers, located in thin deposits of sand and gravel, cannot sustain long-term large-scale withdrawals. The figure at right shows the projected increase in water demand in the I-495 Region. These projections indicate that in nearly 50 Metro Boston communities, the projected year 2030 water demand exceeds currently permitted water withdrawal rates. If nothing is done to modify the projected water demand, various negative consequences might result:

- increasing impacts to rivers, streams, and wildlife;
- longer, more contentious, more expensive water permitting processes;
- higher water rates, affecting homeowners and businesses; or
- limits on new connections, which would stifle economic growth.

In order to ensure continued growth, communities and businesses need to find new supplies that are cost effective and environmentally sustainable. The reuse of treated wastewater can provide a significant increment of supply for use in nonpotable applications, including irrigation, industrial uses, power plant cooling water, toilet flushing, and many other uses. Treated wastewater, also

PROJECTED INCREASE IN WATER DEMAND 2000-2030 • I-495 PROJECT AREA



Source: MAPC, U.S. Census, MassGIS

known as recycled water or reclaimed water, can also be discharged to large-scale soil absorption systems to help replenish local aquifers. With adequate treatment, reused water can satisfy many water demands. Where there is a greater chance of human exposure, enhanced treatment is required.

The use of reclaimed water can provide many advantages to communities and businesses. Large-scale water reuse will reduce the need for expanding water supplies. Where drinking water quality is affected by well drawdown, water reuse will result in higher quality water for residents. Cost effective water reuse systems will allow business and industry to operate and expand at lower cost. Wastewater treatment facilities will discharge less wastewater and may be able to sell some wastewater back to recycled water users, increasing cost efficiencies. Reduced water demand will result in healthier rivers, streams, and lakes for recreation and wildlife.

Water reuse is a growing trend worldwide. As world population continues to grow, the need for water will grow as well. By the year 2000, 2.85 billion people were living in urban regions and by 2030 that number is predicted to rise to nearly 5 billion. In the United States, population growth in urban areas of the western states has led to an increasing conflict between traditional agricultural and livestock water users and the growing cities' needs for drinking, industrial, recreational and environmental water supplies. This growth will mean a corresponding increase in the production of wastewater. Throughout the world, many communities have reached or surpassed their available water supplies. Water reuse and reclamation are essential to increasing and conserving existing water supplies.

Water reuse has increased steadily in the last decade in water-deficient areas such as Australia, the Middle East, parts of Latin America and the Mediterranean but also in temperate regions and countries such as Japan, Belgium, England and Germany. The need for water reuse is now recognized internationally but implementation depends on political willingness to invest in reuse infrastructure projects. Irrigation is still the principal form of water reuse worldwide but nonpotable, commercial reuses, as well as industrial and indirect recharge of water supplies by nonpotable reuse are also increasing rapidly in densely populated urban areas.

Florida and California lead the nation in water reuse. In 2000, Florida's Water Reuse Inventory showed 431 reuse systems in service producing 584 million gallons per day (mgd) of reclaimed water for various uses. Sixty-four percent of reclaimed water is used for both public (44%) and agricultural (19%) irrigation purposes. California uses 48% of the 358 mgd reclaimed water it produces each day for agricultural irrigation and 12% for groundwater recharge projects.

In the United States, wastewater is generally required to be treated to at least the Secondary Treatment Level to be used. The US Environmental Protection Agency (EPA) regulates many aspects of wastewater and drinking water quality and 26 states currently allow for some uses of treated wastewater. Interim Guidelines established in 2000 by the Massachusetts Department of Environmental Protection allow water reuse for the following uses:

- Spray irrigation of golf courses;
- Landscaping;
- Recharging Zone II aquifers in distressed areas or areas with low stream flow; and
- Toilet flushing in commercial properties.

BENEFITS OF WATER REUSE

- Providing an increment of supply for growing communities in stressed basins where increasing withdrawals past the current Water Management Act limits are not likely to be permitted easily.
- Providing an option for wastewater disposal. Wastewater disposal can be a limitation for commercial sites, even if they use package treatment plants with tertiary treatment, since the amount of land necessary for subsurface disposal is cost-prohibitive. Reuse of treated wastewater will reduce the amount of wastewater that needs to be disposed of, making development more feasible and reducing the amount of land that must be dedicated to soil absorption systems.
- Providing a cost-effective supply for industrial users with large-scale demand for nonpotable water, for industrial uses, cooling water, or toilet flushing.
- Reducing the community impact of large developments. Large industrial developments or irrigation-intensive uses such as golf courses may meet stiff community opposition due to water demands. Use of reclaimed water will help to address these concerns and will increase community support.
- Decreasing the diversion of freshwater from sensitive ecosystems. Water diversions for agricultural, commercial and industrial purposes can leave fish, wildlife and plant life with insufficient water flow to support healthy life and reproduction. By supplementing water demands with reused water, water users can leave adequate amounts of water for other environmental users and vital ecosystems.

- Reducing or eliminating treated wastewater discharges into sensitive water bodies will reduce negative environmental impacts. For example, salt marshes can be negatively affected by large, artificial releases of fresh water; water reuse reduces the amount of wastewater discharge, helping to preserve the natural chemistry of the receiving water body.
- Using recycled water to create or enhance wetlands and stream habitats. In some cases, recycled wastewater can be used to help augment natural wetlands functions in areas where impairment has occurred from water diversion.
- Water recycling can reduce and prevent pollution. When water is reused instead of being discharged into a river, ocean or other water body, pollutant loadings to these bodies are lessened. Substances such as the excess nutrients often found in wastewater can be used to reduce the amount of fertilizer needed if the wastewater is reused for irrigation.

COMMERCIAL WATER REUSE

Most water reuse applications allowed in Massachusetts are for commercial water reuse, including irrigation for golf courses and commercial nurseries; and toilet flushing in non-residential developments. Most commercial water reuse relies on dual distribution systems that convey treated wastewater to the location of reuse. Distribution pipes for recycled water are generally purple to distinguish them from potable supplies. If incorporated early into project plans, a dual distribution system can be cost-competitive with a conventional system, especially when water rates are high or nonpotable uses are a large component of the projected total water use.

