# Best Management Practices for
# Commercial and Institutional Water Users

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## Executive Summary

The purpose of this guide is to provide best management practices and technologies that can help reduce water and wastewater costs while conserving our state's most precious resource. The following BMP recommendations summarize the contents of the document. Each recommendation is expanded upon in subsequent chapters.

1. Develop uniformity in determining the total cost of water for performing cost analyses for water conservation projects. The water cost elements include water, wastewater, water and wastewater treatment, energy and special situation costs and perform the analyses on a life cycle basis.
2. Develop a technical systematic approach to examine water use activities to reduce consumption and total costs in commercial and institutional operations. Balance water, wastewater, energy and related costs to achieve the lowest life cycle costs when purchasing new equipment, replacing old equipment or making modifications to existing equipment.
3. Consider water and wastewater utility needs, including existing and future conservation programs, along with rebate and funding opportunities when preparing water conservation programs.
4. Develop a water conservation program at the facility level integrating water efficiency goals with public relation marketing to motivate commercial and institutional facility managers and owners.

# 1.0 Introduction

Water and wastewater rates have risen twice as fast as energy costs over the last 20 years and the trend does not appear to be changing. These rapidly rising costs and increasing limits to water availability in the future mean that all Texans will need to find ways to use water more efficiently. As the 2017 Texas Water Plan clearly states, water efficiency is necessary in meeting the future water needs of Texas.

In the past, many utility based water conservation efforts have focused on single family residential water users. However, thirty percent (30%) of municipal water used is used by conventional commercial and institutional water customers. In addition, multi-family water users, which operate like commercial use for domestic purposes, represent an additional ten percent of municipal water sales. Industrial water customer using municipal water represent an additional 16 percent (16%) of municipal water sales according to the latest survey by the Texas Water Development Board. This means that nearly 54 percent (54%) of all municipal water use is not for single-family residential purposes. In all of these cases, the facilities are owned by a business or institutional entity, operated by the same and pay the water and wastewater bills for the facility. This includes multi-family, which are businesses in all respects in the business of providing housing similar to what hotels do. Yet, the focus of past water conservation efforts has focused on the single family home.

The Texas economy is dependent on the continued availability of its limited freshwater resources. The State will need to spend tens of billions of dollars over the next 50 years to maintain existing water and wastewater infrastructure systems to meet growing population and an expanding economy, and to meet the health and environmental needs of all Texans.

## 1.1 Defining Institutional and Commercial Users

Institutional use is defined as the use of water by an establishment dedicated to public service, such as a school, university, church, hospital, nursing home, park, prison, or government facility. All facilities dedicated to public service are considered institutional regardless of ownership. Commercial use is defined as the use of water by a place of business, such as retail sales establishments, a hotel, restaurant, or office building. This does not include multi-family residences or agricultural, or industrial users.

In some utilities, multi-family housing such as apartments are counted as commercial accounts, since these are commercial, for profit operations. This guide is applicable to these operations also. This guide can be applied to situations where the lines between commercial and light industrial operations are blurred or combined as well, but it is not intended as a guide for large industrial operations.

## 1.2 Purpose

The purpose of this guide is to provide best management practices and technologies that can help reduce water and wastewater costs while conserving our state's most precious resource. A systematic approach should be used when examining water use and using the best management practices. The final goal of these best management practices is to balance water, wastewater, and related costs to achieve the lowest life cycle costs when purchasing new equipment, replacing old equipment, or modifying existing equipment. These best management practices set targets for water conservation and water-use efficiency and meet or exceed state codes. However, some local codes may be more stringent than the state codes and should be reviewed by the facility to assure compliance.

Again, many consider public housing, and group housing to be in the quasi-commercial and institutional domain. For this reason, the best management practices should be equally applicable to these residential facilities that operate as a business.

All best management practices described in this document are technically feasible and have been used in the past, AND are applicable to all commercial and institutional water users. Many are also applicable to industrial operations where a large number of people are employed.

This guide serves two purposes:

1. It provides the owners of commercial and institutional entities with the technical knowhow and cost analysis tools to examine how water is used in their facilities and how they can implement cost effective measures to reduce their bottom line; and
2. It provides water utility and conservation professionals with the knowledge of how water is used by the commercial and institutional sectors and what are the best practices for reducing water use.

In other words, this guide helps the facility manager analyze potential water saving technologies and perform the necessary analysis to financially justify improvements, and it provides guidance to water utility conservation staffs regarding water saving technologies and techniques are possible in the non-residential sectors.

The information contained in this guide is based on the latest information from commercial equipment manufacturers, engineers working in the field, and from the most up to date green water and plumbing codes and standards and equipment standards by the US Department of Energy and Environmental Protection Agency, and the trade organizations that serve these commercial and institutional entities. As a point of reference, Appendix A of this document, highlights the importance of the commercial and institutional (C&I) sectors to the Texas economy.

Since this guide serves a dual purpose of addressing measures for the end user to follow as well as providing information to utilities implementing commercial and institutional water conservation programs, the order in which information is presented is slightly altered from other guides in this series by the Texas Water Conservation Advisory Council. However, all of the components required by the council are contained in this document and additional necessary information is also provided.

# 2.0 BMP: Total Cost of Water

## 2.1 Applicability

The following information illustrate the best management practices to determine the total cost of water for performing cost analyses for water conservation projects. The water cost elements include water, wastewater, water and wastewater treatment, energy and special situation costs. A separate section then shows how to consider both the cost and benefits of water conservation measures and also best practices for reducing water use. The example water cost calculations will provide the technical know how to examine opportunities for implementing cost-effective water conservation improvement projects in commercial and institutional facilities.

## 2.2 Description

A description of the various factors impacting water use and cost that must be considered in determining total cost of water is provided in Appendix B, "The Cost of Water and Cost-Effectiveness Considerations." The following material provides the calculation examples for determining the total water cost for the most common types of water uses in the commercial and institutional sectors. The water cost calculations provided below illustrate how to develop water costs per gallon or thousand gallons by their intended type of use. Eight examples are presented that demonstrate how to determine the cost of water.

## 2.3 Implementation - Cost of Water Calculations Examples

- Example 1. Convert hundreds of cubic feet (CCF) to gallons.
- Example 2. Convert cost of water per CCF to dollars per thousand gallons and cents per gallon.
- Example 3. Cost for heating water
- Example 4. Cost to boost water temperature for dishwasher
- Example 5. Cost of water treatment
- Example 6. Cooling tower cost
- Example 7. Labor and service contract cost
- Example 8. Putting the cost together to determine total cost.

### Example 1. Convert hundreds of cubic feet (CCF) to gallons.

*Question* – The business used 520 hundred cubic feet (CCF) of water in a month. Convert to gallons.

*Answer* – There are 7.48 gallons per cubic foot. Therefore 520 X 100 = 52,000 cubic feet. Multiplying the cubic feet by 7.48 = 388,960 gallons.

**<u>Example 2</u>. Convert cost of water per CCF to dollars per thousand gallons and cents per gallon.**

*Question* – Water cost $2.50 per CCF and wastewater cost $5.00 per CCF for a total cost of $7.50 per CCF. What is that cost in dollars per thousand gallons?

*Answer* – The cost is Divide costs by 0.748 to obtain cost per thousand gallons.

For water – $2.5/0.748 = $3.342 per thousand gallons.
This is equal to 0.334 cents per gallon.

Wastewater cost $5 per CCF = $6.684 per thousand gallons.

Adding water and wastewater costs together, the water use costs $10.027 per thousand dollars or 1.003 cents per gallon.

**<u>Example 3</u>. Cost for heating water**

The water must be heated by 80 $^{o}$F. How much does that cost?

If the water is to be heated, determine the type of energy used to heat the water (gas, electric, etc.) and its cost per unit (Cents per kilowatt-hour, or dollars per therm, or dollars per MCF [thousand cubic feet] of natural gas). One-kilowatt hour equals 3,412 BTU's and most electric hot water heaters are 98 percent efficient. One therm of natural gas equals approximately 100,000 BTU's and one MCF equals approximately one million BTU's. The question of efficiency is more complicated. Conventional gas water heaters, similar to residential heaters, have efficiencies that range from 70 to 80 percent. In other words, one MCF of gas will deliver 700,000 to 800,000 BTU's to the water. Large commercial units can have efficiencies in the 85 percent range when operating properly. Condensing water heaters operate in the 90 to 95 percent range. For this example, it is assumed the facility is a small restaurant and that the rise in temperature will be 80$^{o}$F to achieve the desired hot water temperature. A conventional water heater with an efficiency of 75 percent is used by the restaurant. The restaurant uses 1,250 gallons of hot water a day. Natural gas costs $8.25 per MCF. Water weighs 8.34 pounds per gallon and it takes one BTU to increase one pound of water by one degree F.

*Question* – What is the cost of heating water?

*Answer* – The equation showing how many MCF is use per day = <u>gallons used</u> X 8.34 X <u>temperature rise</u> DIVIDED BY <u>the efficiency</u> X <u>the energy in one MCF of gas.</u>

In this example, the MCF of gas required = (1,250 X 8.34 X80) ÷ (75% X 1,000,000) = 1.112 MCF per day. Since gas costs $8.25 per MCF and the restaurant uses 1.112 MCF, the energy cost per day is $9.174 (917.4 cents) for heating the 1,250 gallons of water.

In other words, the energy cost per gallons = 917.4 ÷ 1,250 = 0.734 cents per gallon. This is equal to $7.34 per thousand gallons or $5.49 per CCF.

**Example 4. Cost to boost water temperature for dishwasher**

The dishwasher requires 250 gallons per day of 180ºF water. The water heater heats water to 135 ºF for general use in the restaurant, so the water must be heated by an additional 45 ºF.

*Question* – The restaurant must heat approximately 250 gallons of hot water by an additional 45 ºF for use in the dishwasher each day with an electric booster heater. Electricity costs 10 cents per kilowatt-hour (kWh). How much does that cost?

*Answer* – One gallon of water weighs 8.34 pounds. It takes 45 BTU's to raise one pound of water by 45 ºF.

The energy to raise 250 gallons by 45 ºF = 250 X 8.34 X 45 = 93,825 BTU's.

There are 3,412 BTU's in one-kilowatt hour of electricity and the heater is 98 percent efficient. At 100 percent efficiency, the kilowatt-hours needed = 93,825 BTU's ÷ 3,412 = 27.498 kWh. At 98 percent efficiency, the total use = 27.495 ÷ 0.98 = 28.1 kWh which at 10 ¢ per kWh costs $2.81. The cost in cents per gallon = $2.81 X 100 ÷ 250 gallons = 1.124 cents per gallon, $11.24 per thousand gallons or $8.41 per CCF.

**Example 5. Cost of water treatment**

The restaurant softens all if its hot water – 1,250 gallons per day and the cold water has a hardness of 200 milligrams per liter (mg/l) {one mg/l = one part per million (ppm)}. The softener uses a meter to recharge and it is rated at 3,000 grains of softening per pound of salt. Salt costs about 11cents a pound based on a price for a 40-pound bag at $4.40.

*Question* – How much does water softening cost per gallon?

*Answer* – The first consideration is to calculate how much salt is needed. One grain of hardness is equal to 17.1 mg/l. Therefore, one gallon of water has 11.69 grains of hardness {200 ÷ 17.1 = 11.69}. The facility uses {softens} 1,250 gallons a day to the total number of grains of hardness that need to be removed is 14,613 {1,250 X 11.69}. One pound of salt removes 3,000 grains of hardness. Therefore, 4.87 pounds of salt are used daily {14,613 ÷ 3,000}. At 11cents a pound, the salt costs 53.6 cents. Since 1,250 of softened water are produced, this is equal to $0.429 per thousand gallons or 0.043 cents a gallon. This equals $0.32 per CCF.

This methodology can be applied to any water treatment chemical cost. This does not include the cost of the equipment, the labor cost, or any service contract. These costs should also be included in the overall analysis of annual operating costs. The equipment cost is added to the cost of implementation and any labor cost (see Example 7). Service contract cost should be included in annual operating cost.

**<u>Example 6.</u> Cooling tower cost**

In addition to the cost of water and energy, the facility cost for the cooling tower service contract including chemicals is $5,950. The cooling tower uses approximately 2,820,000 gallons per year. The facility receives an evaporation credit from the water and wastewater utility. The audit showed that it was operating at 3.9 cycles of concentration.

*Question* – What is the relative cost of cooling tower operations?

*Answer* – Based on water use estimates from the following graph for makeup per ton hour, the tower has a makeup rate of 2.0 gallons per ton hour (see Figure2.1a). The general equation for cooling tower makeup, evaporation and blowdown, assuming minimal drift loss and leaks is:

$$\text{Makeup} = \text{Evaporation} + \text{Blowdown}$$

Based on the latent heat of evaporation for water of 971 BTU/Pound. One ton hour = 12,000 BTU's. Therefore, one ton-hour will evaporate 12.36 pounds of water and one gallon of water weighs 8.34 pounds. From this, one ton-hour will evaporate 1.48 gallons of water.

One important consideration to note is the energy imparted by the air conditioning system on water use. The energy to operate an air conditioning system (i.e., the chiller) as well as the energy to operate the air-handlers and cooling tower pumps, must also be removed by the cooling tower. Figure 2.1a represents the heat load on the tower. Based on the chiller tons, the water use figures in the graph should be increased by twenty five percent (25%). Figure 2.1b illustrates the impact the energy for the chiller, air handling equipment and water pumps has on water use.

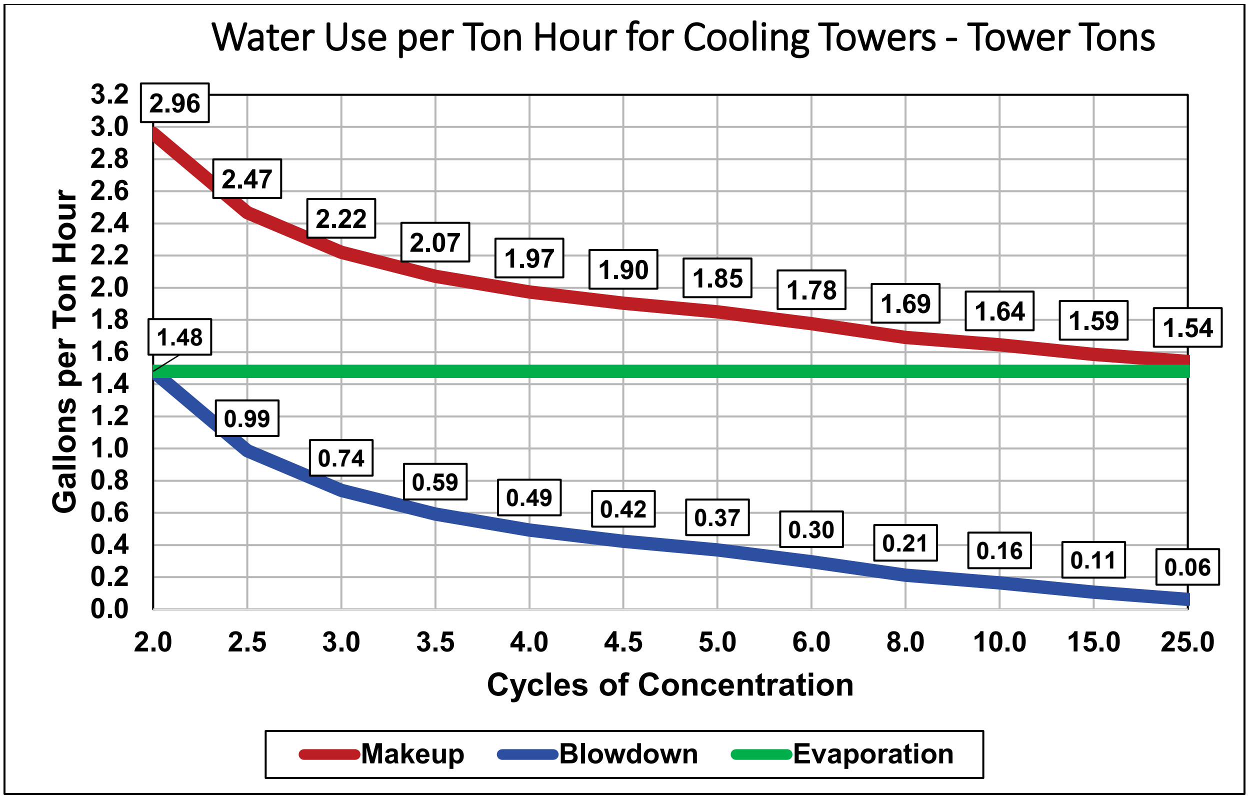
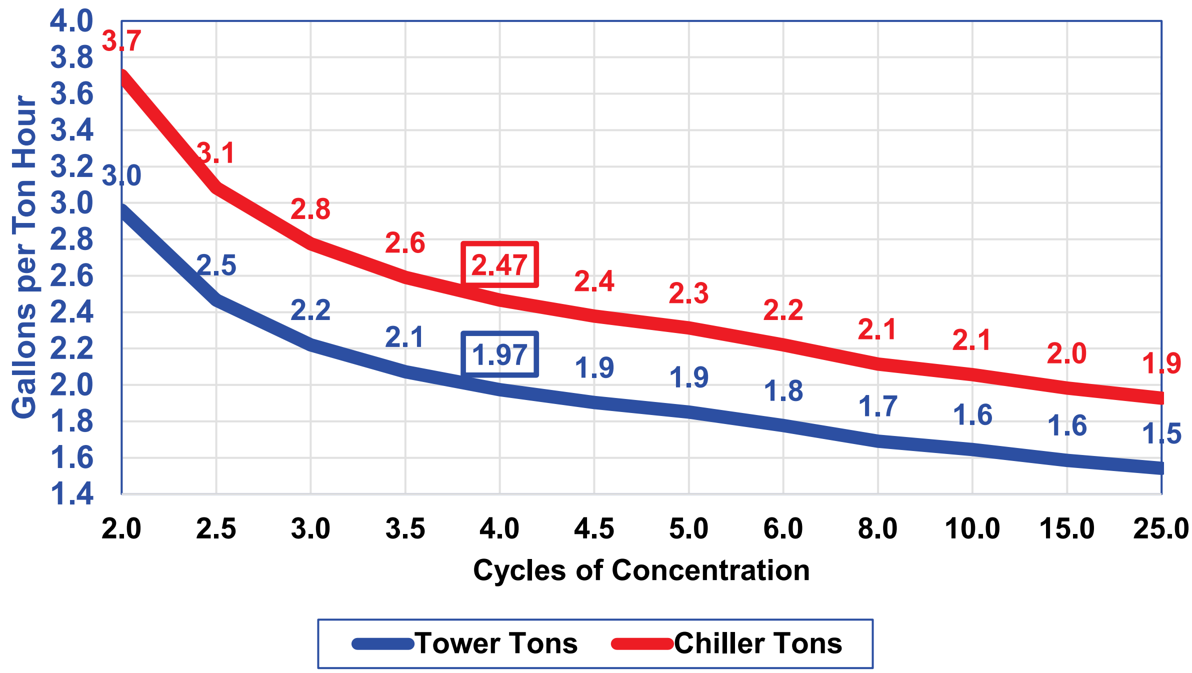



**Figure 2.1.a Makeup, blowdown, and evaporative water use of cooling towers in gallons per ton hour.**

**Figure 2.1.b Makeup Water per Ton Hour for Cooling Towers - Chiller Tons vs Tower Tons**




The blowdown rate is 0.51 gallons per ton hour or 25.6 percent of makeup that equals 729,600 gallons per year. The facility takes advantage of the utilities evaporation credit program. Therefore, the facility pays for all of the 2,820,720 gallons per year and for 729,600 gallons of wastewater. Water costs $3.342 per thousand gallons and wastewater costs $6.684 per thousand gallons.