Retrofitting a developed area with a dual distribution system can be more expensive than initial construction, but can be cost effective if installation prevents a municipality from having to obtain additional potable supplies from a great distance, treat a raw water supply of poor quality (e.g. seawater desalinization), or comply with stricter wastewater surface discharge requirements.

Other types of commercial reuse include:

- Irrigation of public parks and recreational centers, athletic fields, school yards, and playing fields; highway medians and shoulders and landscaped areas around public buildings
- Vehicle washing facilities, laundries, window washing, and water mixed for pesticides, herbicides, and fertilizers
- Fountains, reflecting pools and waterfalls
- Dust control and concrete production
- Fire protection
- Fountains, reflecting pools and waterfalls

Commercial Reuse Issues:

- Commercial reuse can often involve a decision on whether to extend dual water distribution systems to new development, or to retrofit.
- Determining reclaimed water demand:
  - Need to evaluate acreage to be irrigated and rate of irrigation
  - Use of water records to estimate seasonal variations in water demand
  - Permitted withdrawal rates/pumping records
  - Commercial use determined from water bills
  - Determine amount needed to fill recreational pools, ponds, etc.
- Public Health and Reliability Protection Issues:
  - Reused water must meet water quality requirements for intended use
  - Prevent improper operation of system: cross-connections with potable water lines: purple designated for reclaimed water lines
  - Clear marking and signage of above ground facilities
- Design Considerations at Water Reuse Facilities and Reclaimed Water Distribution:
  - Need for higher level of treatment for many commercial water reuses requires filtration and disinfection beyond secondary treatment
  - Onsite storage of treated wastewater: ground or elevated tanks
  - Possible need for large seasonal storage capacity: aquifer storage
  - Distribution systems must be sized to meet peak hourly demands
  - Computer modeling aids in design of transmission system
- Studies have shown that landscaped plants often grow faster using reclaimed water instead of potable water. However in some cases, elevated levels of chlorides in reused water have limited the types of foliage that can be irrigated.

COMMERCIAL WATER REUSE, MASSACHUSETTS CASE STUDY:

Gillette Stadium, Foxborough, MA

Home of NFL's New England Patriots

The Applied Water Management Group of American Water designed and operates this membrane treatment plant that recycles water at the Patriots' 68,000-seat Gillette Stadium.

Project Profile

- Initial Service Date: 2002
- Gallons Per Day: 250,000 (expandable to 1.1 million)
- 3,500 gallons per minute submersible lift station
- 2.4 acre leach field
- Reclaimed water to be utilized for toilet flushing in the stadium
- Town of Foxborough built a 500,000 gallon elevated storage tank
- Water savings of 65%
- $5,500,000 capital cost

AWM Photos/Figures

Background

Background: In 1991, the management of the New England Patriots decided to replace Foxborough Stadium, which had been built in 1971. The new stadium water use was projected to increase as much as 600,000 gallons per day during home games. The increase in wastewater would overwhelm the town of Foxborough's wastewater treatment system and the need for potable supplies would severely stress the town's well fields/storage tank system. To address these concerns, the town worked with MA DEP, the engineering firm EarthTech, and the Patriots' consultant, Rizzo Associates to design and build a larger water storage/delivery system and a wastewater reuse system to reduce demand for potable water.

For water supply, the town built a one million gallon elevated holding tank at the new stadium and added 10,000 feet of new water mains. In addition, a .25 million gallons per day wastewater treatment plant with subsurface disposal was built. For wastewater treatment the plant utilizes a membrane bioreactor filtration system, ozone treatment for color removal and ultraviolet light disinfection. The treated wastewater is pumped to a 500,000 gallon elevated storage tank or to the plant's 2.4-acre leach field. About 60% of the stadium's wastewater gets reused for toilet flushing in the facility. Subsurface disposal of remaining treated effluent helps to recharge groundwater as indirect potable augmentation.

Contact: Applied Water Management Group, New England, 508-675-575

COMMERCIAL WATER REUSE, MASSACHUSETTS CASE STUDY:

Wrentham Premium Outlet Mall at Wrentham, MA

Water treatment and reuse is provided for a 575,000-square foot outlet center, a 550-seat food court, mall management offices, and a 450-seat restaurant. Onsite wastewater treatment plant recycles wastewater as flushwater. Subsurface disposal recharges groundwater.

Project Profile

- Initial Service Date: 1997
- Total Wastewater Treatment Capacity: 100,000 gallons per day
- Population Served: Varies
- Recycle/subsurface disposal
- 50% effluent recycled
- 75% recycled effluent used for toilet flushing, 25% to recharge groundwater
- The town avoids the cost of buying 50,000 gallons per day potable water

AWM Photos/Figures

Background

Background: The 130-store mall was the first commercial water reuse project permitted in Massachusetts. Because of the lack of sewers in this portion of Wrentham, the town, MA DEP, and the developer's wastewater consultant, Applied Wastewater Management (now owned by American Water) chose to use an on-site wastewater disposal system. Wastewater recycling was incorporated into the wastewater system to minimize effluent disposal impacts on the environmentally sensitive land where the plant would be located.

The plant treats the wastewater using a trash trap, an equalization chamber, a series of aerobic digestion chambers and a membrane filtration system to separate solids from liquids. The water is further cleaned by carbon adsorption and disinfected using ultraviolet light. The plant, which measures 34 x 96 feet, is located next to the mall's parking area—underneath which the treated effluent not used to flush toilets in the mall is recharged into the groundwater below. Town officials had originally planned to build some sort of wastewater treatment system for the mall and feel that the reuse of treated wastewater is the most cost effective way to maximize water resources used by the mall.

Contact: Applied Water Management Group, New England, 508-675-5755

COMMERCIAL WATER REUSE, MASSACHUSETTS CASE STUDY:

Bayberry Hills, Yarmouth

The town of Yarmouth, working with consultant Camp, Dresser and McKee (CDM), developed a solid waste master plan in 1995 as part of the town's 55-acre Old Town House Road Landfill closure project. The plan called for expanding the town-owned Bayberry Hills golf course on top of the landfill and utilizing effluent from the adjacent Yarmouth-Dennis septage treatment plant as the irrigation source for seven of the new holes. The seven holes require approximately 18 million gallon of irrigation water per year. Yarmouth's water supply was already stressed during peak summer use periods and the town began to work with MA DEP and CDM to explore how potable water demands could be reduced while still allowing the town to expand it golf course. This project was partially funded under the State Revolving Fund (SRF) and was the first golf course project in Massachusetts to be permitted to utilize reclaimed water as its irrigation water source.

Project Profile

- Initial Service Date: 2001
- Total Wastewater Treatment Capacity: Up to 21 Million Gallons per Year (MGY). Typical range: 8-12 MGY: 22,000 gallons per day – 33,000 gallons per day
- Percent of Effluent Reuse: Typical Range : 40 – 70%
- Recycled water is used primarily for irrigation and groundwater recharge

CMD photo

Background

There are two effluent application sites associated with this project. The first leaching area (Buck's Road) is intended primarily for groundwater recharge and allows up to 21 MGY application. The second site at Links for Bayberry Hills allows for up to 12 MGY application of treated effluent and is used mostly to irrigate the golf course. The Groundwater Disposal Permit issued by DEP allows for the water to be used for golf course irrigation to have higher nitrogen content but also calls for more stringent water quality monitoring requirements to protect public health. The higher nitrogen limits the need to apply commercial fertilizers to the golf course.

Contact: Paul Cabral, Camp Dresser & McKee 617-452- 6000

COMMERCIAL WATER REUSE, INTERNATIONAL EXAMPLES:

Aurora Development, Australia

www.cfd.rmit.edu.au/programs/sustainable_buildings/re_imagining_the_australian_suburb

Aurora is a large, 9000-unit residential development, located in the northern suburbs of Melbourne, Australia. Phased construction began in 2003 and is due for completion by 2018. Twenty-five thousand people will live there when completed. It features sustainable development principles that include a plan to utilize recycled wastewater for nonpotable uses. Wastewater from Aurora will be collected, treated and stored in surface water lagoons or aquifers at decentralized wastewater plants and then sent back to individual residences using a separate, metered pipe system for toilet flushing and irrigation. Melbourne and its suburbs already include separate systems for wastewater, stormwater and potable water.

Mawson Lakes Development, Australia

www.wikipedia.org/wiki/Mawson_Lakes,_South_Australia

Mawson Lakes is an urban, mixed-use development near Adelaide, Australia for up to 9,000 residents. The key objective of the water reuse system is to reduce household potable water demand by at least 50% by using reclaimed stormwater, and wastewater, for all needed forms of irrigation in the development. Collected stormwater will be mixed with treated stormwater and then stored in groundwater aquifers for later irrigation reuse. Houses at Mawson Lakes will all have separate plumbing for potable and nonpotable sources and the reused water will be used for toilet flushing, garden irrigation, and car washing. Stormwater will be harvested from the 1500-acre development site plus another piece of adjoining land of the same size, treated by trash-traps and wetland basin detention areas and then released for storage into established and constructed wetlands near the development site.

INDUSTRIAL WATER REUSE

Industrial water reuse is increasing due to water shortages, population increases and passage of legislation allowing its use. The largest users are utility power plants, petroleum/coal refineries, chemical plants, metal working facilities, paper mills, textile industry and tanneries. Cooling water and industrial processing water make up the two largest users of reclaimed water for industrial use. Currently it is used mostly in California, Arizona, Texas, Florida and Nevada as they have installed reclaimed water distribution lines.

In Massachusetts, EMC currently uses five percent of its reused water for industrial cooling purposes at its Hopkinton plant and Intel recycles about thirty percent of the water it uses at its Hudson chip making facility. The Brayton Point power plant in Somerset has just begun working with MA DEP to use treated effluent for cooling purposes. Secondarily treated effluent will be used for make up water in the plant's three sulfur dioxide scrubber units. Reuse is targeted to begin in early 2008 for one scrubber and the plant operators hope to be using up to 1.28 MGD for scrubber make up water when full production capacity is permitted and built. In Southbridge, MA a new distribution line conveys treated wastewater to a natural gas power plant for use as cooling water.

Key issues for Industrial Water Reuse include:

- In cooling water systems, the most frequent problems with reused water are corrosion, biological growth and scaling, as some reused water may have higher concentrations of contaminants than in potable water.
- Different industrial processes require various levels of water quality: highly treated water for washing circuit boards vs. less treated water for coal/petroleum and tanning processes

Other Examples of Industrial Reuses:

- The Burbank, California power generating plant uses about 5 million gallons per day of municipally treated secondary effluent for cooling water.
- Las Vegas/Clark County Nevada uses 90 million gallons per day of secondary effluent to supply 35% of water needs in the Nevada Power Company's generating stations. http://www.epa.gov/ORD/NRMRL/pubs/625r04108/625r04108chap2.pdf

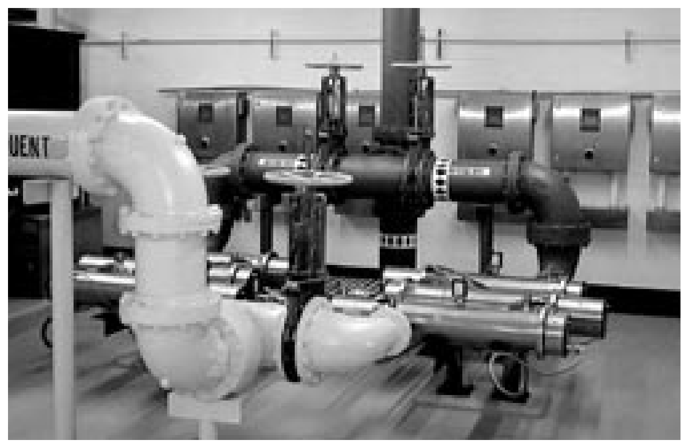
INDUSTRIAL WATER REUSE, MASSACHUSETTS CASE STUDY:

EMC Corporation, Hopkinton

In 1998, EMC planned to add two large engineering facilities at its Hopkinton headquarters, which are located at the junction of three watersheds for the Charles, Concord and Blackstone Rivers. Working with the MA DEP, EMC decided to go beyond environmental compliance and construct a self-distributed wastewater treatment and recycling plant. The two engineering buildings and the wastewater treatment plant extend over nearly one million square feet at the Hopkinton campus.