The water cost = (2,820,000 ÷ 1,000) X $3.342 = $9,424.44 per year

The wastewater cost – (729,600÷1,000) X$6.684 = $4,876.65

The cost for the service contract = $5,950.00

In most cases, the water treatment contract is simply used as an annual cost. It is compared to the water treatment contract cost after implementation of water efficiency measures. However, it can be incorporated into the actual water cost as illustrated in the following. This is done here to show how that can be done.

Therefore, total annual cooling tower cost for water, wastewater, and the treatment service contract = $20,251.09 for the use of 2,820,000 gallons.

The calculated cost for cooling tower water per thousand gallons therefore = $20,251.09 ÷ (2,820,000 ÷ 1,000) = $7.18 per thousand gallons or 0.718 cents per gallon. Another way of looking at this is to equate water cost to cents per ton-hour of cooling. The tower currently uses 2.0 gallons per ton-hour. Therefore, at a cost of 0.718 cents per gallon, it is equal to 1.436 cents per ton-hour.

**Example 7. Labor and service contract cost**

*Question* – The facility installed new equipment for the first time. It will require that staff maintain and operate the equipment. How about facility staff time costs?

*Answer* – Labor cost for the facility staff to operate the tower should also be included. It is estimated that the routine monitoring, inspection and maintenance of the cooling tower will occupy approximately six hours of staff time a week, 52 weeks a year. The salary plus fringe benefits for the employee are $31 per hour.

Annual labor costs = 6 Hours/Week X 52 Weeks X $31 per hour = $9,670 per year.

***IF*** this is a new process and these costs were not present before the measure, these costs should be included in the annual cost of the measure when calculating payback. An example would be a totally new water treatment and recycle system.

***IF*** the process already exists, and labor time would not change, do not include the labor cost before and after simply cancel each other out.

***IF*** the measure results in a reduction in staff time, the reduction in cost should be included in the measures benefits.

Service contract cost can be treated in a similar manner.

**Example 8. Putting the cost together to determine total cost.**

*Question* – How much does a gallon of water actually cost?

*Answer* – That depends on its use. In the above example, cold water costs $10.03 per thousand gallons or about one cent per gallon. Heating water by 80ºF with gas costs an additional $7.39 per thousand gallons is added. Softening adds an additional $0.43 per thousand gallons. Heating the hot water to 180 ºF with electricity costs an additional $11.20 per thousand gallons.

The following table summarizes the types of water uses and their actual total cost. This table should be included in the audit report.

**Table 2.1. Additive cost of water in Example, including all costs for water, i.e. wastewater, energy, chemicals, and contract cost.**

| Additive Cost of Water in Example | | | |
|---|---|---|---|
| **Type of Water Use** | **Dollars per Thousand Gallons** | **Cents per Gallon** | **Example of Use** |
| **Cold Water** | **$10.03** | **1.003 ¢** | Toilet Flushing |
| **Hot Water** | **$17.37** | **1.737 ¢** | Cleaning Floors |
| **Softened Hot Water** | **$17.80** | **1.780 ¢** | Restaurant Cleaning |
| **180 °F Water** | **$29.04** | **2.904 ¢** | Commercial Dishwasher |
| **Cooling Tower (includes water treatment cost in this example)** | **$7.16** | **.716 ¢** | Cooling Tower with Evaporation Credit Plus Cost of Chemical Treatment Contract |

This table ***does not*** include the cost of detergent and chemicals used in the dishwasher or any pre-treatment cost for fats, oils, and greases, etc. Water efficiency measures often result in a reduction in chemical and wastewater treatment costs. These also need to be factored into an appropriate benefit/cost analysis.

The above examples illustrate how to develop water costs per gallon or thousand gallons by their intended type of use. The reasons that these costs are expressed in cents per gallon are threefold:

1. It is much easier to visualize a gallon of water for the average person;
2. Explaining to a person that by replacing a 5.0 gallon per flush toilet with a 1.28 gallon per flush toilet will save 3.72 gallons which in this case is about 3.8 cents per flush has a lot more meaning than expressing it in CCF per year; and
3. Stating the total cost or water for each activity helps the facility manager understand the potential savings of each measure.

## 2.4 Cost-Effectiveness Considerations

When determining whether a best management practice is cost effective, the customer will need to assess the financial costs and benefits of implementing the best management practice. A variety of financial metrics may be used to determine whether a particular best management practice makes economic sense from a cost/benefit perspective. Some important considerations when calculating the costs of best management practices are:

- Water and wastewater savings
- Cost of the measure
- Expected usable life of the measure
- Decrease or increase in energy costs
- Chemical costs or savings
- Waste disposal costs associated with water treatment or use
- Labor costs or savings
- Liability
- Usable life of equipment or processes (See Table 2.2)

Costs are typically calculated for each recommended best management practice within a comprehensive CII water conservation audit.

There are several ways to calculate cost/benefit ratios for business/customer implementation of best management practices. When discussing cost/benefit analyses, some common terms used include "payback period," "return on investment" (ROI), and "internal rate of return" (IRR). These analyses provide guidance in the short term and help to determine if a proposed modification is worth the investment. Longer-term analyses also consider lifecycle factors, such as net present value, inflation, and amortization.

The payback period is the time required for an investment in efficiency to pay for itself. The simple payback is calculated by dividing the total costs (including installation, capital, permitting, and equipment costs) by the annual benefits, giving a simple payback in terms of years. A two-year payback is generally considered extremely cost effective. Many firms may choose a 3-4 year payback period. If a business using a more efficient device does not own the building or the equipment, issues with the economics of payback become more challenging.

Another metric which is similar to payback is Return on Investment (ROI). The ROI is the percent of payback the best management practice produces per year. In the case of a one-year payback, the ROI is 100 percent. If the payback is in 1.6 years the ROI is equal to ($100%/1.6) or 62.6 percent a year.

The internal rate of return (IRR) provides an indication of the efficiency of an investment. It is defined as the effective annual interest rate at which an investment accrues income. The IRR can be compared to the interest rate on borrowed funds or the rate of return that is possible from other investments. If the IRR is higher than the agency's rate of return, then the investment is deemed to be worthwhile.

A business may also want to analyze the costs and benefits over the economic life of the best management practice, particularly for large investments that may have longer payback periods. This analysis may be appropriate if the time for return on investments does not justify making the improvements in the short term and there is a long-term investment involved. A lifecycle analysis will take into consideration the costs and savings over the full life of the best management practice device being installed. In this type of analysis, the business would consider the time value of money, savings through the life of the equipment, and the costs of water, energy, or sewage disposal over the life of the equipment. This analysis may also include labor, tax, and insurance savings.

Net Present Value (NPV) is among the most common financial metric used when performing a life cycle analysis. It sums all costs and benefits over the lifetime of the device and reports their value at the beginning of the project based on some minimum required rate of return. A positive NPV indicates that the benefits of the project exceed the costs over the life of the device. This approach has not been as commonly used by businesses as the ROI or payback approach, but may become more applicable in the future.

When deciding to invest in water use efficiency, businesses may also consider other risk factors and benefits that are less quantifiable, such as potential future mandates, reliability of water supply, or reputational risks and benefits. They may also upgrade to more water and energy efficient equipment when making a business decision to replace outdated equipment.

**Table 2.2. Life expectancy for commercial fixtures, appliances, and equipment shown in years or range of years.**

| **Range of Life Expectancy for Commercial Fixtures, Appliances, and Equipment** | | |
|---|---|---|
| **Type of Equipment** | **Name of Equipment** | **Expected Life Range - Years** |
| **Food Service** | *Ice makers* | 6-10 |
| | *Ice cream, gelato makers* | 8-10 |
| | *Walk in coolers and freezers* | 8-15 |
| | *Combination ovens* | 8-12 |
| | *Food steamers* | 8-12 |
| | *Door & conveyor dishwashers* | 15-20 |
| | *Flight type dishwashers* | 25+ |

| | | |
|---|---|---|
| | *Food waste disposers* | 10 |
| | *Food waste pulpers & scrappers* | 15+ |
| | *Pre-rinse spray valves* | 1-5 |
| **Laundry Equipment** | *Coin/card type washers* | 12-15 |
| | *On premise washer-extractors* | 15-20 |
| | *Tunnel washers* | 20+ |
| | *Home type washers* | 10-14 |
| **Plumbing Fixtures** | *Toilets* | 20-30 |
| | *Urinals* | 20-30 |
| **HVAC Equipment** | *Chiller– water-cooled* | 15-20 |
| | *Cooling Tower - Wood* | 10-20 |
| | *Cooling Tower - Galvanized* | 15-25 |
| | *Cooling Tower – Stainless* | 25-35 |
| | *Cooing Tower - Ceramic* | 35+ |
| **Boilers (Hot Water & Steam)** | *Copper core* | 15-20 |
| | *Steel tube boiler* | 20-40 |
| | *Old cast iron* | 25-50 |
| | *New cast iron* | 20-25 |
| | *Electric* | 10-20 |

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### 2.4.1 References and Additional Information

#### 2.4.1.1 Financial Incentives and Technical Assistance for Water Efficiency

A number of water utilities offer various forms of incentives to their customers ranging from rebates to either partial funding for or actual free water conservation audits and recognition programs. Technical assistance available to commercial and institutional users will depend on the capability of and expertise of utility employees. Training and dissemination of useful information are also ways to incentivize water efficiency. Reduced rates for use of reclaimed water, or discounts of various kinds are also available. Awards and various forms of public recognition are also commonly used.

In this section, three sources of assistance will be discussed, including:

- Technical Assistance;
- Financial Assistance, Water and Energy Rebates, and Tax Incentives; and
- Codes, Standards, and Rating Systems

Technical Assistance: Technical assistance is available to help guide commercial and institutional water users on ways to reduce water use and water and wastewater costs. These forms of assistance fall into four categories:

1. Assistance from water utilities and governmental entities such as the Texas Water Development Boards (TWDB) Water Conservation Division can be useful and are available at no cost. Many local water utilities have staff with expertise in the commercial and institutional areas and should be the initial point of contact to request assistance. The TWDB website for Institutional, Commercial, and Industrial (ICI) water efficiency information can be found at: https://www.twdb.texas.gov/conservation/resources/ici-resources.asp.

2. Trade organizations of various types often have websites, publications, webinars and other sources of information on ways to reduce all forms of water utility costs including water.

3. Water conservation specific websites that may prove useful include:
   - The Alliance for Water Efficiency: The site contains a wealth of information and guides for commercial and institutional entities. It can be found at http://www.allianceforwaterefficiency.org/;

- The US Environmental Protection Agency's publication, *WaterSense at Work Guidebook*, and the Water Sense program, which can be found at https://www.epa.gov/watersense/best-management-practices;
- The Texas Water Conservation Advisory Council website that contains this guide at http://www.savetexaswater.org/bmp/CIBMPindex.htm;
- The State Energy Conservation Office's *Water Conservation Design Standards for State Buildings and Institutions of Higher Education Facilities* can be downloaded from https://comptroller.texas.gov/programs/seco/code/water.php.
- The Maximum Performance Testing website at http://www.map-testing.com/; and
- The California Urban Water Conservation Council at https://www.cuwcc.org/.

The last two sites contain the results of numerous water conservation studies.

4. For-profit companies range from plumbing contractors, engineering firms, and a small number of companies that specialize in water audits and retrofit of commercial and institutional facilities. Currently, there are no standards for such companies like in the energy efficiency sector has, so commercial and institutional water users are cautioned to choose these firms carefully.

*Financial Assistance* is available from several sources. This includes limited assistance from both the Texas Water Development Board and the Texas State Energy Conservation Office. The assistance is for very specific purposes and those interested should visit the following websites:

- Texas Water Development Financial Assistance
- State Energy Conservation Office Loan Star Program

Senate Bill 385, passed by the Texas Legislature in 2013, amended the Property Assessed Clean Energy Act (PACE) to extend this innovative financing program to water conservation projects. PACE enables owners of commercial and industrial properties to obtain low-cost, long-term loans for permanent water conservation, energy-efficiency improvements and renewable retrofits to real property. Water related projects could include cooling tower efficiency improvements, rainwater harvesting, reclaimed water connections, and commercial laundry water treatment systems, among other options. SB 385 also authorizes municipalities and counties in Texas to work with private sector lenders and property owners to finance qualified improvements using contractual assessments voluntarily imposed on the property by the owner. Travis County was the first entity in Texas to administer a local PACE program.

The term of a PACE loan may extend up to 20 years, resulting in utility cost savings that exceed the amount of the assessment payment. As a result, improvements financed through PACE generate positive cash flow upon completion with no out-of-pocket cost to the property owner. If the property is sold before the full amount of the PACE loan is repaid, the repayment obligation automatically transfers to the next owner because the lien securing the PACE assessment follows title to the property. For more information on PACE in Texas, visit their website at: http://www.keepingpaceintexas.org/pace-in-a-box/.

*Water and Energy Rebates* can help finance the replacement to water efficiency equipment. Numerous water utilities offer a variety of forms of assistance. Commercial and institutional entities should check with their local water and wastewater providers to determine if rebates or other forms of assistance are available. Likewise, many types of equipment that are water efficient are also energy efficient. One should check with their electric and gas service providers. There is also a national website that lists energy efficiency programs called DSIRE. It can be found at http://programs.dsireusa.org/system/program?state=TX.

*Tax incentives* from the State of Texas are limited in scope. Both property and sales tax exemptions are available.

Texas provides a sales tax exemption for certain water efficient equipment, supplies, and services used solely for certain types of water conservation. These include:

- Rainwater harvesting
- Water recycling and reuse
- Reduction or elimination of water use
- Desalination of surface or groundwater
- Brush control designed to increase water availability
- Precipitation enhancement
- Regional water or wastewater systems

The purchaser must give the seller a Texas sales tax exemption certificate stating valid qualifications for the exemption. The certificate is available on the Comptroller's internet site at http://window.state.tx.us/taxinfo/taxforms/01-forms.html. For more information, visit: Texas (A sales tax exemption was created in 2001, to encourage water conservation.)

Texas also provides a property tax exemption on property owned on which approved water conservation initiatives, desalination projects, or brush control initiatives have been implemented pursuant to Texas Tax Code §11.32. To apply, visit the following websites:

- Application for Water Conservation Initiatives Property Tax Exemption, Form 50-270. (A property tax exemption is allowed for all or part of the assessed value of a property on which water conservation modifications have been made. Check with your local county appraisal district for guidance.) The form can be found under "Exemption Forms."
- Sales and Use Tax Bulletin 94-123 Water and Wastewater Systems

## 2.5 Determination of the Impact on Other Resources

### 2.5.1 Codes, Ordinances, Standards, and Rating Systems

Codes, ordinances, standards and rating programs guide the design and implementation of water-conserving practices in commercial facilities across Texas. Codes and ordinances are regulatory in nature and can be imposed by regulating entities at a national, state, regional, or municipality/local level. Standards and rating systems, however, are enforceable only if included in codes by direct reference.

The performance standards for water using fixtures and equipment in Texas are governed at the state level under rules of the Texas Commission on Environmental Quality contained in Title 30, Texas Administrative Code, Chapter 290 (30 TAC 290), adopted pursuant to Chapter 372 of the Texas Health and Safety Code. In these rules, the TCEQ has generally adopted by reference the performance standards contained in the American National Standards Institute (ANSI) and the American Society for Testing and Materials (ASTM) except as otherwise provided in the rules.

The TCEQ also regulates the use of reclaimed water in Texas under rules contained in 30 TAC 210. These rules define reclaimed water as "wastewater which has been treated to quality for a suitable use" and defines reclaimed water that is neither domestic nor municipal as "industrial reclaimed water" [TAC§210.2, TAC§210.52]. For example, condensate from commercial air-conditioning units falls in the category of industrial reclaimed water, as defined by TCEQ. TCEQ regulations for other auxiliary water sources such as rainwater and gray water can be found in 30 TAC 290 and 30 TAC 285, respectively. For more information regarding best management practices for auxiliary water systems, see Section 3.

In addition to these state requirements, municipalities will adopt one of two authorized international codes including the International Plumbing Code or the International Association of Plumbing and Mechanical Officials' (IAPMO) Uniform Plumbing Code and then provide supplemental, more stringent or alternative requirements through their local plumbing codes.

Both codes were updated in 2015. Both of these codes have green supplements that contain the latest and most advanced provisions for water efficiency, use of on-site sources of water and the reuse of reclaimed municipal wastewater. Even if your local utility has not adopted the latest codes, they can be useful in examining possibilities for selection of the most water efficient equipment, appliances, fixtures and practices.