EMC is Hopkinton's largest water user, which gets its water from its own well fields and from neighboring Ashland. Due to water shortages during summer peak use periods, Hopkinton has banned outdoor water use in five of the last seven summers. The town has credited the EMC water recycling project with removing the strain from the town's water supply system.

Project Profile



- Initial Service Date: 2000
- Total Wastewater Treatment Capacity: 83,500 gallons per day using a sequential batch reactor system
- The plant currently treats about 32,000 gallons per day of wastewater
- 11,000 gallons per day are used in water reuse
- Treatment of wastewater to tertiary stage including ultraviolet processing
- Reclaimed water is used for toilet-flushing (95%) and industrial cooling (5%), with more projected for cooling purposes in the future
- Currently, the wastewater treatment plant is providing recycled water to only one of the engineering facilities

Contact: Kevin Biernacki, Corporate Environmental Health Officer, 508-435-1000

INDUSTRIAL WATER REUSE, MASSACHUSETTS CASE STUDY:

Intel Corporation, Hudson

Intel's semiconductor fabrication facility (Fab17) is a high volume manufacturing plant located in Hudson, Massachusetts. Hudson's town water supply is the primary source of water for Intel manufacturing operations with the ability to provide a safe sustainable 650,000 gallons/day of water. Wastewater discharge is permitted at 600,000 gallons per day.

In the early 1990s, Intel found its desire to expand its Hudson plant limited by the capacity of the Hudson waste water treatment plant to effectively treat phosphorous discharges to the Assabet River. The water conservation strategy of the Hudson site was established when Digital Equipment Corporation's Semiconductor Operations designed its new fabrication facility in the early 1990's. Digital recognized the water and wastewater infrastructure constraints during the initial factory design. They incorporated an Ultra Pure Water (UPW) recycle system that reclaims water used in the manufacturing process and returns it to the UPW system where it is reprocessed for reuse in the manufacturing process.

To meet its permit requirements, Intel planned to recycle more of the water it uses to rinse microchips during manufacturing. To accomplish this, Intel built a state-of-the-art water treatment facility that currently produces about thirty percent of the water used at the facility for industrial cooling purposes. The new plant allowed Intel to boost production fifty percent while decreasing discharge levels to the Hudson wastewater treatment plant. The treatment process also reclaims ninety percent of the phosphorous used in the chip manufacturing process.

The focused attention to managing water use allows the site to maximize the efficiency of the water reclaim and recycle system, successfully recovering approximately 145,000 gallons per day of water from the manufacturing process stream for reuse, conserving 52 million gallons per year. It has also allowed the site to successfully achieve high volume manufacturing within existing wastewater discharge limits.

Contact: Ann Hurd, Intel Public Affairs Officer, 978-553-4000

For more information:
Global Citizenship Report: http://www.intel.com/intel/finance/gcr04/
Environmental, Health & Safety: http://www.intel.com/go/ehs
Community: http://www.intel.com/community

AGRICULTURAL WATER REUSE

Irrigation for agricultural uses accounts for 75% of total water use worldwide. More than 80% of all water use in Montana, Colorado, Idaho and California, the top four states for irrigation, is for agricultural irrigation. Agricultural irrigation in California accounts for 48% of all reclaimed water use in the state. Numerous studies have shown reclaimed water to be as safe to use for irrigation as well water and that yields of crops tend to be higher using reused water for irrigation. The Massachusetts Interim Guidelines on Reclaimed Water of 2000 do not allow the use of reclaimed water for agricultural purposes.

Key issues for agricultural water uses include:

- The ability to accurately estimate agricultural irrigation demands as part of an overall water reuse program. High agricultural demands for water can equal significant benefits offered by water reuse in this area.
- Reclaimed water quality. Depending on treatment levels, reused water may have higher salinity, sodium, chlorine, trace elements and nutrient levels than groundwater or surface water supplies. Different plants and crops have varying levels of tolerance.
- Levels of these elements depend on municipal water supply, waste streams being treated by the municipal waste water plant, and the type of storage facilities used. Examples of potential problems include:
  - Higher Total Dissolved Solids (TDS) in reused water = higher salinity
  - Saltwater intrusion into sewage systems in coastal areas = higher chloride levels
  - Household detergents and fabric softeners contribute excess sodium and chloride to reused water
  - Trace elements at elevated levels of greatest concern are copper, cadmium, molybdenum, nickel and zinc. Studies have shown that the input of these heavy metals from commercial fertilizer were much greater than that contributed by reused water.
- Other issues with agricultural water reuse include the modification of current best practices to include:
  - System reliability. Treatment and distribution systems must operate reliably to provide needed water quality and quantity
  - The use of site use controls such as buffer zones around application areas, restricted application times and site access
  - Monitoring requirements. Groundwater monitoring wells are often required under state regulation at the application site and should be included in any capital cost/ benefit estimation.
  - Runoff Controls. The use of reclaimed water for agricultural irrigation may require runoff controls or a National Pollution Discharge Elimination System (NPDES) Permit.

- Marketing Incentives. The use of reclaimed water must offer benefits to potential users and be economically competitive with existing irrigation practices. Subsidizing reused water rates may prove less expensive to a reused water supplier, such as a municipality, if reuse allows the supplier to avoid higher wastewater treatment and disposal costs.

Example of Agricultural Reuse

- "Integrated on-farm drainage practices" in California's San Joaquin Valley include trying new subsurface drainage techniques for reused water irrigation practices. Reclaimed water is used on more salt-tolerant crops and the final discharge water goes to solar evaporators to collect the dry agricultural salt. http://cati.csufresno.edu/cit/upda/99/summer/halophytes.html

France

France is considered to be water self-sufficient but water resources are distributed unevenly throughout the country, as in the United States. Demand for water has increased 21% since 1994, primarily due to more agricultural land under irrigation. Resort areas with golf course and irrigation needs have increased as well but the need for industrial water and domestic uses has declined over the same ten year period as water efficiency in these sectors has increased.