Many cities also incorporate international "green" plumbing code provisions into their Green Building Programs that typically apply to new development and/or certain areas within the city. These include the International Green Construction Code (IGCC) and the International Association of Plumbing and Mechanical Officials' (IAPMO) Green Plumbing and Mechanical Code Supplement (GPMCS). If not adopted by the city, these requirements of the IGCC and

GPMCS are considered as recommendations for best practices but are not legally binding. Similarly, the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) standards and the National Sanitation Foundation (NSF) standards are also considered recommendations for best practices. In a similar manner, standards and rating systems such as the US Green Building Council's LEED (Leadership in Energy and Environmental Design) can also provide insight and guidance.

In 2018, IAPMO and the American National Standards Institute (ANSI) issued a new water efficiency standard (WE-STAND). It contains the latest information on water efficiency standards.

A side-by-side of all of these codes, standards, and rating systems can be found on the Maximum Performance website at: http://www.map-testing.com/assets/files/2015-april-comparison_of_green.pdf.

Local jurisdictions and authorities do not have to adopt the latest code versions and may often make local amendments. Therefore, the above sites may contain more up-to-date information.

# 3.0 BMP: Best Practices and Activities for Water Savings

## 3.1 Applicability

Significant opportunity exists for water-use efficiency that will result in greater economic and environmental benefits for the Texas commercial and institutional sectors. This chapter focuses on water conservation best management practices (BMP) and activities for the C&I sectors to reduce water use and lower facility operating costs.

## 3.2 Description

Commercial and institutional operations use water in a variety of ways. While it is important to realize that no two facilities are alike, a systematic approach can be used when examining water use activities for efficiency and cost savings. The technical and economic feasibility of each activity will need to be examined on a case-by-case basis. The BMPs presented in this section should be considered when purchasing new equipment, making modifications to existing systems, or when upgrading existing equipment nearing the end of its useful life expectancy. The final goal of the following BMPs is to balance water, wastewater, energy and related costs to achieve the lowest life cycle costs when purchasing new equipment, replacing old equipment or making modifications to existing equipment.

The determination of economic feasibility, the benefits and impacts on other resources, and related topics are identified in this chapter and the following practices and activities are described.

- Metering, Monitoring, and Measurement
- Plumbing Fixtures, Fittings, and Equipment
- Food Service Operations
- Laundry Operations
- Water Treatment
- Laboratory and Medical Facilities
- Cooling Towers, Boilers, and Other Thermodynamic Operations
- Swimming Pools, Spas, and Fountains
- Vehicle Washes
- Alternate Sources of Water

The following BMPs are efficiency measures that save a quantifiable amount of water, either directly or indirectly, and can be implemented within a specific timeframe. The BMPs are achievable, implementable and practical measures that should be used in the planning, construction and renovation of buildings used by state agencies and higher education institutions.

Table C.1 in Appendix C: Water Use Technologies in the Commercial & Institutional Sectors, illustrates some of the more common water uses found in these various C&I sectors.

## 3.3 Implementation – Practices and Activities

### 3.3.1 Metering, Monitoring, and Measurement

The first step in managing any resource is to meter its use, monitor how and when it is being used, and measure the effectiveness of any implemented water efficiency practice. The saying, "If you don't measure it, you can't manage it," is certainly true for the management of water use in a commercial or institutional facility. The basic tool is the meter. It allows the facility to measure use, monitor potential problems, and verify the water saving technology is working properly.

Most modern water efficiency codes require that larger water uses within a facility or campus is metered separately. A water meter should be installed in buildings connected to a public water system, including municipally supplied reclaimed (recycled) water. Meters should be easily accessible for reading and monitoring. A separate meter or sub-meter should be installed in the following locations:

- The water supply for irrigated landscape with an accumulative area exceeding 2,500 square feet (232 $m^2$).
- The makeup water supply to cooling towers, evaporative condensers, and fluid coolers.
- The makeup water supply to one or more boilers collectively exceeding 1,000,000 British thermal units per hour (Btu/h) (293 kW).
- The water supply to a water-using process where the consumption exceeds 1,000 gallons per day (gal/d) (0.0438 L/s), except for manufacturing processes.
- The water supply to each building on a property with multiple buildings where the water consumption exceeds 500 gal/d (0.021 L/s).
- The water supply to an individual tenant space on a property where any of the following applies:
  - Water consumption could exceed 500 gal/d (0.021 L/s) for that tenant.
  - Tenant space is occupied by a commercial laundry, cleaning operation, restaurant, food service, medical office, dental office, laboratory, beauty salon, or barbershop.
  - Total building area exceeds 50,000 square feet (4645 $m^2$).
- A makeup water supply to a swimming pool.
- The makeup water supply to an evaporative cooler having an airflow exceeding 30,000 cubic feet per minute ($ft^3$/min) (14,158.2 L/s).

Sub-metering of irrigation systems also allows for the facility to receive sewer credits where available and is a useful tool to monitor during drought conditions.

Where daily total building water use of either potable or reclaimed water exceeds 1,000 gallons a day or alternate sources of water exceeds 500 gallons a day, the water meters or submeters should be connected to a common monitoring site so that data can be recorded and accessible for viewing by the property manager or engineer.

Data on water use and energy use should be recorded so that it can be used to track trends to determine equipment efficiency. This type of data is also vital to benchmarking the effectiveness of water conservation efforts. It is important to monitor energy use associated with water consumption because experience has shown that water and energy consumption often go hand-in-hand. The overall economics of a system often improve significantly when energy savings are included with water conservation improvements.

### 3.3.2 Plumbing Fixtures, Fittings, and Equipment

In Texas, the Texas Commission on Environmental Quality (TCEQ) is responsible for setting minimum standards for water use by various plumbing fixtures under 30 TAC 290 g. Table 3.1 follows that regulation, but also makes additional recommendations based on the US Environmental Protection Agency's WaterSense program and recently promulgated national codes and standards. This includes performance testing of plumbing fixtures.

**Table 3.1. Maximum fixture and fixture fitting flow rates.**

| FIXTURE TYPE | FLOW RATE |
|---|---|
| Showerheads | 2.0 gpm @ 80 psi |
| Kitchen faucets | 1.8 gpm @ 60 psi |
| Lavatory faucets residential | 1.5 gpm @ 60 psi |
| Lavatory faucets other than residential | 0.5 gpm @ 60 psi |
| Metering faucets | 0.25 gallons/cycle |
| Metering faucets for wash fountains | 0.25 [rim space (in.)/20 gpm @ 60 psi] |
| Wash fountains | 2.2 [rim space (in.)/20 gpm @ 60 psi] |
| Water closets (tank-type, and pressure and vacuum assist) | 1.28 gallons/flush[a] |
| Water closets - flush valve | 1.28 gallons/flush (1.6 gpf in remote locations)[c] |
| Urinals | 0.5 gallons/flush[b] |

a Should also be listed to EPA WaterSense Tank-Type High Efficiency Toilet Specification.

b Should also be listed to EPA WaterSense Flushing Urinal Specification.

c Remote location is where a water closet is located at least 30 feet upstream of the nearest drain line connections or fixtures and where less than 1.5 drainage fixture units are upstream of the water closet's drain line connection.

<u>Flushometer-Valve Activated Water Closets</u>

Flushometer-valve activated water closets should be tested in accordance with Maximum Performance Testing by a MaP approved testing facility to ensure that it flushes more than 350 grams per flush. The website for this information is http://www.map-testing.com/

<u>Non-water Urinals</u>

Non-water urinals should comply with ASME A112.19.3/CSA B45.4, ASME A112.19.19/CSA B45.4, or IAPMO Z124.9. Non-water urinals should be cleaned and maintained in accordance with the manufacturer's instructions after installation. Where non-water urinals are installed, they should have a water distribution line roughed-in to the urinal location at a height not less than 56 inches (1422 mm) above the finished floor to allow for the installation of an approved backflow prevention device in the event of a retrofit. Such water distribution lines should be installed with shutoff valves located as close as possible to the distributing main to prevent the creation of dead ends. Where non-water urinals are installed, not less than one water-supplied fixture rated at not less than one drainage fixture unit (DFU) should be installed upstream on the same drain line to facilitate drain line flow and rinsing.

Residential, Commercial and Kitchen Faucets

All faucets should be listed to the U.S. EPA WaterSense High-Efficiency Lavatory Faucet Specification. The maximum flow rate of residential kitchen faucets should not exceed 1.8 gallons per minute (gpm) (0.11 L/s) at 60 pounds-force per square inch (psi) (414 kPa). Kitchen faucets are permitted to temporarily increase the flow above the maximum rate, but not to exceed 2.2 gpm (0.77 L/s) at 60 psi (414 kPa), and must revert to a maximum flow rate of 1.8 gpm (0.11 L/s) at 60 psi (414 kPa) upon valve closure.

Lavatory Faucets

The flow rate for lavatory faucets installed in residences, apartments, and private bathrooms in lodging, hospitals, and patient care facilities (including skilled nursing and long-term care facilities) should not exceed 1.5 gpm (0.09 L/s) at 60 psi (414 kPa) in accordance with ASME A112.18.1/CSA B125.1 and should be listed to the U.S. EPA WaterSense High-Efficiency Lavatory Faucet Specification.

Multiple Showerheads Serving One Shower Compartment

The total allowable flow rate of water from multiple showerheads flowing at any given time, with or without a diverter, including rain systems, waterfalls, body sprays, and jets, should not exceed 2.0 gpm (0.13 L/s) per shower compartment, where the floor area of the shower compartment is less than 1,800 square inches (1.161 $m^2$). For each increment of 1,800 square inches (1.161 $m^2$) of floor area thereafter or part thereof, additional showerhead allowed the total flow rate of water from all flowing devices should not exceed 2.0 gpm (0.13 L/s) for each such increment.

*Exceptions*

Gang showers in non-residential occupancies: Singular showerheads or multiple shower outlets serving one showering position in gang showers should not have more than 2.0 gpm (0.13 L/s) total flow. Where provided, accessible shower compartments should not be permitted to have more than 4.0 gpm (0.25 L/s) total flow, where one outlet is the hand shower. The hand shower should have a control with a non-positive shutoff feature.

Bath and Shower Diverters
The rate of leakage out of the tub spout of bath and shower diverters while operating in the shower mode should not exceed 0.1 gpm (0.006 L/s) in accordance with ASME A112.18.1/CSA B125.1. The latest "green" plumbing codes and standards require zero leakage.

Shower Valves
Shower valves should meet the temperature control performance requirements of ASSE 1016 or ASME A112.18.1/CSA B125.1 when tested at 2.0 gpm (0.13 L/s).

Drinking Fountains
Drinking fountains should be self-closing.

Emergency Safety Showers and Eye Wash Stations
Emergency safety showers and emergency eyewash stations should not be limited in their water supply flow rates.

Water Supplied Trap Primers
Water supplied trap primers should be electronic or pressure activated and should use no more than 30 gallons (114 L) per year per drain. Where an alternate water source, as defined by this code, is used for fixture flushing or other uses in the same room, the alternate water source should be used for the trap primer water supply. Exception: flushometer tailpiece trap primers are exempted from the provisions of this section. Flush activated, pressure sensitive, and electronic primers as well as the use of drain systems that use lavatory p-trap water are acceptable.

Pressure Reducing Valves
Proper pressure control is an important water conservation measure. High pressure can damage fixture and equipment valves and cause leaks. If a leak is present, high pressure will cause it to leak faster. Faucets, showers, hoses, and other equipment will also have higher flow rates unless they are of the pressure compensating type. Irrigation equipment will mist and operate inefficiently if the pressure is too high. All indoor fixtures and appliances should operate at pressures of 60 pounds per square inch (psi). Reduce in-building pressures to 60 psi or less, but keep the pressure above 30 psi. Follow manufacturer's instruction on pressure requirements for water using equipment and irrigation equipment.

Pumps

In the past, pumps almost always were sealed using packing glands. This packing was designed to “weep” so that it remained moist. This allowed it to seal around the pump shaft to the motor to keep it cool and expanded to form a seal. Weep rates, according to manufacturer’s specifications are typically less than one gallon per minute, but as the packing wears, these rates tend to increase. Some fire codes require building fire pumps to have packing glands, but most pumps can be converted to mechanical seals that do not weep water. Therefore:

- Use only mechanical seal type pumps unless code requires packing glands.
- Where packing glands are used, locate the pump so that the shaft and gland discharge are clearly visible.
- If packing glands are used, the entity should investigate the use of a water collection system for beneficial reuse.

Backflow Devices

Backflow devices are essential to the protection of potable water supply systems. They must follow code requirements and be kept in proper working order to accomplish this. One specific type of backflow preventer is the reduced pressure zone device (RPZ). By code, these devices must be located so that their discharge is visible. A discharge indicates that a backpressure event has occurred. If the device continues to leak, a seal has failed and it needs repair.

### 3.3.3 Food Service Operations

Food service operations are found in many commercial and institutional facilities, ranging from prison kitchens to fine dining restaurants. Water use in commercial kitchens includes water used for cleaning, cooking, scullery operations, and related activities. The following list provides guidance for purchasing and using equipment, appliances, fixtures, and water using devices in commercial kitchens.

Scullery Operations

All kitchens must clean plates, pots, pans, utensils, and equipment used in the preparation of food. The following lists equipment commonly found in scullery operations and provides guidance for their purchase and use.

- *Pre-rinse spray valves* should comply with the U.S. Environmental Protection Agency's WaterSense labeled products. Commercial Pre-Rinse Spray Valves: Pre-rinse spray valves should comply with the flow rate for a pre-rinse spray valve installed in a commercial kitchen to remove food waste from cookware and dishes prior to cleaning should not be more than 1.28 gpm (0.08 L/s) at 60 psi (414 kPa). Where pre-rinse spray valves with maximum flow rates of 1.0 gpm (0.06 L/s) or less are installed, the static pressure should not be less than 30 psi (207 kPa). Commercial kitchen pre-rinse spray valves should be equipped with an integral automatic shutoff.

- *Ware Washers*: Dishwashers are found in many food service operations. Many are leased equipment, especially in restaurants. Institutional facilities tend to purchase such equipment. Whether purchasing or leasing equipment, it is the responsibility of the establishment leasing the equipment to ensure that the equipment is efficient. For leases, the efficiency of the equipment should be stated in the lease. The U.S. Environmental Protection Agency's Energy Star program provides lists of such equipment including information on water and energy efficiency for under the counter, door-type, and conveyor-type ware washers. The Energy Star program requirements are listed in Table 3.2 below.

**Table 3.2. Energy efficiency requirements for commercial dishwashers.**

| **Machine Type** | **High Temp Efficiency Requirements** | | **Low Temp Efficiency Requirements** | |
|---|---|---|---|---|
| | **Idle Energy Rate*** | **Water Consumption**** | **Idle Energy Rate*** | **Water Consumption**** |
| **Under Counter** | **≤ 0.50 kW** | **≤ 0.86 GPR** | **≤ 0.50 kW** | **≤ 1.19 GPR** |
| **Stationary Single Tank Door** | **≤ 0.70 kW** | **≤ 0.89 GPR** | **≤ 0.60 kW** | **≤ 1.18 GPR** |
| **Pot, Pan, and Utensil** | **≤ 1.20 kW** | **≤ 0.58 GPSF** | **≤ 1.00 kW** | **≤ 0.58 GPSF** |
| **Single Tank Conveyor** | **≤ 1.50 kW** | **≤ 0.70 GPR** | **≤ 1.50 kW** | **≤ 0.79 GPR** |
| **Multiple Tank Conveyor** | **≤ 2.25 kW** | **≤ 0.54 GPR** | **≤ 2.00 kW** | **≤ 0.54 GPR** |
| **Single Tank Flight Type** | **Reported** | **GPH ≤ 2.975x + 55.00** | **Reported** | **GPH ≤ 2.975x + 55.00** |
| **Multiple Tank Flight Type** | **Reported** | **GPH ≤ 4.96x + 17.00** | **Reported** | **GPH ≤ 4.96x + 17.00** |

*Idle results should be measured with the **door closed** and represent the total idle energy consumed by the machine including all tank heater(s) and controls. Booster heater (internal or external) energy consumption should not be part of this measurement unless it cannot be separately monitored per the ENERGY STAR Test Method.
**GPR = gallons per rack; GPSF = gallons per square foot of rack; GPH = gallons per hour; x = maximum conveyor speed (feet/min as verified through NSF 3 certification) x conveyor belt width (feet).

- Disposal for Food Waste: In recent years, all have realized that food wastes are "misplaced resources." Composting of food waste has become commonplace in some communities. Composting facilities tend to fall into four categories:
    1. On-site composting,
    2. Off-site composting facilities,
    3. Composting at sanitary landfills and waste disposal facilities, and
    4. Collection and composting of sewage sludge that contains waste from garbage disposals.

  Composting is not specifically a water efficiency measure even though compost helps save water in the landscape. The choice of disposal methods, however, will influence the food waste handling technology used in the kitchen. However, composting saves water by reducing or eliminating the need to use a garbage disposer or other water using equipment.

  Commercial and institutional entities have several choices of how to handle food wastes within their kitchen facilities. The use of scraping into collection bins and the use of strainer baskets to catch food waste instead of using mechanical systems has increased in recent years. Table 3.3 summarizes the operating characteristics of the options available. In addition to disposal equipment (grinders, mechanical strainers, pulper/compactors, and strainer baskets), troughs that are fed with either potable or recirculating water may be used in place of scraping into garbage receptacles to flush food waste down the drain.

**Table 3.3. Summary of four waste disposal methods.**

| Parameter | Grinder | Mechanical Strainers | Mechanical Pulper | Strainer Basket |
|---|---|---|---|---|
| **Solids to Sewer** | Yes | No | No | No |
| **Recirculate** | No | Yes | Yes | No |
| **Strain Solids** | No | Yes | Yes | Yes |
| **Compost Produced** | Potentially at Wastewater Facility | Yes | Yes | Yes |
| **Solid Waste Produced** | No | Yes | Yes | Yes |
| **Flow Restrictor** | Yes | No | No | n/a |
| **Horsepower** | 1-10 | 0.75-7.5 | 3-10 | 0 |
| **Potable Water Use (gpm)** | 3-8 | 1-2 | 1-2 | 0 |
| **Sluice Trough (gpm)** | 2-15 | 2-15 | 2-15 | 0 |

Based on information from the State Energy Conservation Office's "Water Conservation Design Standards: For State Buildings and Institutions of Higher Education Facilities" (2016) and several national "green plumbing" codes, the following recommendations are made:

- If applicable, manual scraping and scrapping baskets should be used instead of garbage grinders and disposals.
- All garbage disposals should be air-cooled.
- Manual pre-wash units should have shut-off valves that turn water off when nozzle is not in operation.
- All garbage food waste grinders' (disposals) water flow rates should not exceed the minimum water flow rate specified by the manufacturer. A flow restrictor should be installed on the water supply to limit the water flow rate to the minimum flow as specified by the manufacturer.
- Disposals (grinders) and mechanical strainers and pulper systems should be equipped with solenoid valves that shut off the equipment every ten minutes. This will require the operator to push the start button, but prevents equipment using energy and water when not in use.
- Pulpers and mechanical strainer systems should have potable water flow rates that do not exceed 2.0 gallons per minute.