- An example of integrated water management and water reuse is Noirmoutier Island which combines intensive agricultural needs with a ten-fold increase in tourist populations in the summer season. Treated effluent (1.6 million gallons per day) is stored in maturation ponds for disinfection and storage: 30% is used for the 1,235 acres of local vegetable crops, helping to reduce the need for potable water by nearly .5 million gallons per day.

ENVIRONMENTAL AND RECREATIONAL REUSE

Since 1800, over 50% of the wetlands in the continental United States have been destroyed for uses such as agriculture, mining, forestry, and urbanization. Wetlands provide a wide array of functions including flood storage, wildlife habitat, food chain productivity support, aquifer recharge and water quality improvement. In addition, wetlands provide water conservation by regulating the rate of evapotranspiration. Environmental reuses of treated wastewater include wetland enhancement and restoration and constructed wetlands for wildlife habitat and stream augmentation.

Constructed wetlands are effective in the treatment of Biological Oxygen Demand (BOD), Total Suspended Solids (TSS), nitrogen, phosphorous, pathogens, metals, sulfates, organics, and other toxic substances. Recreational applications for reused water include golf course water features as well as water impoundments for boating, wading, and swimming.

California used 10% of its reclaimed water for recreational and environmental purposes as of 2000. Florida uses 6% of its recycled water for wetland enhancement and restoration only. Examples of environmental water reuse include the city of West Palm Beach, Florida wetlands reclamation project and the Eastern

Municipal Water District constructed wetlands in Riverside County, California. In Yelm, Washington, the community created an 8-acre city park made up of submerged and constructed wetlands that "polish" reclaimed water before recharging it to groundwater. http://www.ecy.wa.gov/news/2002news/2002-012

Key issues for constructed wetlands water reuse include:

- Significant land use requirements
- Limited application in urban settings
- Potential for nuisance vegetation and algae
- Wetlands may need to be lined to maintain water retention period

GROUNDWATER RECHARGE REUSE

The primary uses for reclaimed water involving groundwater recharge include establishing saltwater intrusion barriers in coastal aquifers, to provide further treatment for future water reuse, to supplement existing potable or nonpotable water supplies, and to control or prevent groundwater subsidence. The pumping of groundwater in coastal aquifers in coastal areas can result in saltwater intrusion and make the supply nonpotable. Reclaimed water can be directly injected into the aquifer to prevent intrusion by saltwater. Infiltration of reused water takes advantage of natural removal mechanisms and filtering provided by the soils and provides additional treatment of reused water. In addition, groundwater aquifers can store reclaimed water for seasonal peak use and avoid the need to build costly surface storage facilities.

The Los Angeles County Sanitation Health Districts Study of 1978- 1984 to measure the health effects of using treating wastewater for groundwater recharge indicated no measurable adverse effects on area groundwater or health of the people ingesting the water.

Massachusetts allows effluent treated to the tertiary level to be used for groundwater recharge in stressed river basins. Groundwater recharge and reducing the need to provide water from expensive, stressed or distant water supplies is a key component of the EMC, Intel, Gillette Stadium, Wrentham Mall, Yarmouth, and Kingston reuse projects.

Methods of groundwater recharge include:

- Surface Spreading: A direct method of recharge in which the reused water is infiltrated and percolated directly into the aquifer
- Soil Aquifer Treatment Systems: all reclaimed water is recovered using well, drains or seepage into surface water. SAT systems tend to remove more Biological Oxygen Demand than Surface Spreading, so secondary treatment of effluent may not be required for nonpotable reuses.
- Vadose Zone Injection: Designed in the 1990s, these wells are economical alternatives to expensive SAT systems but can clog easily and effluent requires more pretreatment compared to SAT.
- Direct Injection: Used to direct reclaimed water directly into confined aquifers where the soils are not conducive to surface spreading. Effluent must be treated beyond the secondary level to avoid contamination of the aquifer.

Groundwater Recharge Reuse issues include:

- Large amounts of land may be needed for groundwater spreading basins and for the operation and maintenance of a ground water supply system.
- The cost of treatment, water quality monitoring and injection/infiltration facilities may be quite high.
- Insufficient treatment of reused water for groundwater recharge can lead to aquifer contamination.
- Some recharged water may migrate beyond the aquifer and not be retrievable for future use.
- Geologic faulting and transmissivity of the aquifer may reduce the effectiveness of the recharge project.
- Current groundwater laws may not provide protection for groundwater recharge project and may present liability issues for the water supplier.

GROUNDWATER RECHARGE REUSE, MASS. CASE STUDY:

Indian Pond Estates, Kingston

Kingston is a coastal, residential community about 30 miles south of Boston. Development pressure has increased in recent years in conjunction with the advent of rail service to Boston. Failing septic systems in the densely populated Rocky Nook section of Kingston threatened water in the Jones River watershed and Kingston Bay. In addition, town wells within the Jones River watershed were being overdrawn during peak summer use. The town hired consultant Camp, Dresser and McKee in 1997 to draft a wastewater facilities plan. Subsequently, Kingston chose to construct its first wastewater treatment plan and sewers in or near sensitive ecological areas and groundwater.

The town had planned to site the wastewater treatment plant near its solid waste transfer station but found that effluent disposal would cause groundwater to rise under the town's landfill and contribute to nutrient and hydraulic overloading at a nearby cranberry bog. Faced with constraints for subsurface disposal, the town chose to use part of the treated effluent for irrigation at the proposed golf course at the Indian Pond Estates and Country Club during the growing season while the rest would go to a subsurface leaching field. The treated, reused water sent to the leaching field helps to recharge the aquifer system that supplies the town's drinking water wells, private wells, vernal pools and surface water base flow. The leaching field provides disposal when irrigation is not needed and if water quality did not meet acceptable criteria to be used for irrigation.

Project Profile

- Initial Service Date: 2001: The plant has been permitted and built but contractual and legal agreements are still being worked out and the plant is not yet in operation.
- Total Wastewater Treatment Capacity: 375,000 gallons per day
- Recycle/subsurface disposal of effluent treated to tertiary level including UV treatment
- Total Project Cost: $29.5 million: $10.5 million for plant , $19 million for sewers

Contact: Donald Freeman, Camp Dresser & McKee, 603-222-8371

AUGMENTATION OF POTABLE SUPPLIES REUSE

Indirect potable augmentation supplements a community's raw water supply by adding treated wastewater to it and then filtering both through an environmental buffer prior to final drinking water treatment. Direct potable reuse is the introduction of treated wastewater into a water distribution system without intervening storage, such as in an aquifer. Indirect potable reuse using water drawn from river water sources have been used for many years in Philadelphia, New Orleans, and Cincinnati. Municipal water systems treat surface water augmentation using conventional drinking water treatments. Surveys indicate that the public will accept many types of nonpotable reuses of water but not potable reuse. Indirect potable reuse is more acceptable as the water is felt to be cleaned as it moves through an environmental buffer such as a river, aquifer or lake.

- Direct potable reuse is currently used only in one city in the world, Windhoek, Namibia.
- Most potable reuse research is occurring in Denver, Tampa and San Diego in the United States.
- The portion of potable water used in a community is small in proportion to other uses and the use of reused water to replace potable water will free more high quality water for future use.

Issues with Augmentation of Potable Supplies Reuses include:

- Potential impacts to human health become harder to define when reclaimed water and domestic water supplies come into contact. Traditional water supply policy mandated strict separation between wastewater and water supply as the primary means to protect public health.
- The National Primary Drinking Water Regulations under the Safe Drinking Water Act were not designed to measure reclaimed water, even if it meets the regulatory standards.
- Current analytical wastewater testing methods are insufficient to identify potential contaminants at concentrations that may impact human health.
- Traditional wastewater practices were not designed to treat water supplies for the many chemicals that have been introduced into the environment in the last 50 years.
- Although wastewater treatment beyond the tertiary stage and environmental filtering/storage seem to provide additional protection against organic contaminants, the detection, measurement and effects of these possible contaminants will remain a concern until water testing sophistication is able to detect and treat them.

AUGMENTATION OF POTABLE SUPPLIES: INTL. CASE STUDY

United Kingdom

http://www.iemss.org/iemss2002/proceedings/pdf/volume%20uno/105_jeffrey.pdf

http://www.epa.gov/ORD/NRMRL/pubs/625r04108/625r04108chap8.pdf

A severe drought in southeast England during the early 1990s convinced water planners that global climate change was occurring and that water supplies had to be made more efficient and new sources incorporated. The United Kingdom has long pumped water upstream from existing sewage treatment plants to help augment potable and nonpotable water uses. In 1997, the British National Rivers Authority permitted the first European indirect potable reuse project at the Hanningfield Reservoir. Treated sewer effluent is being used to augment flow in the River Chelmer and to augment the 875-acre, raw water reservoir in Essex, England.

- Effluent is treated by ultraviolet light and then sent to Hanningfield Reservoir for additional cleaning /residence time of up to 214 days. This is followed by advanced potable water treatment.
- Up to 7.9 million gallons per day of the treated effluent is then discharged into the River Chelmer, withdrawn, treated and used for drinking water supply.

TECHNICAL ISSUES AND COST CONSIDERATIONS

Issues to consider when planning for the reuse of treated wastewater would include:

- Identification and characterization of potential demands for reclaimed water
- Determining the potential for existing sources of reclaimed water
- Investigating the level of treatment necessary for the intended water reuse application
- Estimating the amount of storage capacity needed to balance seasonal water demand with supply and incorporating reused water supply into that amount
- Determining what supplemental facilities such as distribution systems, alternative supplies and disposal facilities should be included as part of a wastewater reuse project or system
- Identifying possible environmental impacts of implementing water reclamation
- Possession of adequate skills and knowledge to operate, maintain and train others in the use of reclaimed water systems

SUGGESTED WATER RECYCLING TREATMENT AND USES*

Increasing level of treatment →

Wastewater Collection System

↓

Primary Treatment: Sedimentation → **Secondary Treatment:** Biological Oxidation, Disinfection → **Tertiary/Advanced Treatment:** Chemical Coagulation, Filtration, Disinfection

Primary Treatment:

- No uses Recommended at this level

Secondary Treatment:

- Surface irrigation of orchards and vineyards
- Non-food crop irrigation
- Restricted landscape impoundments
- Groundwater recharge of nonpotable aquifer**
- Wetlands, wildlife habitat, stream augmentation**
- Industrial cooling processes**

Tertiary/Advanced Treatment:

- Landscape and golf course irrigation
- Toilet flushing
- Vehicle washing
- Food crop irrigation
- Unrestricted recreational impoundment
- Indirect potable reuse: Groundwater recharge of potable aquifer and surface water reservoir augmentation**

Increasing level of human exposure →

* Suggested uses based on Guidelines for Water Reuse, developed by U.S. EPA.
** Recommended level of treatment is site-specific

Source: EPA Guidelines for Water Reuse 2004

Basic Water Reuse Cost Issues

Funding a water reuse facility involves significant capital expense. Some of the key issues to be aware of when planning for such a facility can include:

- Capital improvements at the wastewater treatment plant to incorporate water reclamation
- The additional cost of installing new reclaimed water transmission lines to identified agricultural, commercial and recreational reuses
- Operational, maintenance and replacement costs for power, water quality monitoring requirements, and administrative costs such as billing
- Enhanced cross-connections prevention program and public education program cost
- A water reuse contingency plan. Even if reused water saves your utility money by creating a cheaper way to dispose of waste water and augment water supplies, a utility should have a plan on how to conserve its reused water supplies.
- A supplier should be prepared to deal with the associated drop in revenues from reduced potable water use if reused water becomes available in its place, especially if the water and wastewater systems are owned by different utilities

Determining Cost Effectiveness and Benefits of Water Reuse

There are a series of decision-making tools that can be used when considering the addition of water reuse as a way of adding water supply or decreasing demand. Evaluation steps include:

- Cost-Effectiveness Analysis
- Cost/Benefit
- Financial Feasibility

Cost-effectiveness is the comparison of several alternatives to measure the effectiveness of each alternative with regard stated criteria. Alternatives are ranked on their ability to achieve the same result. For example, a community might have a goal of producing additional water production either by reducing demand or adding supply. Adding additional potable water supply could be weighed against refitting a wastewater treatment plant for water reuse and against taking no action whatsoever. Benefits from adding reclaimed water could include:

- The reduction of nutrient-rich effluent discharges to local wastewater systems
- The avoided/delayed cost of expanding water supply and treatment facilities
- Delay in having updating of potable water treatment cost
- Delay or elimination of updated to the existing wastewater treatment systems

Once the most effective and feasible alternatives are selected, the process moves to a cost benefit analysis, which considers what the economic impacts of the alternatives would be on various groups such as industrial, commercial, and residential users. This would present the relationship of water demand to current price and look at impacts when water is abundant (cheaper) and scarce (more costly). This step will help determine what the present value of each alternative is and whether or not it is affordable. For example, looking at impacts to all users under various water price scenarios can help compare the cost of expanding water reuse in a community versus the cost of traditional sewer effluent disposal and increasing potable water supplies.