<u>Cooking Equipment</u>

Steamers, combination ovens, pasta cookers, steam kettles, and similar equipment all use water in the cooking process.

- *Steamers*: Steamers are used to cook food with steam generated either in an external boiler or from water in a pan with a heating element under it at the bottom of the pan. All steamers should meet US EPA Energy Star specifications. Boiler type steamers must be connected to both a water supply and a drain to the sewer. Boilerless types do not need such connections unless they are connected to an automatic refill valve. Boiler-type steamers find use in restaurants where the door is opened often and temperature recovery time is critical. Boilerless types do not recover temperature as fast, but are significantly more energy and water efficient. Boiler-type steamers are sometimes required to have cold water lines that drain into the sewer to keep temperatures in the sewer below 140 ºF. Many such "tempering water" lines are simple copper or plastic tubes connected to a valve where the water runs continuously all day. The best practice is to set the discharge from the steamer so that tempering water is not needed. If that is not possible, a solenoid valve that only opens when the boiler is in operation should be installed.

In summary, steamers should meet the following criteris

- o *<u>Boilerless</u>* type steamers shall not consume more than **2.0 gallons (7.6 L) per cavity (compartment) per hour.**
- o <u>Boiler type</u> steamers shall not consume more than 1.5 gallons (5.7 L) per pan per hour.

- *Combination Ovens*: Combination ovens, as the name implies, can cook in several modes including baking, broiling, and steaming or a combination of the three. The U.S.

Environmental Protection Agency has not yet developed standards for combination ovens. Combination ovens should adhere to the following criteria:

- Combination ovens ***should not use water*** in the convection mode except when utilizing a moisture nozzle for food products in the oven.
- The total amount of water used by the moisture nozzle in the convection mode should not exceed a ***half a gallon per hour per oven cavity***.
- When operating in the steamer mode, combination ovens should use no more than ***1.5 gallons per hour per pan***.

I

- *Pasta Cookers*: Pasta cookers are used where large volumes of cooked pasta are prepared. They look much like a commercial fryer, but are used to bring water to a boil and cook pasta. They can be continuously filled with some water overflowing to the drain to maintain starch levels in the water. U.S. Environmental Protection Agency has not yet developed standards for pasta cookers. Pasta cookers should be equipped with temperature controls to keep them at a simmer rather than a rolling boil. If overflow is practiced, it should be minimized.
- *Steam Kettles*: Steam kettles are used to cook large volumes of food. The steam enters a chamber surrounding the cooking vessel and condenses which heats the cooking vessel and its contents. Steam can either be supplied by a remote boiler or by a self-contained boiler. In both cases, the steam condensate should be returned to the boiler. Cooking pot valves at the bottom of the cooking vessel are used to drain liquids and cooked foods from the pot. These valves tend to develop leaks if not maintained and should be checked routinely.

Refrigeration, Ice Makers, Freezers, and Similar Equipment

Refrigeration is used to remove heat from food products to cool them or freeze them. The recommendations regarding this equipment will help reduce both water and energy use.

- All once through (pass through) cooling should be eliminated.
- All ice machines should be U.S. Environmental Protection Agency Energy Star listed.
- Flake ice machines should be used where possible since they are the most energy and water efficient types.
- Cube-type ice machines and others producing hard ice should use less than 20 gallons per 100 pounds of ice.
- Air-cooled equipment should be used exclusively.
- Remote systems should reject heat to the outside to reduce the heat load in the building.
- Water-cooled equipment is strongly discouraged. However, where water-cooled equipment is necessary, it should be connected to a chilled water or cooling tower loop.

Most new plumbing codes ban the use of once through cooling. Based on the latest information from the U.S. Department of Energy, water cooled ice machines reduce electric costs 13.7 cents per 100 pounds of ice made at 10 cents per kilowatt hour, but these machines require from 85 to 200 gallons of cooling water for every 100 pounds (12 gallons) of ice made.

Current national average commercial combined water and wastewater costs are over $11 per thousand gallons. Based on the 2016 Black and Veatch report for rates for the nation's largest cities, the lowest combined water and sewer rate was $4.38 per thousand gallons. Even at a combined water and sewer cost of *$2.50 per thousand gallons*, lower than most all utilities in the USA, water and wastewater costs far outweigh the energy savings for making ice with water cooled machine. Figure 3.1 below illustrates that most Texas cities charge far more than $2.50 for combined water and sewer costs, so the savings in using an air-cooled machine are even greater as illustrated in Table 3.4.

**Figure 3.1 2017 Water & Wastewater Rates for Commercial Users in 687 Cities *(50,000 gallons/Mo.)***

***Source: Texas Municipal League***

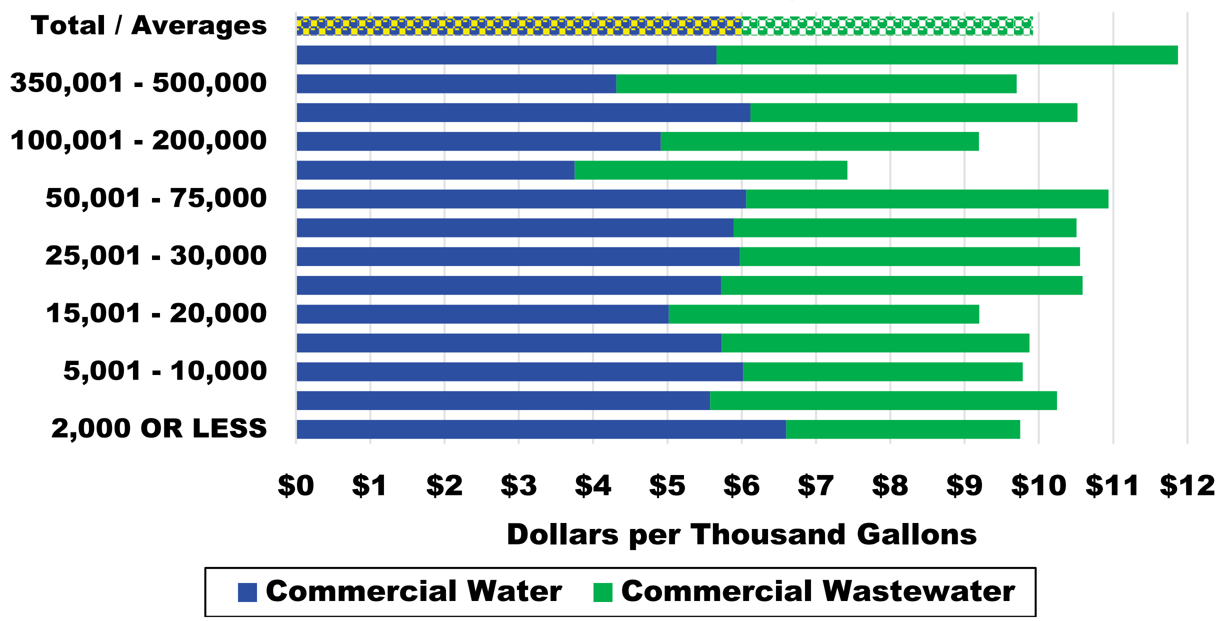


**Table 3.4. Air-cooled cost savings for ice machines.**

| **Gallons of water per 100 lb. of Ice*** | **Cost of Water/ Wastewater** at *$2.50* **per kGal** (Cents/100 Pounds) | **Energy Savings per 100 lbs. with Water-Cooled Equipment at 10 Cents per kWh.** (Cents/100 Pounds) | **Net Savings per 100 lbs. with Air-Cooled Equipment** (Cents/100 Pounds) |
|---|---|---|---|
| 85 | 21.25 | 13.7 | 7.6 |
| 100 | 25 | 13.7 | 11.3 |
| 150 | 37.5 | 13.7 | 23.8 |

| | | | |
|---|---|---|---|
| 200 | 50.0 | 13.7 | 36.3 |

*Based on a survey of all water-cooled ice machines available on the U.S. market

***The bottom line is that it is always more cost effective to use an air-cooled machine!***

In summary, ice making machines should always be air cooled and meet the following water use criteria established by the US Environmental Protection Agency Energy Star program:

- Continuous (flake) machines should use no more than 15 gallons per 100 pounds of ice;
- Batch (cube) ice machines rated at 200 pounds of ice pre day of more should us no more than 20 gallons of water per 100 pounds of ice; and
- Batch (cube) ice machines rated at less than 200 pounds of ice per day should use no more than 25 gallons of water per 100 pounds of ice.

Other Equipment

- *Wok Stoves*: A wok stove is a Chinese pit-style stove. In a conventional wok stove, the burner chimney and ring are affixed to the top of the stove; as a result, heat is trapped under the cook top. Water jets are installed to enable cooling water to flow at approximately 1.0 gpm per burner across the cook top to absorb the heat. Waterless wok stoves, a relatively new technology, are cooled with air, and thus do not require the use of cooling water. These wok stoves function by creating an air gap between the burner chimney, ring, and the top of the stove so that the heat can be released directly from beneath the cook top and vented to the kitchen exhaust. Commercial kitchens using woks should investigate using this new technology that saves both water and energy.
- *Grease Interceptors*: Grease interceptor maintenance procedures should not include post-pumping/cleaning refill using potable water. Refill should be by connected appliance accumulated discharge only.
- *Dipper Well Faucets*: Where dipper wells are installed, the water supply to a dipper well should have a shutoff valve and flow control. The flow of water into a dipper well should be limited by at least one of the following methods:
  - Water flow should not exceed the water capacity of the dipper well in one minute at a supply pressure of 60 psi (414 kPa), and the maximum flow should not exceed 2.2 gpm (0.14 L/s) at a supply pressure of 60 psi (414 kPa). The water capacity of a dipper well should be the maximum amount of water that the fixture can hold before water flows into the drain.
  - The volume of water dispensed into a dipper well in each activation cycle of a self-closing fixture fitting should not exceed the water capacity of the dipper well, and the maximum flow should not exceed 2.2 gpm (0.14 L/s) at a supply pressure of 60 psi (414 kPa).

Practices and Policies

Simple, effective practices are the cornerstone to sustainability and water conservation. Integrating water efficiency into employee training and company policies set a tone that the organization is committed to sustainability and conservation. Most water conservation practices require simple, low, or no cost changes by staff and management that can quickly integrate into employee's daily routines. There are literally hundreds of ways to save water in foodservice operations. A few are listed here:

- Defrost meats in refrigerators rather than under running water. If you must use running water, keep the water flow to a minimum rate that circulates the water.
- Keep lids on boiling water during slow times.
- Use dry cleaning techniques (broom and mop) rather than spraying water to clean floors or use a waterbroom instead of a hose.
- Do not use running water to melt ice. Put the ice in the mop sink or dish sink where it will melt during regular use.
- Implement proper fat, oil, and grease handling best practices.
- Serve water to guests only on request.

### 3.3.4 Laundry Operations

Laundry operations in commercial and institutional facilities generally can be grouped into three types of operations:

1. Self-Service (coin or card operated) laundry equipment found in facilities such as laundromats, dorms, self-serve hotel laundry rooms, and apartments.
2. On-premise laundry equipment found at hotels, hospitals, prisons, nursing homes and other facilities that wash clothing, bedding, and food service toweling in a common laundry facility.
3. Industrial laundry operations that take in laundry from a variety of entities.

Self-Service laundry equipment was once dominated by “single load” top loading washers. With the advent of front loading equipment, clothes washers have become much more efficient. Coin and card type laundry rooms at apartments and dormitories, laundromats, guest laundries in hotels and similar locations are where most self-service laundry equipment is found.

The U.S. Environmental Protection Agency EnergyStar program specification for clothes washers expresses water efficiency ratings using the term – Water Factor (WF). The Water Factor (WF) is the quotient of the total weighted per-cycle (load) water consumption for cold wash, Q, divided by the capacity of the clothes washer, C. The lower the value, the more water efficient the clothes washer is. The equation is:

$$WF = \frac{Q}{C}$$

Table 3.5 shows current and proposed water factors for clothes washers based on the Energy Star specifications.

**Table 3.5. U.S. Environmental Protection Agency clothes washer standards**
*(Source: Energy Star)*

| | | |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |

The ENERGY STAR criteria for clothes washers was changed on February 5, 2018 and is as follows:

| Product Type | Current Criteria Levels (as of February 5, 2018) |
|---|---|
| ENERGY STAR Residential Clothes Washers, Front-loading (> 2.5 cu-ft) | IMEF ≥ 2.76<br>IWF ≤ 3.2 |
| ENERGY STAR Residential Clothes Washers, Top-loading (> 2.5 cu-ft) | IMEF ≥ 2.06<br>IWF ≤ 4.3 |
| ENERGY STAR Residential Clothes Washers (≤ 2.5 cu-ft) | IMEF ≥ 2.07<br>IWF ≤ 4.2 |
| ENERGY STAR Commercial Clothes Washers, Front-loading | $MEF_{J2} \geq 2.20$<br>IWF ≤ 4.0 |

Over 80 percent of the commercial clothes models listed on the current Energy Star website meet or are less than a WF of 4.0. Most self-serve clothes washers are leased from "rout operators." The contract and service agreement with the rout operator should specify that all clothes washers have a WF of 4.0 or less.

<u>On-Premise laundry equipment</u> is rated by the pounds of laundry that can be washed in a single load. Sizes range from 50-pound to 800-pound machines. The common term used to describe

these large clothes washers is “washer-extractor” since they both wash and “spin-dry” the clothes. Unlike self-serve equipment that have a set wash cycle, on premise equipment can be set to the type of laundry being washed. Variable factors include formulation of detergent and chemicals used, number of washes, rinse and additive cycles, water level, water temperature, and wash (dwell) time. To maximize the efficient operation of commercial washer-extractor equipment, consider the following:

- Consult manufacture’s literature and compare energy and water efficiencies of equipment when leasing or purchasing new washer-extractors.
- Separate and wash laundry based upon the extent to which materials are soiled and type and color of materials. Set water levels, number of cycles, and formulation accordingly. This can have a significant impact on total water use. Highly soiled materials can typically require over 3.0 gallons of water per pound of laundry, while sheets and lightly soiled materials require only about 2.0 to 2.5 gallons of water per pound of laundry.
- Work with the equipment manufacturer and supplier to provide an ongoing service and maintenance program.
- Consult service personnel and the laundry’s supplier of chemicals for the wash equipment to ensure that equipment is operating at optimal efficiency.

<u>Industrial laundries</u> are similar to on premise systems, but offer laundry services to mainly commercial entities that do not wish to operate on premise systems. For washer-extractor equipment, the recommendations are the same as that for on premise laundries. For very large operations, continuously operating tunnel washers can be used in place of washer-extractors. Tunnel washers maximize energy and water efficiency. Dirty clothes are continuously loaded on one end into the “first flush” chamber, while fresh water enters the final rinse chamber at the other end. This water is cascaded. These systems are capable of washing over 2,000 pounds of laundry an hour. Even heavily soiled materials use under 2.5 gallons per pound of laundry and overall operations reduces water use to about 2.0 gallons per pound of laundry or less for lightly soiled materials. Tunnel washers are very efficient, but also very expensive. Each industrial laundry operation will need to conduct a cost - benefit analysis to determine if a tunnel washer is an option for their operations.

<u>Water Recycle, Reuse, and Ozone Addition</u>

Recycling, reusing, or adding ozone are other ways to reduce potable water use. Recycle refers to recycling water with little treatment. An example of this is the recycle of final rinse water for first flush or for the surfactant (soap) cycle. Reuse involves some level of treatment before the water is reused. Ozone is used as a disinfectant and a way of reducing other chemical use.

- Recycle systems are the least expensive type systems. They can be installed on washer-extractors for a few thousand dollars.
- Reuse equipment can treat and reclaim water used by washer-extractors. Some systems only reuse various rinse waters while others treat all water discharged from washer-

extractors. Recovery ranges from 20 percent of water use to 85 percent of water use depending on the sophistication of the system. Cost can range from thousands of dollars to hundreds of thousands of dollars for large systems that recover over 80 percent of the water.

- Ozone is a powerful disinfectant and whitener. For lightly soiled clothes, it can reduce water use by reducing the number of wash cycles a washer-extractor must use. Water savings in the range of 20 to 30 percent have been reported. Heavily soiled material, especially cloth solid with grease or oil will still require the use of detergent cycles. Ozone systems can be easily disconnected or left off. Management will have to ensure that workers are trained so that the full benefit of these systems can be realized.

The selection of recycle, reuse or ozone systems is encouraged, but each laundry operation will have to conduct its own cost-benefit analysis.

### 3.3.5 Water Treatment

Institutional and commercial sectors use treated water in the following ways:

- To improve the longevity and function of water using equipment,
- To treat water that is being recycled,
- To treat alternate sources of water,
- To pre-treat wastewater to meet discharge standards to a sanitary sewer, and
- To treat wastewater for disposal on site.

Treatment needs range from the need to soften water for laundry operation to treating water at hospitals for kidney dialysis. Table 3.6 shows examples of water treatment used in commercial and institutional operations.

**Table 3.6. Examples of water treatment systems commonly found in commercial facilities.**

| Operation | Treatment Technology | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Sediment Filtration | Act. Carbon | Softening and Ion Exc. | Membrane Process | Distillation | Disinfection | Biological Treatment | Other |
| Food Service | X | X | X | X | | X | | X |
| Laundry and Dry Cleaning | X | | X | ? | | X | | X |
| Hospital and Laboratory | X | X | X | X | X | X | | X |
| Car Wash | X | | X | X | | X | X | X |
| Cooling Towers and Boilers | X | | X | X | | X | | X |
| Pools, Spas and Water Features | X | | | ? | | X | | |
| Office and Non - Process Uses | X | X | X | X | | X | ? | X |

When considering the treatment of water for commercial purposes, protection of public health should always be a primary consideration. Licensed plumbers, and those licensed to install point of use/point of entry equipment are trained to properly install water treatment devices. For more complicated systems, the services of a licensed engineer may be needed. Treatment of the water should not exceed the level of quality needed for the intended end use. The following best practices will minimize water use. The best conservation method is to not install water treatment equipment if it is not needed for the intended use of that water.

## Filters

Sediment filters include sand, coated media such as diatomaceous earth, cartridge, bag, and membrane filters (micro and ultra-filters). All of these filters remove particulates by capturing them on their surface. At some point, the buildup of sediment will have to be removed. Sand and membrane filters are cleaned by backwashing. Coated medial filters are flushed of sediment and recoated, and some cartridge and bag filters are removed and washed.

- For sand and membrane filters:
    - Backwash based on pressure drop, not timers.
    - Size the filter to the need.

  - Consider ways to reuse the backwash water.

- For coated media filters:
  - Choose filters that have a recoat function so that the media (such as diatomaceous earth, perlite, or cellulose) can be “bumped off” and recoated several times before the pressure drop reaches the level needed for backwash.
  - Backwash based on pressure drop.
  - Size the filter to the need.
  - Consider ways to reuse the backwash water.
- For washable cartridge and bag filters:
  - Wash based on pressure drop, not timers.
  - Minimize water use for the cleaning operation.

**Softening and Ion Exchange**

These technologies are used to remove cations and anions. In the case of softening, sodium ions are exchanged for calcium and magnesium cations. Ion exchange devices actually replace cations and anions with hydrogen and hydroxyl ions.

- Do not use timers to regenerate systems.
- For smaller systems, use flow meters that are set to regenerate based on average water quality. Actuation of regeneration of water softeners should be by demand initiation. Water softeners should be listed to NSF/ANSI Standard 44. Water softeners should have a rated salt efficiency exceeding 3,400 grains (gr) (0.2200 kg) of total hardness exchange per pound (lb) (0.5 kg) of salt, based on sodium chloride (NaCl) equivalency, and should not generate more than 5 gallons (19 L) of water per 1,000 grains (0.0647 kg) of hardness removed during the service cycle.
- In residential buildings where the supplied potable water hardness is equal to or less than 8 grains per gallon (gr/gal) (137 mg/L) measured as total calcium carbonate equivalents, water softening equipment that discharges water into the wastewater system during the service cycle should not be used except as required for medical purposes.
- For larger systems, use analytical equipment to determine when softener or ion exchange beds are nearly exhausted.

**Reverse Osmosis (RO) and Nanofiltration**

Small, under-the-counter units tend to waste a large percent of water processed. Their use should be limited to absolute need. Some such systems will actually repressurize the reject water and reintroduce it into the potable water plumbing for use elsewhere in the building. When purchasing RO and nanofiltration equipment for large commercial use, larger units should recover at least 75 percent of the feed water. Smaller systems will be less efficient. Careful selection to minimize the percent of reject water will maximize water efficiency. RO and nanofiltration reject water should be captured and reused for irrigation, cooling tower makeup, and other appropriate uses wherever possible.

**Distillation systems for water purification**
The systems should have at least an 85 percent recovery rate for distillated water and not be cooled by once-through-cooling.

**All other treatment devices**
All other devices not mentioned previously should be sized properly. Most do not have reject streams or need backwashing. In the case of wastewater treatment for on-site reuse or recycling, choose equipment that treats to the quality needed. All recycle systems and on-site wastewater treatment systems should follow all applicable regulations of the Texas Commission on Environmental Quality and requirements from local jurisdictions having authority.

### 3.3.6 Laboratory and Medical Facilities

Laboratory and medical facilities include but are not limited to:

- Clinics
- Hospitals
- Dental offices
- Veterinary facilities
- Medical laboratories
- University and analytical laboratories
- Industrial and commercial laboratories
- Any operations using similar equipment

Equipment of specific interest include:

- Vacuum systems
- Sterilizers
- Instrument and glassware washers
- Vivariums
- Exhaust hood scrubbers
- Large frame X-ray film developers
- Water treatment equipment to produce ultra-pure water
- Laboratory and medical equipment cooling

In addition to the equipment listed above, most of these facilities have domestic, food service, cooling, heating, irrigation, and related water uses. These uses are discussed in their own sections.

**Vacuum Systems**

- Almost all modern laboratories, hospitals, and dental offices have vacuum systems for either creating a vacuum to remove bodily fluids or to draw fluids and gasses. Very high vacuum pump systems find limited use in some special areas and are not the topic of this discussion.
- In the past, aspirator or venturi vacuum systems were common. These form a vacuum using the Bernoulli Effect. They are extremely wasteful but have been the mainstay for many chemistry labs since the fumes from organic compounds and acids are immediately mixed with water. The liquid ring vacuum pump is another common vacuum system. These systems use mechanical pumps that use water to cool the pump and create the seal for generating the vacuum. For years, most hospitals and dental offices used these pumps.
- Modern dry vacuum pump systems are both more energy efficient and eliminate the use of water. With the exceptions of explosive or very corrosive environments, dry vacuum systems should be used for all vacuum purposes. Currently the only exception is the use of medical vacuum sterilizers in the United States. They are limited to a liquid ring or venturi vacuum system according to the Federal Drug Administration requirement. However, laboratory and pharmaceutical vacuum sterilizers can us dry vacuum systems. In Europe and elsewhere, dry medical vacuum systems are now being approved.

**Sterilizers**

Based on the Federal Drug Administration regulations, sterilizers are divided into medical, pharmaceutical, and laboratory categories. Medical sterilizers are further divided into gravity, vacuum, and table-type systems. Table top sterilizers are small systems that use little water and should not be of concern. These best management practice recommendations regard large, stand-alone gravity and steam sterilizers. These sterilizers require a supply of "high purity" steam which means that the boiler for the sterilizer is fed with distilled water. The two main concerns regarding sterilizers are the way steam trap discharge is handled and the type of vacuum system used for vacuum sterilizers.

- *Steam Trap Discharge*: For both types, the steam jacket surrounding the actual chamber in which instruments are place is kept hot with live steam. Some of this steam condenses and therefore, several times a day, a small amount of steam condensate (pure water from steam) is discharged. Current plumbing codes require that water entering the sanitary sewer may not exceed 140 °F (60 °C). In the past, tap water was continuously discharged to the same trap that the steam condensate discharged to. The water was left running and significant volumes of water were wasted. There are five methods to reduce this use. They are arranged in the order of maximizing energy and water savings from least savings to most savings. These include:
    - Installing water tempering devices (since 2000 most all systems contain these devices).

  - Using a chilled water loop to cool the condensate prior to discharge.
  - Install sterilizers with self-contained boilers that return all steam jacket condensate.
  - Capture waste heat for other uses.
  - Returning the steam jacket condensate to the high purity boiler.
- **Vacuum Sterilizer Systems**
  - Eliminate the use of venturi type vacuum systems.
  - Use dry vacuum pumps and systems for all non-medical vacuum needs.
  - For medical sterilizers, use liquid ring vacuum systems until dry vacuum systems are approved for use.

**Instrument and Glassware Washers**

Instrument washer-disinfectors and laboratory glassware washers are not rated for water use. However, when purchasing such equipment, compare models for water and energy efficiency. The 2014 LEED Version 4 report (U.S. Green Building Council, 2013) recommends that washer-disinfectors use no more than 0.35 gallons of water per standard U.S. instrument tray.

**Vivariums**

- Vivariums are found in many laboratory, medical, pharmaceutical, and related research facilities. These can range from laboratory rat and rabbit operations to primate facilities.
- Vivariums use equipment and practices specific to animal care, such as automatic animal watering systems. Vivariums and other animal maintenance facilities can consume large volumes of water because of the need for constant flows and frequent flushing cycles. If the water is properly sterilized, it can be recirculated in the watering system rather than discharged to drains. Where water cannot be recycled for drinking because of purity concerns, but can sterilized, the water can still be acceptable for other purposes, such as cooling water make-up, or for cleaning cage racks and washing down animal rooms.
- Cage, Rack, and Bottle Washers: These systems are found in vivariums and animal research facilities. The equipment ranges from conveyor washers for mice and rat cages that closely resemble conveyor dishwashers, to large compartment washers that can hold carts of cages or large primate cages. The following Best Management Practices information is provided as part of the U. S. Environmental Protection Agency's "Labs for the 21st Century" program:
  - Replace older inefficient cage and rack washers with more efficient models. Look for models that recycle water through four cleaning stages, using potable water in a counter-current rinsing process. In counter-current rinsing, the cleanest water is used for the final rinsing stage. Water for early rinsing tasks (when the quality of rinse water is not as important) is water that was previously used in the later stages of the rinsing operations.

- Retrofit existing cage and rack washers to make use of the counter-current flow system.
- Use tunnel washers for small cage cleaning operations.
- Sterilize and recirculate water used in automatic animal watering systems instead of discharging water to the drain. Consider using water that cannot be recycled for drinking due to purity concerns in other non-potable applications, such as cooling water make-up or for cleaning cage racks and washing down animal rooms.

**Exhaust Hood Scrubbers**

- Liquid scrubber systems for exhaust hoods and ducts should be of the recirculating type. Liquid scrubber systems for perchloric acid exhaust hoods and ducts should be equipped with a timer-controlled water recirculation system. The collection sump for perchloric acid exhaust systems should be designed to automatically drain after the wash down process has completed.

**Large Frame X-Ray Film Developers**

- Small X-ray film processors such as those found in dental offices use little water and are not of concern. Medical facilities that have not converted to digital systems for large X-rays should be encouraged to do so. Processors for X-ray film exceeding 6 inches (152 mm) in any dimension should be equipped with water recycling units.

**Water Treatment Equipment to Produce Ultra-Pure Water**

Water treatment equipment that employs nanofiltration or reverse osmosis (RO) all have reject streams of water from the equipment. The general rule of thumb is that the larger the equipment, the more efficient it is. For this reason, where large volumes of RO water are needed, a single central large RO system that has a product water recovery rate of 75 percent or better can be used. For smaller operations that do not require a central system, product water recovery rates of 50 percent are possible. All systems should be shut down when not in use. Kidney dialysis systems, ultrapure water systems for laboratory use, and high purity steam requirements for sterilizers should all be designed using the water treatment best practices discussed in that section.

**Laboratory and Medical Equipment Cooling**

Once through cooling should be eliminated except for emergency conditions in medical settings. A detailed discussion of cooling is presented in the sections on Cooling and Boilers. For medical and laboratory equipment, the following best management practices should be followed:

- Use air cooling where possible
- Connect equipment to chilled water loops
- Use stand-alone chiller systems
- Connect to a cooling tower loop

The type of system selected to eliminate once through cooling will depend on the specific circumstance.

### 3.3.7 Cooling Towers, Boilers and Other Thermodynamic Operations

Once-through cooling, also known as single-pass or pass-through cooling, is currently banned by all green codes, standards, and green rating systems.

Cooling and heating of living spaces and equipment is commonplace in commercial and industrial operations. The first and most critical consideration is what type of system to use to heat or cool spaces or equipment. For heating living spaces, there are boilers (steam), hydronic heating, and hot water heat exchanger systems. All of these use water. There are also a number of other space heating systems such as hot air, heat pump, and radiant heating.

For cooling spaces, chilled water/cooling tower type air conditioning have been the classic methods to cool larger commercial and institutional spaces. In smaller spaces, evaporative (swamp) coolers have been used. Both of these evaporate significant volumes of water. Ground-geothermal systems, air cooled variable refrigerant volume (VRV), direct expansion (DX) systems, and desiccant systems all provide waterless ways to cool a space.

The first best management practice is to use heating and cooling systems that do not rely on the intensive use of water to heat or cool a building or equipment. Advances in geothermal heat pumps and variable refrigerant volume or flow (VRV or VRF) systems offer real opportunities to avoid cooling tower systems while still being cost effective.

A life cycle cost/benefit analysis of the cooling and heating systems should be performed to determine if a waterless system should be used. Keep in mind that water and wastewater costs are projected to continue to rise faster than energy costs.

If boilers, evaporative cooling, or cooling towers must be used, follow these principles:

**Steam Boilers**

Large commercial and institutional water heating systems are sometimes called boilers, but do not actually produce steam. Large water heating systems should have cold water makeup meters. These water heating "boilers" are not the subject of these Best Management Practices.

Steam boilers require water to be de-aerated and for most applications softened prior to use. As they operate, fresh water must be fed to the boiler to replace steam lost through leaks or otherwise not returned to the boiler, and for boiler blowdown to maintain water quality in the boiler. The following represent best management practices for boiler operations:

- Use a hot water heater (boiler) if actual steam is not required. This eliminates losses due to steam leaks, lack of condensate return, and blowdown.
- Meter cold water makeup to the boiler.
- Maximize steam condensate return.
- Practice good energy conservation to minimize steam use.
- Install conductivity controllers to determine when blowdown is needed (no timers).
- Minimize water use for blowdown cooling by installing heat recovery systems.
- Minimize sampler cooler water and find ways to reuse sampler cooling water.
- Use condensing boilers or retrofit existing boilers with condensing sections to maximize energy recovery. Use the condensate for cooling tower makeup, irrigation, or other uses after pH adjustment.

**Evaporative (Swamp) Coolers**

Evaporative coolers use wetted pads to cool air drawn through them by evaporating the water. Literature shows that the most significant water efficiency potential is in the control of bleed-off from the sump to control the buildup of dissolved solids and hardness that causes deposits on the pads and corrosion. The U.S. Environmental Protection Agency's 2009 WaterSense Single-Family New Home Specification sets specific standards for evaporative coolers. WaterSense recommendations are as follows:

- Use a maximum of 3.5 gallons (13.3 liters) of water per ton-hour of cooling when adjusted to maximum water use.
- Blowdown should be based on time of operation, not to exceed three times in a 24-hour period of operating (every 8 hours). Some recommend the use of a dump valve that actuates each time the equipment is started or shut down.
- Blowdown should be mediated by conductivity or basin water temperature-based controllers.
- Systems with continuous blowdown/bleedoff, and systems with timer-only mediated blowdown management should not be used.
- Cooling systems should automatically cease pumping water to the evaporation pads when airflow across evaporation pads ceases.

In addition to the WaterSense Best Management Practices for large systems of more than 30,000 cubic feet of air per minute, it is recommended that the systems be equipped with the following:

- Makeup meter on water supply.
- Overflow alarms for water level in the basin.
- Conductivity controllers should be used to blowdown on an “as needed” basis.
- Automatic water and power shutoff systems for freezing.

- Locating drain for bleed off where the flow is visible so that leaks and other problems can be easily detected.

Evaporative coolers consume water. They also add to humidity and can aggravate mold growth. Their use is limited to the more westerly parts of the state since they do not perform well in most Texas climates.

**Cooling Towers**

The first question to ask is has the facility maximized energy efficiency. Simply put, every ton hour rejected to a cooling tower requires from 1.8 to 2.5 gallons of makeup water.

The second question to ask is does a cooling tower provide the best life cycle alternative based on the rapid rise in water and wastewater rates compared to electricity, treatment, labor, liability, water and wastewater infrastructure, and supply consideration. Hybrid cooling towers, wet-dry systems, geothermal heat sinks, and newer air-cooled equipment such as variable refrigerant volume technologies may become better choices when total lifecycle considerations are evaluated.

The third question is how can the heat being rejected to the cooling tower be reduced through energy conservation or captured and beneficially used for heating and other uses.

Fourth, it is imperative that the total cost cooling tower use be balanced against rapidly rising water and wastewater costs. Currently, using a cooling tower saves between 0.2 and 0.4 kWh per ton hour thus saving from 1.6 to 3.2 cents per ton hour. Current water and wastewater rates in Texas average $10 per thousand gallons and a typical cooling tower uses 1.8 to 2.5 gallons of water per ton hour of cooling. This means that water and wastewater costs alone are in the range of 1.8 to 2.5 cents per ton hour and this does not include cooling tower chemical and labor costs. If water and wastewater rates increase as they have over the last 20 years, they will double in just 12.4 years while electricity rates are projected to only increase much less.

If a cooling tower is used, best management practices can be divided into three categories including:

- Operational Considerations
- Vendor Selection
- Design and Equipment Selection

Operational considerations are the first consideration in the efficient operation of a cooling tower. For cooling towers larger than 500 tons, a continuous electrical record of operations should be available for download. If that record is not available, the operator should maintain a written shift log. At a minimum, the shift log should contain:

- Details of make-up and blowdown quantities, conductivity, and cycles of concentration.
- Chiller water and cooling tower water inlet and outlet temperatures.
- A checklist of basin levels, valve leaks, appearance, and a description of potential problems.
- Above all, ensure that the employee responsible for the cooling tower operations is knowledgeable of accurate record keeping and visual examination of the cooling tower.

Select a water treatment vendor that focuses on water efficiency. Request an estimate of the quantities and costs of treatment chemicals, volumes of make-up and blowdown water expected per year, and the expected cycles of concentration that the vendor plans to achieve. Specify operational parameters such as cycles of concentration (CC) in the contract. Increasing cycles from three to six reduces cooling tower make-up water by 20 percent and cooling tower blowdown by 50 percent.

Work with the water treatment vendor to ensure that clear and understandable reports are transmitted to management in a timely manner. Critical water chemistry parameters that require review and control include pH, alkalinity, conductivity, hardness, microbiological growth, biocide, and corrosion inhibitor levels.