REGULATORY OVERVIEW

There are currently no federal regulations that deal with the reuse of treated wastewater. The EPA's *Guidelines for Water Reuse*, published in November, 2004 can serve to help shape a wastewater use program at the state or local level. Twenty-five states had adopted regulations for water reuse programs by the end of 2002, sixteen states had guidelines to aid in developing wastewater programs and nine states had no regulations or guidelines. In these states, wastewater cases are sometimes permitted on a case by case basis.

Most states do not have regulations that cover all possible uses for reclaimed water. Almost all of the current state regulations and guidelines address commercial and agricultural uses only. Regulations tend to be in the same categories named in the Types of Systems section of this report, ranging from unrestricted/restricted commercial uses such as irrigation of parks and golf courses to groundwater recharge and indirect potable reuse. A complete list and review of the reuse types is as follows:

- Unrestricted commercial reuse-irrigation of areas where public access is not restricted: parks, playgrounds, school yards, residences, toilet flushing, fire protection, air conditioning, public fountains
- Restricted commercial reuse: irrigation of areas with controlled public access: golf courses, cemeteries, highway medians
- Agricultural reuse on food crops: irrigation of food crops for human consumption, either raw or processed
- Agricultural reuse on non-food crops: fodder, fiber, seed, pasture, commercial nurseries
- Unrestricted recreational use: impoundment of reclaimed water with no public contact restrictions
- Restricted recreational use: limited to non-contact activities such as fishing or boating
- Environmental reuse: reclaimed water for constructed wetlands, enhance natural wetlands or to augment stream flow
- Industrial reuse: cooling systems, boiler feed water, processing water and washdown
- Groundwater recharge: infiltration basins, percolation ponds or injection wells to recharge aquifers
- Indirect potable use: discharge of highly treated water into surface waters or groundwater for potable uses

Massachusetts Water Policy

Although Massachusetts receives 44 inches of precipitation on average every year, the thin, discontinuous aquifers in eastern and central Massachusetts and the bedrock aquifers of the western portion of the state often limits overall storage capacities. Much of our precipitation runs off or is disposed of as unused stormwater. In dry years, surface water supplies often can not meet seasonal demand uses and aquifers are not fully recharged. Land use practices often deplete water recharge capacities further by mandating large lot, single-family residential style construction which decreases watershed recharge areas by increasing impervious areas and soil compaction through road and driveway construction and lot clearing. Most current land use regulations also contribute to the depletion of local water supplies by mandating the piping of stormwater away from individual lots rather than infiltrating onsite. Development in outlying areas with thin, wet or rocky soils often eventually leads to the net exportation of water outside of a local watershed when septic systems fail and the area is sewered.

In 2004, the Massachusetts Secretary of the Executive Office of Environmental Affairs convened a Water Policy Task Force to help develop a state water resource management policy that effectively mirrors the current administration's Smart Growth goals. The basic principles of Smart Growth include repairing existing infrastructure vs. constructing new; encouraging compact, mixed-use, transit-oriented development; and proactive protection of future water supplies and critical water resources.

The Water Policy seeks to advance the following principles:

- Keep water local and seek to have municipalities live within water budgets from a local watershed perspective
- Protect clean water and restore impaired waters
- Protect and restore fish and wildlife habitat
- Promote development strategies consistent with sustainable water resource management

The principles of the new state Water Policy are intended to unify and build upon the regulatory framework now governing Massachusetts water use, using the Federal Clean Water Act as its foundation. Current regulations and guidelines include:

- 1996 Water Supply Policy
- Interim Inflow and Infiltration Policy
- Wetlands and Stormwater Policies and Guidance
- Water Management Act
- Interbasin Transfer Act

Recommendations of the Water Policy Task Force

The 2004 Water Policy Task Force report recognizes the importance of reusing water more effectively in Massachusetts. Under Recommendation 4 (Increase Treated Wastewater Recharge and Reuse), the Water Policy recommends the following actions:

- "Create a working group including DEP, the Office of Technical Assistance (OTA), Massachusetts Association of Boards of Health (BOH) and representatives of consultancies, municipalities, and commercial properties to review current treated wastewater disposal policies and practices and to recommend ways to augment reuse and recharge efforts."
  - Encourage communities expanding or building new wastewater treatment plants to use treated wastewater to recharge groundwater aquifers
  - Research wastewater reuse efforts in other states, especially technologies in removing pharmaceuticals and organics from wastewater
  - Identify suitable sites for groundwater recharge and create incentives to use them
- "Recommend that Boards of Health track and regulate septic system maintenance to extend septic system life and maintain proper performance. Furthermore, provide specific recommendations to guide BOH work after assessing the performance of the SEPTRACK electronic data sharing effort in Buzzards Bay and the septic system management system in Gloucester."
- "Actively promote reclaimed water reuse at specific recreational and venues and new large development sites."
  - Encourage use of reclaimed water at state maintained properties, ball parks, golf courses and large scale developments through the Massachusetts Environmental Protection Act (MEPA) review process and relevant grant programs
  - Work with developers and consultants to develop guidance documents for distribution to the Department of Housing and Community Development and through technical assistance.

Recommendation 9 in the Water Policy advocates to "develop clear guidance and planning materials (including the "Growing Smarter Tool Kit") to help municipalities, developers and consultants advance development that reduces negative impacts on the environment."