Design and retrofit best management practices include proper instrumentation, tower design, and operation as listed below:

- Install a conductivity controller that can continuously measure the conductivity of the cooling tower water and will initiate blowdown only when the conductivity set point is exceeded. Working with the water treatment vendor, determine the maximum cycles of concentration that the cooling tower can sustain, then identify and program the conductivity controller to the associated conductivity set point, typically measured in microSiemens per centimeter (US/cm), necessary to achieve that number of cycles. Conductivity controller systems cost from $3,500 to $100,000 depending on the nature of the facility in which it is installed. Possible savings depend on the increase in cycles of concentration.
- Install flow meters on make-up and blowdown lines. On most cooling towers, meters can be installed at a cost of between $1,000 and $50,000. Manually read meters can be used for smaller towers, but if the tower is 500 tons or more, meter readings should be automated and be connected to an electronic data management system.
- Install automated chemical feed systems or treatment equipment. These systems minimize water and chemical use while protecting against scale, corrosion, and biological growth.
- Install overflow alarms on cooling tower overflow lines and connect the overflow alarm to the central location so that an operator can determine if overflows are occurring. The

alarm can be as simple as a flashing light in the control area to more sophisticated systems that include a computer alert.

- Install drift eliminators that are capable of achieving drift reduction to 0.002 percent of the circulated water volume for counterflow towers and 0.005 percent for cross-flow towers.
- A biocide should be used to treat the cooling system recirculation water where the recycled water may come in contact with employees or members of the public.
- The U.S. Green Building Council's 2014 LEED report for new buildings recommends the following maximum concentration parameters for cooling tower water quality.

**Table 3.7. Recommended maximum concentration parameters for cooling tower water quality.**

| Parameter | Maximum Level |
|---|---|
| Ca (CaCO3) | 1,000 ppm |
| Alkalinity | 1,000 ppm |
| SiO2 | 100 ppm |
| Cl | 250 ppm |
| Conductivity | 3,500 US/ml |

Additional equipment and systems that reduce water and improve cooling system efficiency use include:

- Side stream treatment to soften tower water or remove dissolved solids.
- The use of alternate sources of water is strongly encouraged.
- Side stream filtration to remove particulate matter. This may allow for an increase in cycles of concentration and it will help increase overall energy efficiency by maintaining clean tower and heat exchanger surfaces.

*Cooling tower water use*

Cooling towers dissipate heat by evaporation. On ton hour, but definition, equals 12,000 BTU's. The latent heat of evaporation, the energy dissipated to evaporate water, is 971.4 BTU's per pound. This means that for every ton-hour 1.48 gallons of water are evaporated. Air conditioning systems are rated on the tons of cooling they can achieve. With today's mechanical systems, the compressor, air moving fans and the pumps to circulate cooling tower and chilled water loops all generate heat in their operation. This "parasitic" load of waste heat from the operation of the mechanical equipment is also rejected to the cooling tower.

The American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) estimates that for one ton hour of cooling (chiller ton hours), 15,000 BTU's are rejected to the cooling tower. This means that for every 12,000 BTU's of air conditioning, 15,000 BTU's 1.85 gallons of water are evaporated.

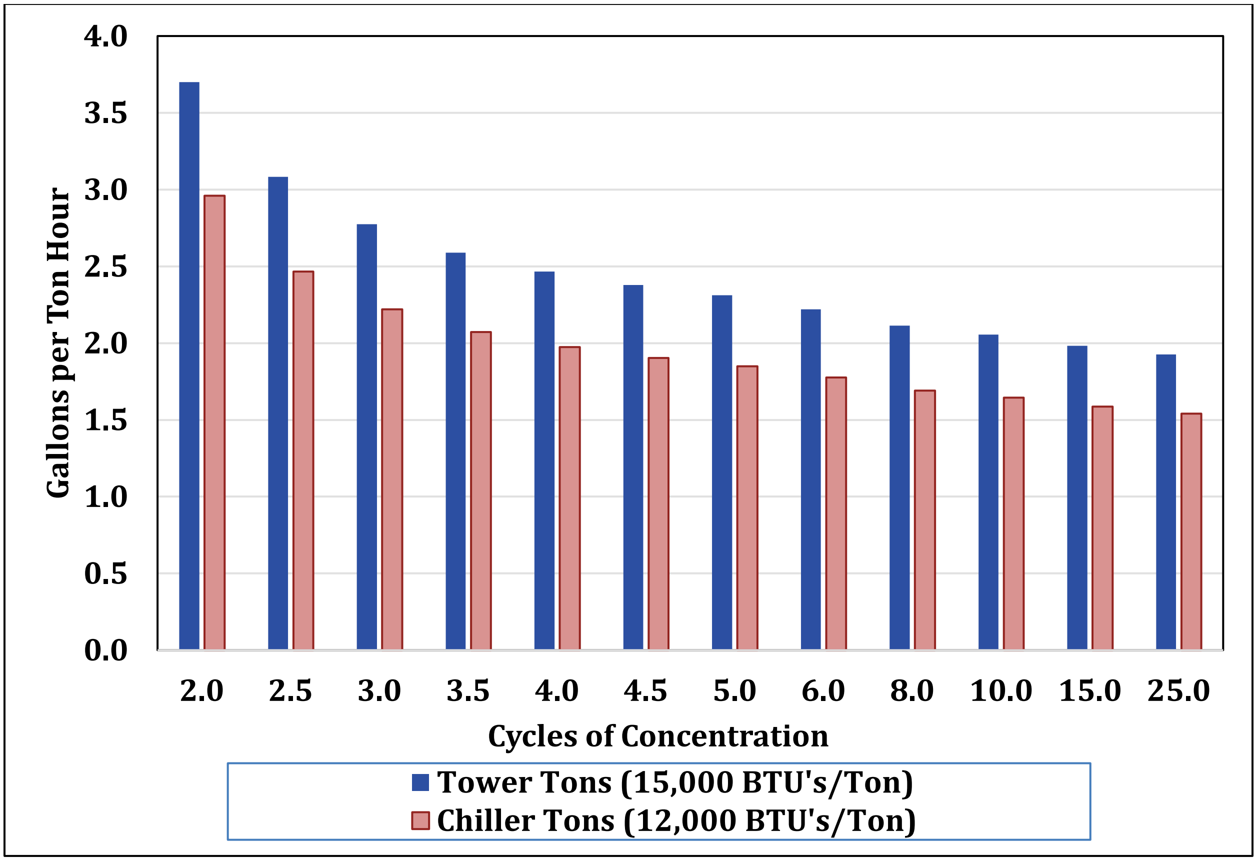


**Figure 3.2. Compares chiller and tower ton water use per ton hour.**

### 3.3.8 Swimming Pools, Spas, and Fountains

Texas ranks third in the nation behind California and Florida for the number of swimming pools. Based on information from the Association of Pool and Spa Professionals, ninety-five percent of all installed pools, both above and in-ground pools, are residential. The remaining five percent though, represent the largest volume and therefore the largest water users. Places where commercial pools are found include:

- Apartment complexes
- Hotels and motels
- Parks and public pools
- Schools and universities
- Health facilities

Reducing water use by pools, hot tubs, and ornamental recirculating fountains depends on six factors:

1. Reducing evaporation,
2. Splash-out loss,
3. Efficient filtration equipment,
4. Providing proper maintenance,
5. Examining the potential for alternate on-site sources of water, and
6. Changing human behavior.

**Evaporation**

Evaporation varies significantly across Texas. Pan evaporation data shows that in East Texas on the Louisiana border, approximately 65 inches of water are lost annually through evaporation. This increases to 100 to 120 inches a year in Far West Texas. Heated pools and spas lose even more water to evaporation as the following table illustrates.

**Table 3.8. Evaporation from heated indoor pools.**

| Pool Type | Water Temperature °F | Air Temperature °F | Evaporation Factor Gal/hr/sqft | | Activity Factor | Gal/dy/sqft at 60% Humidity | Gal/dy/sqft at 50% Humidity |
|---|---|---|---|---|---|---|---|
| | | | 60% Humidity | 50% Humidity | | | |
| Residential | 85 | 87 | 0.02 | 0.03 | 1.0 | 0.06 | 0.08 |
| Hotel | 82 | 84 | 0.02 | 0.03 | 1.3 | 0.07 | 0.10 |
| Hot Tub | 104 | 88 | 0.07 | 0.08 | 2 | 0.41 | 0.45 |
| Health/ Competition | 79 | 81 | 0.02 | 0.02 | 1.6 | 0.08 | 0.11 |
| Public Pool | 85 | 87 | 0.02 | 0.03 | 2 | 0.12 | 0.16 |

*(Source: Dehumidifier Corporation of America)*

Pool covers significantly reduce evaporation, but are often difficult to take on and off and therefore tend to not be used regularly. In recent years, liquid pool covers have become available on the market. These products form an invisible, non-toxic layer on the water surface that is only a few molecules thick. Swimmers are not affected by the thin film and will not notice it. The thin film retards evaporation, but not as well as plastic pool covers. Their advantage is that as long as the liquid is replaced, the reduction in evaporation is continuous.

**Splash-Out**

Splash-out and drag-out occur in all pools as swimmers dive, swim, play, and get in and out of the pool. Three design features will reduce this water loss. They are:

- Gutters (splash troughs) around the perimeter of the pool that catch splash-out and direct it back into the pool,

- Rounded edges that slightly protrude over the edge of the pool, and
- Proper free board.

**Filter System Selection**

Choosing the proper filter will determine how much water is used for backwashing. Sand, zeolite and other granular material filters must be backwashed until the media has been washed and cleaned of the debris it filtered out. Precoat filters include conventional diatomaceous earth (DE), cellulose, or perlite filters, as well as regenerative filters that reuse the filter media. Cartridge filters use pleated paper-type material. The filter elements need cleaning only a few times a year. Old disposable filter cartridges should not be re-used. However, modern re-usable cartridges need only to be washed off with a hose and returned to the filter housing. Table 3.9 summarizes basic characteristics of the different types of swimming pool and spa filters. The same principles apply to recirculating ornamental fountains.

**Table 3.9. Filter selection for pools.**

| | Sand | Coated Media | Cartridges |
|---|---|---|---|
| **Frequency of cleaning** | Every week | Every 4-8 weeks | Depends on unit |
| **Difference in pressure (determines when to clean)** | 5-10 psi | 8-10 psi | 8-10 psi |
| **How unit is cleaned** | Backwash | Backwash[a] | Disassemble and wash with hose |
| **Filtration** | 20-40 microns | 5 microns | 10 microns |
| **Time between replacement** | 3-6 years | Every backwash | 2-4 years |
| **Cost** | \$0.50 to \$1.00/lb | \$0.15-\$0.50/lb | \$15-\$100 each |
| **Residential use** | Yes | Yes | Yes |
| **Commercial use** | Yes | Yes[b] | Not recommended |
| **Backwash flow time** | 2-5 min[c] | 1-5 min[c] | Remove and wash |

[a]DE and Pearlite filters should be bumped and swirled whenever pressure drop across filter reaches 8-10 psi

[b]DE not recommended for apartments, condominiums, or hotels since the filters quickly become clogged with the high rate of use. Specially designed DE and Pearlite filters are made for high volume use.

[c]Typical times, filter should be backwashed until sight glass is clear.

*(Source: Hoffman, 2010)*

For all filtration systems, the following is recommended:

- Do not use timers to automatically back wash filters
- Backwash based on measured pressure drop across filter
- Backwash only when needed
- Where possible, discharge filter water to landscape unless algaecides are being used

For sand, granular, and zeolite filters install a sight glass to determine when the media has been cleaned and operate the backwash cycle only until the water appears clear in the sight glass.

For coated media filters, choose regenerative types. With regenerative pre-coat filters, the media is periodically bumped off by backflow, air agitation, mechanical shaking, or a combination of the three and then recoated. Regenerative filters save significant volumes of water and filter media since the media can be recycled up to 30 times before being discarded. No water is lost in the recoating process.
For large commercial pools, automated pre-coat regenerative filters are available. Pressure drop should be used to determine when to bump and when to dump the filters. Only two or three filter volumes need to be rejected when dumping and removing the spent coating material. Diatomaceous earth should not be dumped into the sanitary sewer since it will settle out and clog the sewer. Many codes require that the media be captured in a settling device and disposed of as solid waste.

For cartridge filters, only washable reusable types should be used to reduce the cost of filter replacement and solid waste issues. Pressure drop should be the determining factor for when to clean the filter. When washing the filter with a hose or pressure washer, allow the water to drain onto the landscape.

## Proper Maintenance

Keeping pools cleaned and maintaining proper water chemistry and disinfectant levels is vital in providing an attractive pool and reducing the need to dump and refill and backwash. Vacuuming a pool and skimming floating debris off the top are part of this maintenance. For commercial pools, four types of vacuum systems are available including (1) the type that connects to the suction port for the filter, (2) the type that uses the discharge port energy to operate a vacuum pump in the water, (3) a stand-alone portable filter system that often uses a cartridge or bag filter, and (4) an electrically powered vacuum system that moves along the bottom of the pool. The first type that connects directly to the suction side of the filter will fill the filter with debris faster than the others and requires more frequent backwash.

Maintaining the concentration of dissolved solids and minerals in the water is part of good pool maintenance. As water evaporates, minerals remain behind. The traditional way of balancing salt levels is to periodically drain and refill the pool with fresh water.

## Alternate Sources of Water

The reader should also read the chapter on Alternate Sources of Water. For swimming pools, use filter backwash water for irrigation where possible. Air conditioning condensate, rainwater, and other alternate sources of water can be treated to the levels acceptable for swimming pool use.

## Changing Human Behavior

Proper training and supervision is needed to ensure that commercial and institutional swimming pools are operated correctly. Professional pool companies and local health departments can provide information.

### 3.3.9 Vehicle Washes

Vehicle washes include self-service equipment such as spray wands, foamy brushes, roll-over (also called express or in-bay) equipment like those found in many gasoline service stations, commercial conveyor type systems, and special large vehicle washing equipment. Water recycle systems should be installed on roll-over and conveyor systems. Best management practices for all types include:

- Metering use
- Minimizing drag-out by installing small humps to direct water dripping from washed vehicles back into the car wash
- A main shutoff valve so that water to the system can be easily turned off
- Spot-free reverse osmosis reject water (if used) must be recycled
- All towel ringers (if applicable) must have a positive shut-off valve
- Spray nozzles must be replaced annually
- Where applicable, a 5 second dwell time should be created before the customer’s vehicle exits the bay to enable water to run-off the vehicle into the bay collection pit

Recommended maximum water use per vehicle for automobiles and pickup trucks are as follows:

- In-bay automatic car washes – 40 gallons (151 L) per car
- Conveyor and express – 35 gallons (132 L) per car
- Spray wands and foamy brushes – 3.0 gpm (0.06 L/s)

For large vehicle washes, recycle or reuse systems should be installed and the best management practices for all types of systems followed.

### 3.3.10 Alternate Sources of Water

The use of alternate sources of water is one of the most dynamic areas in water conservation and resource management today. These sources include both reclaimed water and on-site sources. Texas is a national leader with respect to reclaimed water, rainwater, and gray water reuse.

Texas adopted two initiatives to encourage these types of strategies:

- Sales tax incentive under the tax law administered by the Office of the Comptroller (Tax Code Section 151.355(1))

- Property tax relief under the environmental quality law administered by the Texas Commission on Environmental Quality (30TAC 17) is available in limited cases

Underlying Concepts

Before discussing the best management practices for use on alternate water sources, the following must be considered:

1. The use of alternate on-site sources of water is a best management practice (BMP) in and of itself.
2. Alternate on-site sources of non-potable water should be used efficiently.
3. Any water source can be treated to meet the needs and conditions of a desired end use. Economics and volume of water available are the major limiting factors.
4. These sources of water are perfect candidates to use in conjunction with potable water, recycled water, and self-supplied fresh water.
5. The potential of this resource is only limited by the limits of the amount available and the ingenuity of the user.

In addition to reclaimed water, alternate on-site sources can include:

- Rainwater harvesting
- Storm water harvesting
- Air conditioner condensate
- Swimming pool filter backwash water
- Swimming pool drain water
- Cooling tower blowdown
- Reverse osmosis (RO) and Nanofiltration (NF) reject water
- Gray water (shower, bath tub, hand washing lavatories, and laundry water only)
- On-site treated wastewater
- Foundation drain water

Just as there are many sources, there are many possible uses of alternate sources of water, including:

- Irrigation
- Green roofs
- Cooling tower makeup water
- Toilet and urinal flushing
- Makeup for ornamental ponds/fountains
- Swimming pools
- Laundry
- Industrial process use
- Other use not requiring potable water

- Potable use

At the writing of this document, many things are still in the state of change. For rainwater, new Texas legislation in 2011, House Bill 1073, Senate Bill 1073, and House Bill 3391directs that:

- Financial institutions may consider making loans for developments that will use harvested rainwater as the sole source of water supply.
- New state buildings with a roof measuring at least 10,000 square feet must incorporate an on-site reclaimed system into its design.
- Individual homes can use rainwater for potable water supply as long as they obtain the consent of the water utility serving them and follow proper backflow procedures.

Texas leads the nation in promoting and implementing rainwater harvesting. House Bill 1073 and Senate Bill 1073 further clarify the use of rainwater harvesting and provide protection to utilities in case of cross connections. The State Board of Plumbing Examiners will also add a rainwater certification and training to its licensing authority and the Texas Water Development Board (TWDB) will provide educational material. The Texas Commission on Environmental Quality (TCEQ) is also developing appropriate regulations to implement this legislation. For more information on rainwater harvesting, see the following Texas Water Development Board website: http://www.twdb.texas.gov/innovativewater/rainwater/faq.asp.

TCEQ regulations for the use of alternate on-site sources of water including gray water, air conditioning condensate, and all of those listed above was promulgated on December 29, 2016. These regulations cover all uses except where separate regulation exist regarding rainwater harvesting. The reader is directed to the TCEQ Rules website for the actual rules on on-site water reuse at: https://www.tceq.texas.gov/assets/public/legal/rules/rules/pdflib/210f.pdf. The guidance document for the use of alternate sources of water and gray water can be found at https://www.tceq.texas.gov/assets/public/comm_exec/pubs/rg/rg-536.pdf

New national codes and standards that provide guidance for implementing the use of all types of alternate sources of water have been developed in the last two years. These include:

- International Association of Plumbing and Mechanical Officials (IPMO) Green Plumbing and Mechanical Code Supplement, 2015
- International Association of Plumbing and Mechanical Officials (IPMO) Green International Code Council (ICC), International Green Constriction Code, 2015
- NSF/ANSI Standard 350*:* On-site Residential and Commercial Water Reuse Treatment Systems, NSF International, 2011
- NSF/ANSI Standard 350-1: On-site Residential and Commercial Graywater Treatment Systems for Subsurface Discharge, NSF International, 2011

When considering using an alternate source, it is important to keep in mind that each type of source is different. Table 3.10 summarizes some of the water quality characteristics that the various sources may have.

**Table 3.10. Water quality considerations for alternate on-site sources of water.**

| Sources | Water Quality | | | | | |
|---|---|---|---|---|---|---|
| | Sediment | (TDS) | Hardness | Organic (BOD) | Pathogens | Comments |
| **Rainwater** | 1-2 | 1 | 1 | 1 | 1 | None |
| **Storm water** | 3 | ? | 1 | 2 | 2 | May contain pesticides and fertilizers |
| **Air conditioner condensate** | 1 | 1 | 1 | 1 | 2 | May contain copper |
| **Pool filter backwash** | 3 | 2 | 2 | 1 | 2 | May contain treatment chemicals |
| **Cooling tower blowdown** | 2 | 3+ | 3 | 2 | 2 | May contain treatment chemicals |
| **RO & NF reject water** | 1 | 3+ | 3 | 1 | 1 | High salt content |
| **Untreated Gray water** | For subsurface application only. May need lint screening. | | | | | May contain detergents and bleach |
| **On-site wastewater treatment** | 3 | 2 | 2 | 3+ | 3+ | May contain human waste |
| **Foundation Drain Water** | 1 | ? | ? | 2 | 2 | May contain pesticides and fertilizers |
| **Other Sources** | ? | ? | ? | ? | ? | Depends on source |
| 1. Low level of concern<br>2. Medium level and may need additional treatment depending on end use<br>3. High concentrations are possible and additional treatment likely<br>? Dependent on local conditions | | | | | | |

When deciding on the type of treatment for an alternate source of water, remember that it is necessary only to treat to the level needed for that application. Table 3.11 summarizes treatment methods that may be employed for various end uses of these sources.

**Table 3.11. Types of treatment for alternate sources of water.**

| Source | Filtration | Sedimentation | Disinfection | Biological Treatment | Softening | Comments |
|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| Rainwater (non-potable) | ? | | ? | | | Depends on end use |
| Rainwater (potable) | X | | X | | | Follow local code |
| Storm water | X | ? | X | ? | ? | May contain oils and heavy metals |
| Air conditioner condensate | ? | | X | | ? | May contain copper and bacteria |
| Pool filter backwash | X | ? | X | | ? | May contain sediment, bacteria, chemicals, and salts |
| Cooling tower blowdown | X | | X | | X | High dissolved solids, may contain bacteria and sediment |
| RO & NF reject water | | | ? | | ? | High dissolved solids |
| Gray water | X | X | X | ? | | May contain bacteria, BOD, and sediment |
| On-site wastewater treatment | X | X | X | X | ? | May contain bacteria, BOD, and sediment |
| Foundation Drain Water | X | | X | | ? | May contain hardness, bacteria, and sediment |

The Texas Water Development Board, Texas Commission on Environmental Quality, the Texas State Board of Plumbing Examiners, and many local jurisdictions are currently developing new rules, information, and guidance regarding these alternate sources of water. Application of this best management practice will continue to grow in the future.

Air Conditioning Condensate Recovery Systems

The amount of condensate that can be recovered depends on the outdoor and indoor conditions – both temperature and relative humidity – and the amount of outdoor air that is exchanged with indoor air. In hot, humid climates of Central Texas, for example, where high humidity coincides with the hottest summer temperatures and greatest cooling loads, considerable condensate can be produced, especially for shopping malls and other frequently visited buildings and warehouses. Other good candidates include high tech manufacturing or pharmacy storage facilities that require closely controlled humidity conditions.

According to a San Antonio Water System (SAWS) publication entitled, *Condensate Collection and Use Manual for Commercial Buildings* (Glawe 2013), a typical hourly condensate production rate for large buildings in San Antonio, Texas, during the summer months was between 0.1 and 0.3 gallons of water per ton of cooling, or approximately 0.5 to 0.6 gallons/hour per 1,000 $ft^2$ of conditioned floor space, or a peak rate of 0.5 to 0.6 gph per 1000 sq ft of cooled area. SAWS reported that the downtown Rivercenter Mall generates 250 gallons each day from its air handlers, which is used for cooling water makeup and paid for itself in less than six months. SAWS also reported that San Antonio Public Library produces about one gallon per minute, or 1,400 gallons per day.

This provides a useful guideline for other areas in Texas with a climate similar to San Antonio. Condensate recovery ranges from 5% to 15% of required cooling tower makeup water (Guz 2005) for typical commercial buildings and up to 45% for high-ventilation buildings such as laboratories (Sieber 2010).

The Alliance for Water Efficiency (AWE) estimates that the amount of condensate water can range from 3 to 10 gallons per day (gpd) per 1,000 square feet (sq ft) of air-conditioned space.

SAWS' publication (Glawe 2013) provides an excellent guide for the use of air conditioning condensate. The guide was developed by Dr. Diana Glawe at Trinity University in San Antonio. It can be found at:
http://www.saws.org/conservation/commercial/Condensate/docs/SACCUManual_20131021.pdf.

If condensate is being used only for cooling tower makeup, the condensate can often be fed directly to the cooling tower without storage since the condensate produced in a building generally will not exceed the evaporative losses from the cooling tower. These gravity-fed condensate collection systems are relatively inexpensive with payback periods of less than a year based on reduced water and wastewater charges from offsetting 5% to 15% of potable makeup water, and can be financially viable for any size building.

AC condensate is much like distilled water, which has a pH of around 5.8 and can cause reactions with metals, iron and steel. Pathogenic organisms are of greater concern – Legionella proliferates in warm water such as storage tanks. For this reason, above ground irrigation with collected water may be regulated by local ordinance (Glawe, 2013, p. 37). Other concerns include:

- Lower pH – Can be very corrosive
- Can carry contaminants that originate in the AC system or condensate drain pan. It is highly important to keep the entire HVAC system clean
- If considering potable use, it is very important that all surfaces consist of food grade materials
- Should be treated if stored or aerosolized

TCEQ rules under 30 TAC Chapter 210 include the commercial use of air conditioning condensate as uses subject to "Special Requirements for Use of Industrial Reclaimed Water." This requires commercial entities that want to use air conditioning condensate for toilet flushing to get formal approval from TCEQ and perform weekly water quality testing. This could be an impediment to commercial entities wishing to use air conditioning condensate for toilet flushing but further research is needed (City of Austin staff memo to city council, October 1, 2014).

The use of air conditioning condensate for cooling tower make-up and outdoor irrigation is exempt under Type I authorization from individual TCEQ permitting or notification requirements (30 TAC 210.53 and 210.56). Some Texas cities require AC condensate recovery systems for new development. San Antonio City Code Sec. 34.274.1 (City of San Antonio, 2014) requires new commercial construction on or after January 1, 2006, to have a single independent condensate collection line to collect condensate for use as process water, cooling tower makeup, and landscape irrigation. In addition, the ordinance prohibits drainage to stormwater collection systems, roof drain overflow systems, or impervious surfaces. This ordinance has also been adopted by New Braunfels almost verbatim effective January 1, 2007 (City of New Braunfels, 2014) The City of Austin is in the process of adopting similar requirements in 2017.

City zoning ordinances and other criteria often require a Green Building rating. For example, Austin's Green Building program requires certain percentage reductions in indoor and outdoor water use and lists potential strategies to achieve these reductions, including the use of AC condensate systems, but does not prescribe the specific strategies that must be used to achieve the reductions (Austin Energy, 2010, pp 43-44). The 2012 City of Dallas Green Ordinance, Sec 703.4, contains a condensate recovery requirement for all new commercial facilities effective October 1, 2013 to qualify under the City of Dallas Green Building Program (2012).

# 4.0 BMP: Implementation, Scope, and Schedule

The implementation of best management practices for the commercial and institutional sectors must consider steps needed by water and wastewater utilities wishing to implement commercial and institutional water conservation programs and those steps that the actual commercial and institutional water user should take to implement these savings in their facility.

## 4.1 Utility Implementation Plan

For the utility, the following steps are needed to develop and implement a water conservation plan:

- *Scoping opportunities*: The first activity should be to find out who the ICI customers are and which of these customers the biggest users are. This will help to develop statistics in identifying opportunities. Data could include monthly use, sub-metering information if available, type of user (hotel, school, etc.), size of user (square feet, number of people, number of rooms, etc.), and information on the use of irrigation systems, cooling towers, etc. The basis for much of the analysis may be included in the latest water conservation plan. The utility data is the first important starting place. It is from this information that the utility can begin to build its business case.
- *Evaluating program elements*: This is the "how to" of the program. The utility will need to list all of the ways that an ICI program could be structured. From this list, program elements should be derived.
- *Funding, rebates, and buy-back opportunities*: The utility will need to analyze all possible incentive programs that they could implement. The utility should also analyze the benefits such a program could have on delaying the need for future treatment construction. With commercial, institutional, and industrial customers, utilities can consider water efficiency programs as ways to buy-back capacity in the system.
    - In examining opportunities, utilities should look at all aspects of encouraging water efficiency, including rebates, tax incentives, free equipment such as pre-rinse spray valves, as well as the public relations value to the customer. Coordination with other incentive programs offered for economic development or energy conservation can significantly enhance the effectiveness of the program.
- *Working with commercial and institutional customers*: The utility's commercial and institutional customers are stakeholders in the process. At this point, it is most helpful to bring them into the process as the utility's commercial and institutional plan is being developed. When building new facilities, the elements in this guide should be included in the initial design. Costs for inclusion into the initial design are always less costly than retrofitting later.
- *Plan Development*: Stakeholder input will significantly benefit the development of the plan. The utility will need to consider steps 1 through 4 above to determine what is

feasible for their operation. The final product will be a plan of action with all utility costs, staffing needs, and program elements considered.

- *Implementation*: The next step is implementation. The reader is referred to the municipal best management practices for additional input. These guidelines can be found on the Texas Water Conservation Advisory Council's website: http://www.savetexaswater.org/.
- *Program evaluation*: The program evaluation measures how well the program achieved its goals, both from a process and performance measures/impact side. The process evaluation identifies areas for program improvement while the impact analysis provides an objective measure of the program success quantified in terms of savings achieved in reductions of water use and avoided costs.

## 4.2 Commercial and Institution Implementation Plan

Developing a water conservation program at the facility level is a multi-phase process. The first step to take is to ask what are the goals. For most entities, reducing costs are the key consideration, but presenting a "green" image, supporting community needs, and public relations potential can also motivate commercial and institutional facility managers and owners. To begin the process, facility managers should take stock of current water and wastewater use, costs associated with water use, including energy costs such as water heating, chemical costs associated with water use, labor costs and needs associated with operations that also use water, and the cost of these inputs.

Once records are gathered, it is important to physically walk through the facility and talk to all staff involved in operations that use water. The following seven questions are very helpful in this effort. They are also the seven questions that will need to be asked when an actual plan of action is developed. The questions are:

1. How much water is used for this activity?
2. Where is water used?
3. When and how long is water used?
4. How is water used?
5. Who controls water use?
6. Why does water have to be used?
7. What can be done to eliminate the need for water in this operation?

The next step is to develop and implement a plan of action. Steps in this process may include:

- Organizing metering and records
- Record location and type of use
- Obtain information on time and volume of use
- Determine possible conservation measures
- Calculate cost of use vs. benefit

- Consider alternate supply
- Put it to paper
- Implement the plan (A plan on paper does not save water, implementation of the program does.)
- Evaluate and make changes (No plan is perfect and situations change. Programs must change accordingly over time).

# 5.0 References for Additional Information

## 5.1 References

There are many sources of assistance regarding water conservation for commercial and institutional water users to draw from. Many local utilities have water conservation professionals that can provide assistance. At the State level, the Texas Water Development Board and the Texas Commission on Environmental Quality have professional water conservation staff that can provide information and assistance. Companies that specialize in all aspects of water conservation are also available. Some water service companies can even offer funding and performance contracting. These companies can perform detailed audits of all aspects of water use and corresponding associated energy use. There are also several organizations and governmental agencies that have excellent resources available on their websites. Examples include:

- Alliance for Water Efficiency - www.allianceforwaterefficiency.org
- American Rainwater Catchment Association, http://www.arcsa.org/
- Arizona Department of Water Resources - www.azwater.gov/conservation
- Bureau of Reclamation - Water Conservation - http://www.usbr.gov/waterconservation/
- California Urban Water Conservation Council - www.cuwcc.org
- Conserve Florida Water Clearinghouse - http://www.conservefloridawater.org/
- Consortium for Energy Efficiency - www.cee-1.org
- EPA Water Sense and Energy Star - www.epa.gov/watersense, www.energystar.gov
- Food Service Technology Center - www.fishnick.com
- H2O Conserve - www.h2oconserve.org
- Save Texas Water – www.savetexaswater.org
- Texas Commission on Environmental Quality - www.tceq.state.tx.us/
- Texas Water Development Board - www.twdb.state.tx.us
- Texas Water Foundation - www.texaswater.org/
- Water – Use it Wisely - http://www.wateruseitwisely.com/

Professional organizations can also provide assistance. Examples include:

- American Society for Healthcare Engineering (ASHE)
- American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE),
- American Water Works Association
- Association of Facilities Engineers (AFE)
- International Facility Managers Association (IFMA)
- Building Owners & Managers Association (BOMA)
- Texas Sales Tax Exemptions for Water Related Equipment with Application (A sales tax exemption was created in 2001, to encourage water conservation.)
- Application for Water Conservation Initiatives Property Tax Exemption (A property tax exemption is allowed for all or part of the assessed value of a property on which water

conservation modifications have been made. Check with your local county appraisal district for guidance.)

- Sales and Use Tax Bulletin 94-123 Water and Wastewater Systems

Other resources include:

1. California Urban Water Conservation Council Reports on:
   - Commercial Food Services
   - High-Efficiency Clothes Washers
   - Landscape Irrigation Technologies
   - Medical and Health Care Technologies
   - Potential Best Management Practice
   - Residential Dishwashers
   - Residential Hot Water Systems
   - Toilet Fixtures
   - Urinal Fixtures
   - Vehicle Washes
   - Wet Cleaning
   - End-Use Studies
   - National Efficiency Standards
   - http://www.cuwcc.org/resource-center/resource-center.aspx

*2.* California Urban Water Conservation Council, Maximum Performance (MaP) of Toilet Fixtures - Flushometer Valve/Bowl Combinations, *http://www.cuwcc.org/WorkArea/showcontent.aspx?id=15786*

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| | |
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### 5.3 Definitions

***Alternate water source*** is defined as a source of non-potable water that is not suitable for human consumption. Examples of alternate water sources are: rainwater, stormwater, condensate, treated graywater, process reject water, blowdown, foundation drain water, etc.

***Automatic shut-off device*** is defined as an active system that stops the flow of water automatically when a leak is detected or a programmable system that stops the flow of water when the equipment is not in use.

***Closed loop system*** is defined as a system that has no contact with the outside environment.

***EPA Energy Star*** is defined as a joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy helping to save money and protect the environment through energy efficient products and practices.

***EPA Water Sense*** is defined as a U.S. Environmental Protection Agency sponsored partnership program that seeks to protect the future of the nation's water supply by promoting water efficiency and enhancing the market for water-efficient products, programs, and practices.

***ICI (Institutional, Commercial and Industrial)*** are no-residential type customers. Institutional customers include schools, hospitals, and governmental buildings, commercial customers range from car washes to hotels and restaurants, and industrial customers include manufacturers, power generators, mining operations and related activities.

***Non-potable water*** is defined as water that is not suitable for drinking.

***Once through cooling*** is defined as water that is pumped through heat exchange equipment and then discharged into the environment.

***Potable water*** is defined as water which is fit for consumption by humans and other animals.

***Reclaimed water*** is defined as water from domestic or municipal wastewater which has been treated to a quality suitable for beneficial use.

***Recycled water*** is defined as water which, as a result of treatment of waste, is suitable for a direct beneficial use or a controlled use that would not otherwise occur.

***Reuse*** is defined as treated wastewater that can be used for beneficial purposes.

***Self-closing*** is defined as a device, usually in a faucet or nozzle, which must be turned on by the user by pushing or pulling and closes when the user releases the handle or tap.

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# APPENDIX A - Importance of the C&I sectors to the Texas Economy and Water Use

## Economic Significance of the Commercial and Institutional Sectors to Texas

The commercial and institutional sectors represent a major component of the Texas economy and our institutions form the backbone of the necessary services to make the economy work. The majority of Texans, 85 percent, are employed in the commercial and institutional (CI) sectors as represented by Figure A-1. These two sectors also account for over 70 percent of the state's gross domestic product as seen in Figure A-2. Figure A-3 shows a breakdown of employment in Texas by sector.