- Action (b) under this Recommendation "Seeks legislative approval to expand the mission of the Massachusetts Office of Technical Assistance (OTA) from that of providing technical assistance exclusively to businesses to include technical assistance to communities, developers and consultants." OTA currently offers a range of assistance and information to help facilities improve water use efficiency, comply with federal and state regulations, reduce wastewater discharge and implement other effective water conservation measures. These services include site visits to facilities by OTA staff, workshops designed for facilities and for municipalities, and publications such as a list of best management practices for industries and case studies, which highlight successful water conservation attempts by industry.
  - OTA is developing an initial focus on proactive water conservation services and assistance to help municipalities focus on their industrial water users so that these industries can maintain a flexible manufacturing operation using less water. Additional outreach and education tools for municipalities will be developed to help them develop conservation strategies for businesses based on policy and effective controls for industry sectors. In the course of working with municipalities, OTA will establish relationships and collect information about areas of need, creating the basis for further expansion of OTA's services.

Regulatory Constraints and Disincentives for Water Reuse

The Massachusetts EOEA published its revised Interim Guidelines on Reclaimed Water in January of 2000. Massachusetts is one of sixteen states that currently have guidelines in place on reclaimed water use. EOEA researched the reuse programs of other states and developed guidelines that allow for the following uses:

- Spray irrigation of golf courses (restricted commercial reuse)
- Landscaping at commercial nurseries (agricultural reuse on non-food crops)
- Recharging of aquifers in basins, sub-basins and watersheds acknowledged to be stressed water resource areas, where it is necessary to replenish streamflow, enhance the productivity capacity of an aquifer, and/or improve or mitigate water quality problems (groundwater recharge, indirect potable reuse)
- Toilet flushing in commercial applications only (restricted commercial reuse)

The Massachusetts Department of Environmental Protection is currently evaluating the use of reclaimed water for irrigation in public parks and playgrounds, landscaping in nonresidential developments and cemeteries, highway landscaping and cooling water for industrial reuses. Although the state has convened a Water Reuse Task Force to review current policy (as suggested in the 2004 Water Policy), until the task force completes its work, water reuse options remain limited to the four practices listed above.

Other possible constraints and barriers could include:

- MA Plumbing Code does not make provision currently for allowing separate transmission lines for reclaimed distribution
- Lack of regional water supply and wastewater authorities in Massachusetts beyond MWRA to provide public education, create regional water plans incorporating water reuse, coordinate municipalities, arrange financing alternatives, operate and maintain plants
- Water supply and waste water planning/ implementation are often not administered together locally at the local level- lack of coordinated water resource management.
- Administrative and regulatory inconsistency between Boards of Health, Conservation Commissions and Water Departments could hinder the development of wastewater reuse in Massachusetts.
- Massachusetts zoning law does not require that local zoning comply with community development plans. This can uncouple water use planning from actual land uses and hinder public acceptance of water reuse.
- No-growth advocates tend to view the addition of any additional water supply as a ticket to unlimited local development and will oppose it unless clear growth constraints are allowed or water capacity limits understood.
- Lack of public education for both town officials and residents as to the potential uses, costs, and benefits of reclaimed water.

RECOMMENDATIONS

- The Water Reuse Task Force should continue to investigate how current water reuse options can be expanded in the state. Reuse such as providing industrial cooling water at reduced cost to business could help with business retention strategies and promote competitiveness.
- Support legislative approval to expand the mission of the Office of Technical Assistance to include providing industrial water recycling, conservation and wastewater reuse technical assistance directly to communities, consultants and developers.
- EOEA should work proactively with communities, businesses and institutions to promote reclaimed water use projects by helping communities to identify specific water reuse sites such as ballparks, golf courses, malls, and other commercial developments as well as state maintained properties.
- The state should consider establishing minimum thresholds for water reuse for the development or redevelopment of any of its properties that can practically accommodate water reuse, and for projects that use state funding, such as schools and housing.
- Work to involve the public and key stakeholders as partners early on in any water reuse project or education effort. Effective outreach methods can include:
  - convening a public advisory committee early in a project's development
  - engaging members of the committee to speak on behalf of the project
- Working in partnership with area non-profits and community officials, conduct a public education campaign on the need for reclaimed water and the benefits it can provide; present successful water reuse projects from US, Massachusetts, and the world. Promote holistic water planning conversations through educational forums on water reuse and integrated water management. Methods can include:
  - developing easy-to-understand information materials and distributing them widely to potential stakeholders
  - including water reuse information on a municipal or group website
  - establishing a project website for any proposed project
  - making presentations to community groups and holding open houses and workshops
  - including water reuse information in water bill mailings
  - taking members of the public and key stakeholders on site visits to successful reuse projects similar to proposed project
- Consider incorporating water reuse education into high school science curriculums to promote local understanding of water reuse. High schools in Pinellas County, Florida worked with water utility officials and county teachers to develop the "Develop a Cleaner Tomorrow" curriculum as part of its core science curriculum and preparedness for state comprehensive assessment tests.
- Maintain a strong public health focus by developing effective operations training for municipal water staff. OTA or DEP could develop and implement a water reuse training program for municipal water supply and wastewater managers which would include site visits to successful water reuse projects to interview managers of these sites.
- Encourage municipal linking of land use and zoning goals with the estimated water

carrying capacity of a community; limits to growth may help alleviate the “no growth” groups within a community when it considers supporting water reuse projects.

- Provide technical assistance to communities to develop and adopt local water reuse bylaws and ordinances; develop and help incorporate model water reuse standards into site plan review, zoning, subdivision and conservation regulations.
- Promote the use of reclaimed water projects by including active or planned reuse projects as a category where a community could gain points under its annual Commonwealth Capital Fund application towards a wide variety of state grant programs.
- Promote the formation of regional water use districts using communities that share water management issues such as the district being proposed by Randolph, Holbrook and Braintree. Regional water districts could supply and treat water more efficiently and help offset the cost of developing water reuse facilities and increase water supply.
- Consider incorporating water reuse standards and cost benefit analysis of potable water use vs. reclaimed water use into the MEPA review process for projects over a water use threshold.

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