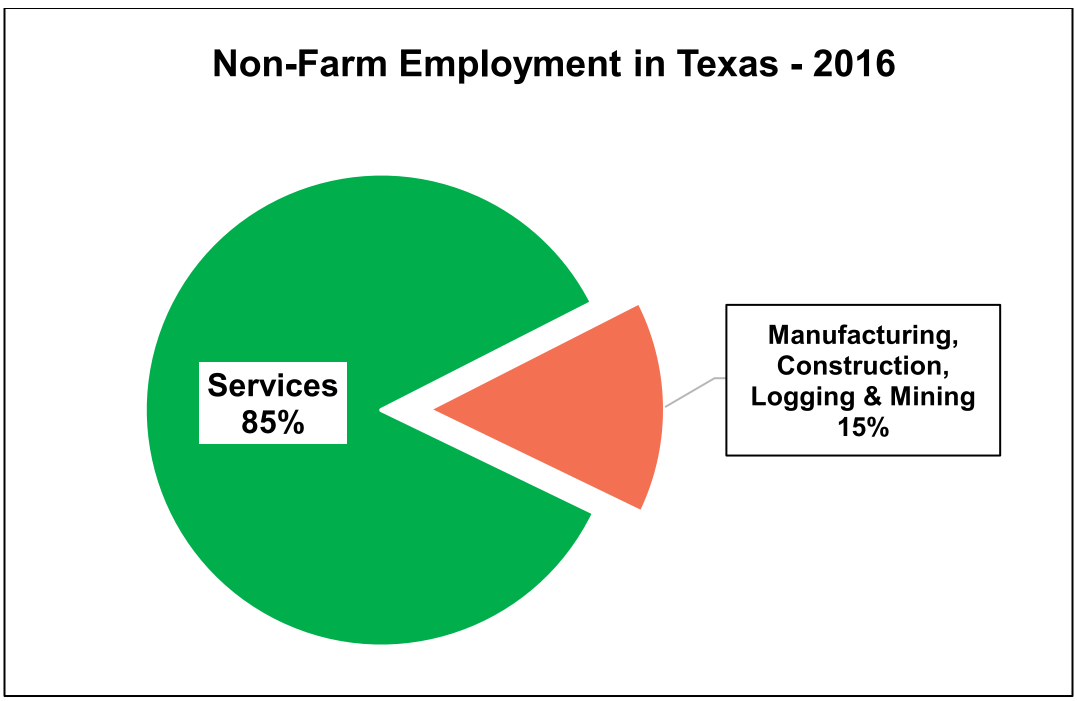



**Figure A-1. Shows the percentage of non-farm employment in Texas for 2016.**
*(Source: Bureau of Labor Statistics, U.S. Department of Labor)*

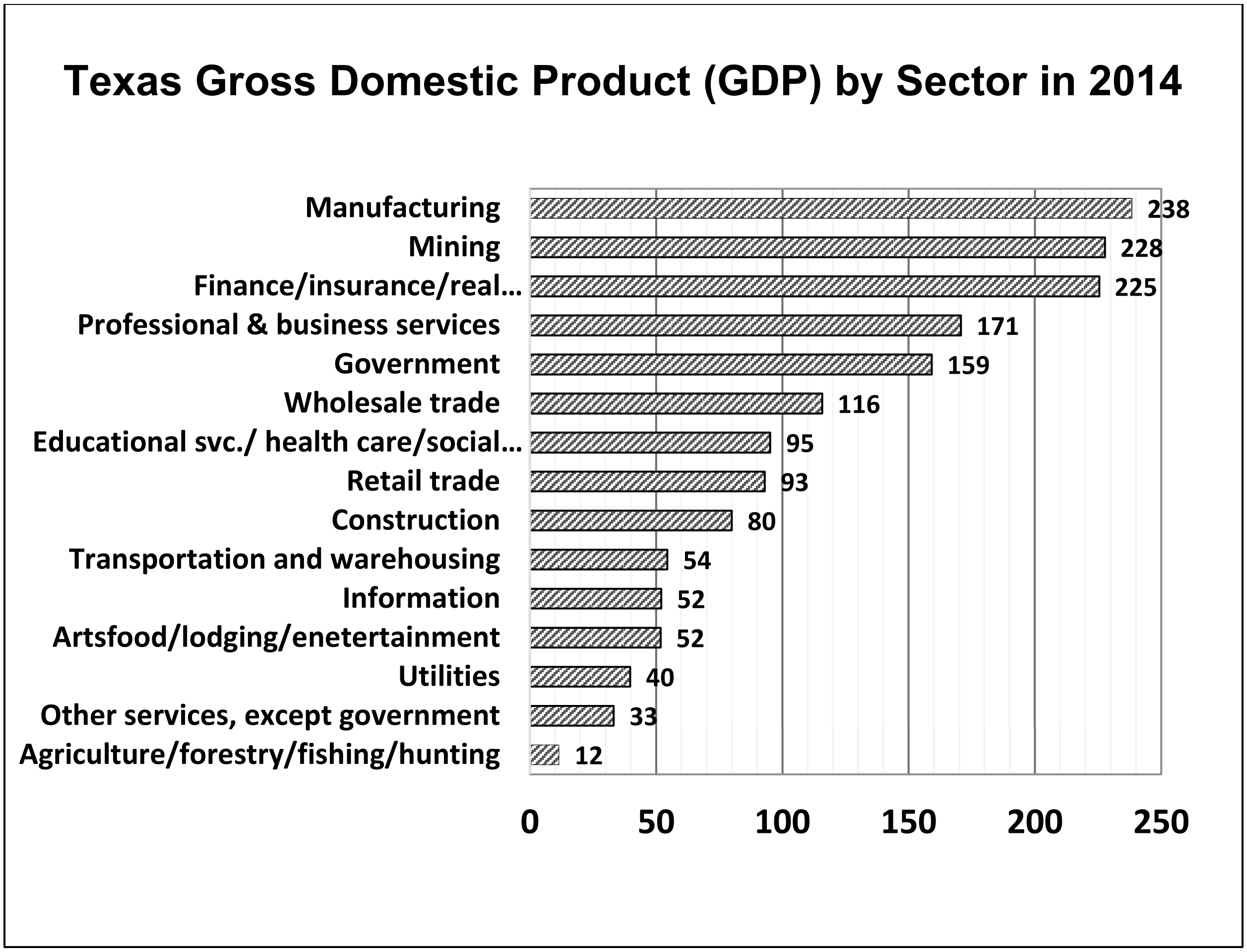



**Figure A-2. Texas gross domestic product (GDP) in billions of dollars broken down by sector for 2014. Texas's total GDP for 2014 equaled $1.65 trillion**.

*(Source: Bureau of Economic Analysis, U.S. Department of Commerce)*

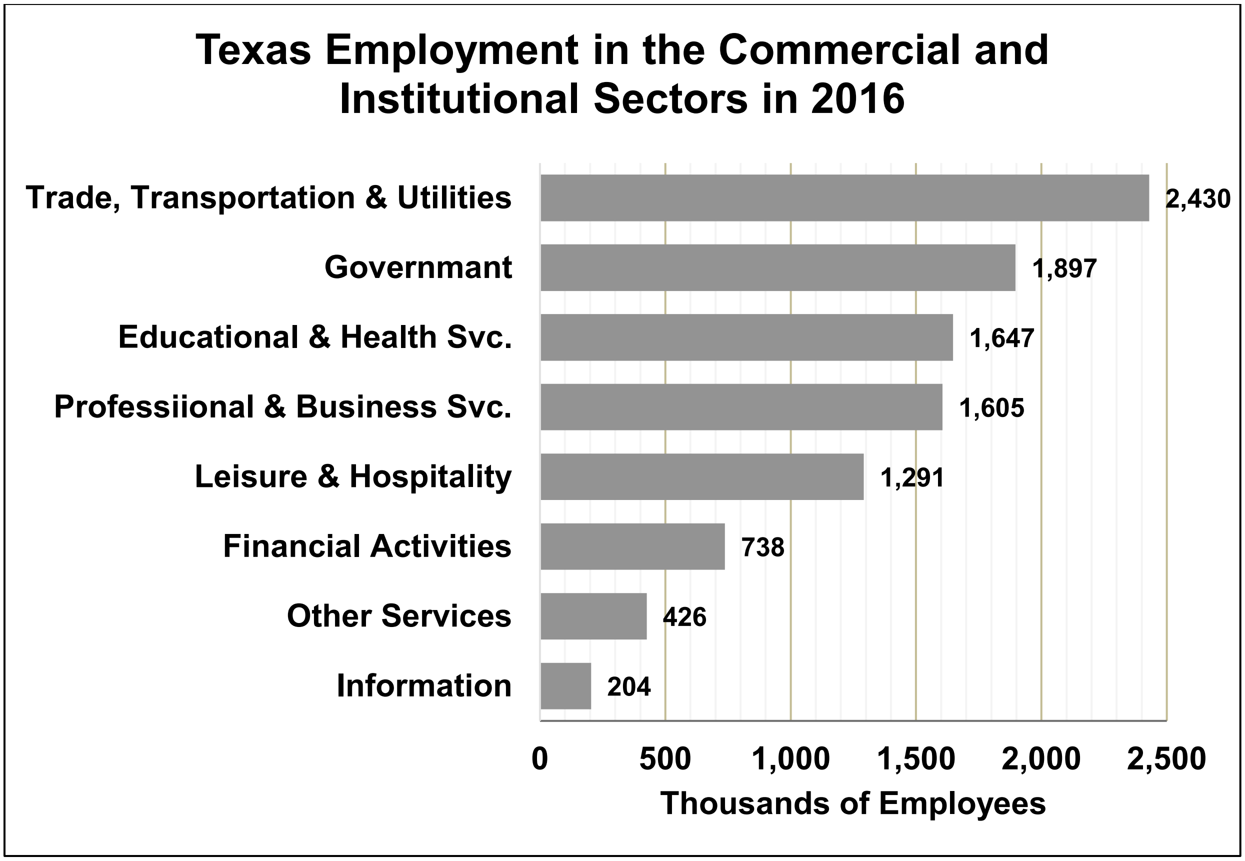



**Figure A-3. Texas Employment in the commercial and institutional sectors in 2016. The total in June 2016 equaled 11.99 million.**

As this information shows, most Texans work in the commercial and institutional sectors. The importance of this is obvious.

Texas has over half a million commercial and institutional buildings occupying approximately eight billion square feet, based on estimates derived from the U.S. Energy Information Administration (2016b), Commercial Buildings Energy Consumption Survey for 2012.

Although states are not broken out individually, the data was estimated by population for Texas, which is 70.4 percent of the West South Central geographical area according to report. This includes Texas, Arkansas, Oklahoma and Louisiana. Figure A-4 shows this distribution of floor space by type of activity.

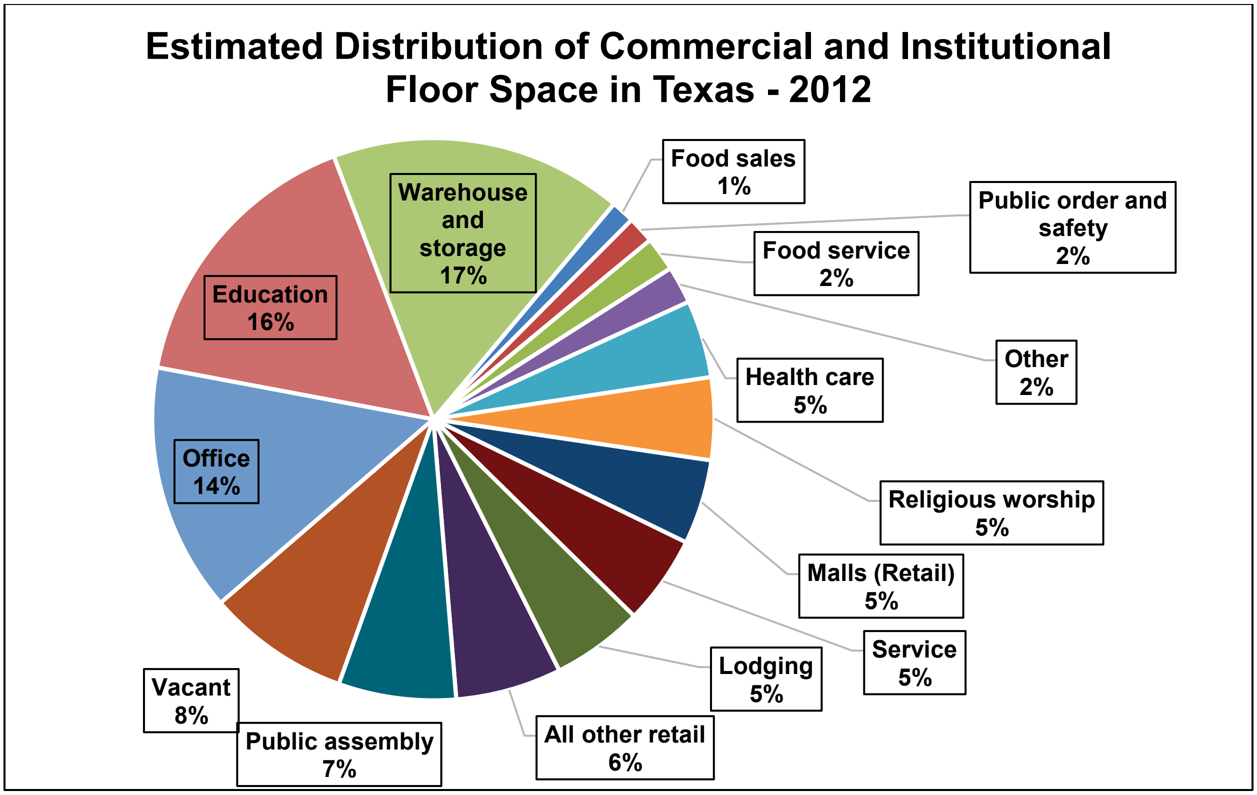



**Figure A-4. Percentage of estimated distribution of commercial and institutional floor space in Texas for 2012.** *(Source: U.S. Energy Information Administration, U.S. Department of Energy, 2016a and 2016b)*

**Water Use by the C&I**

Municipal water use as defined by the Texas Water Development Board's annual water use survey, includes water supplied to the single and multi-family sectors, commercial and institutional users, and water loss. It does not include industrial use. Over the last 15 years, use has remained fairly constant at about 4.3 million-acre feet per year in spite of a population growth from 20.94 million in 2000 to 26.96 million in 2014. Annual use is shown in Figure A-5.

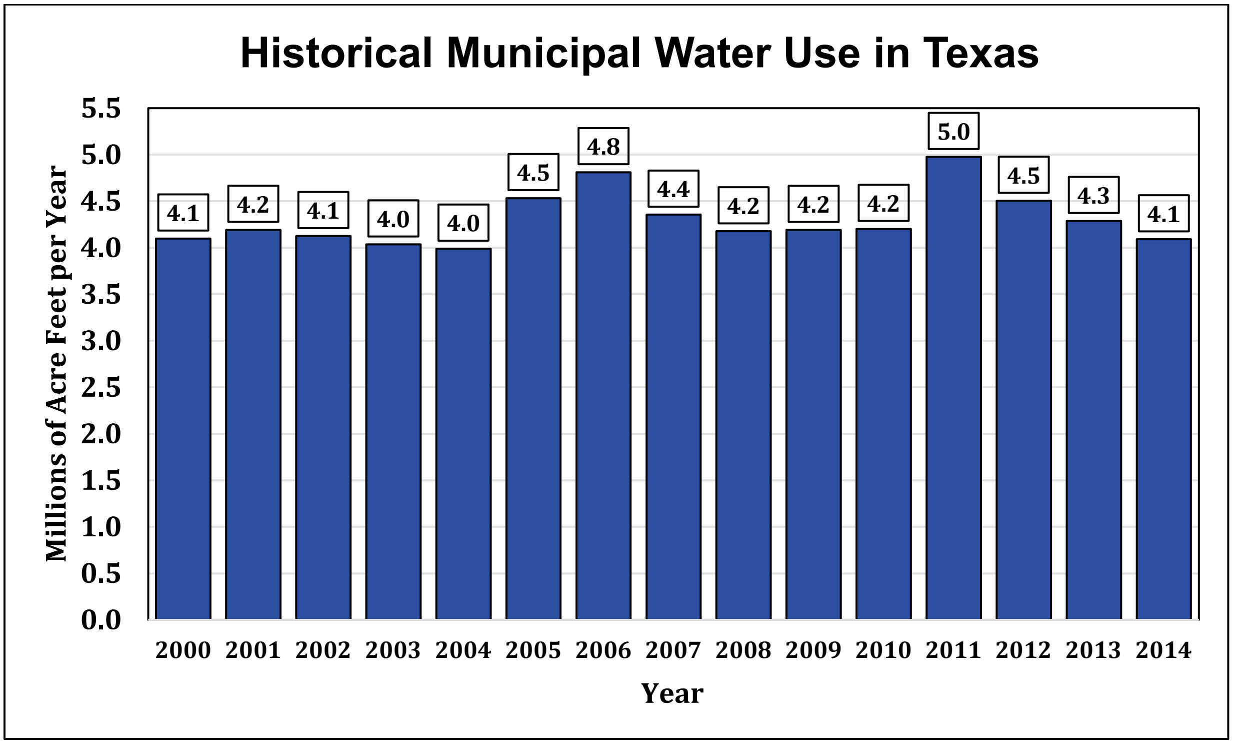



**Figure A-5. Historical municipal water use in Texas, 2000 – 2014, in millions of acre-feet per year.** *(Source: TWDB, Water Use Summary Estimates, 2000 to 2014)*

The municipal water use figures do not include sales of water to industry. The amount of water used by the Industrial commercial and institutional sectors is also significant. Based on the 2017 Texas Water Development Board report, "Water Use of Texas Water Utilities: A Biennial Report to the Texas Legislature," commercial and institutional use accounts for 42 percent based utilities and cities surveyed. The survey is based on utilities with 3,300 water connections or above. Although it varies from one system to another, this is roughly equivalent to a population of 9,900.

Table A-1 shows the breakdown of water use by market sector for the average of all utilities from 2012 through 2015. Figure A-6 shows the 2015 water use breakdown by utility size graphically. The volume of water used by the entities over 3,300 connections in the survey was 2,853,560 acre feet, but 16 percent of this was sales to industrial users. Also, these figures do not include non-revenue water lost through leaks and other losses, which is averaging 13 percent in Texas. This loss is not included in the TWDB's (2017) biennial report. When the 16 percent industrial use is subtracted and the 13 percent leak loss is added, approximately 67 percent of all of the four million plus acre-feet of annual municipal use is accounted for by the report. The remaining municipal use, 23 percent is used by utilities with less than 3,300 connections, self-supplied water, plus a few utilities with more than 3,300 connections that did not report. Based on the U.S. Geological Survey report of water use in 2010, 90 percent of Texans are supplied by a public water supply system, 10 percent are self-supplied by wells, and other sources (Maupin *et al*. 2014).

**Table A.1. Historical sector-based use by surveyed utilities.**

| Year | Use Sector | | | | | | |
|---|---|---|---|---|---|---|---|
| | Single-Family | Commercial | Industrial | Multi-Family | Institutional | Other | Agricultural |
| **2012** | 45% | 19% | 15% | 9% | 3% | 8% | 0% |
| **2013** | 47% | 20% | 15% | 9% | 4% | 5% | 0% |
| **2014** | 48% | 21% | 16% | 10% | 3% | 2% | 1% |
| **2015** | 48% | 21% | 16% | 10% | 4% | 1% | 1% |

**Figure A.6. Distribution of Water Use by all Utilties and Cities Surveyed in 2015**

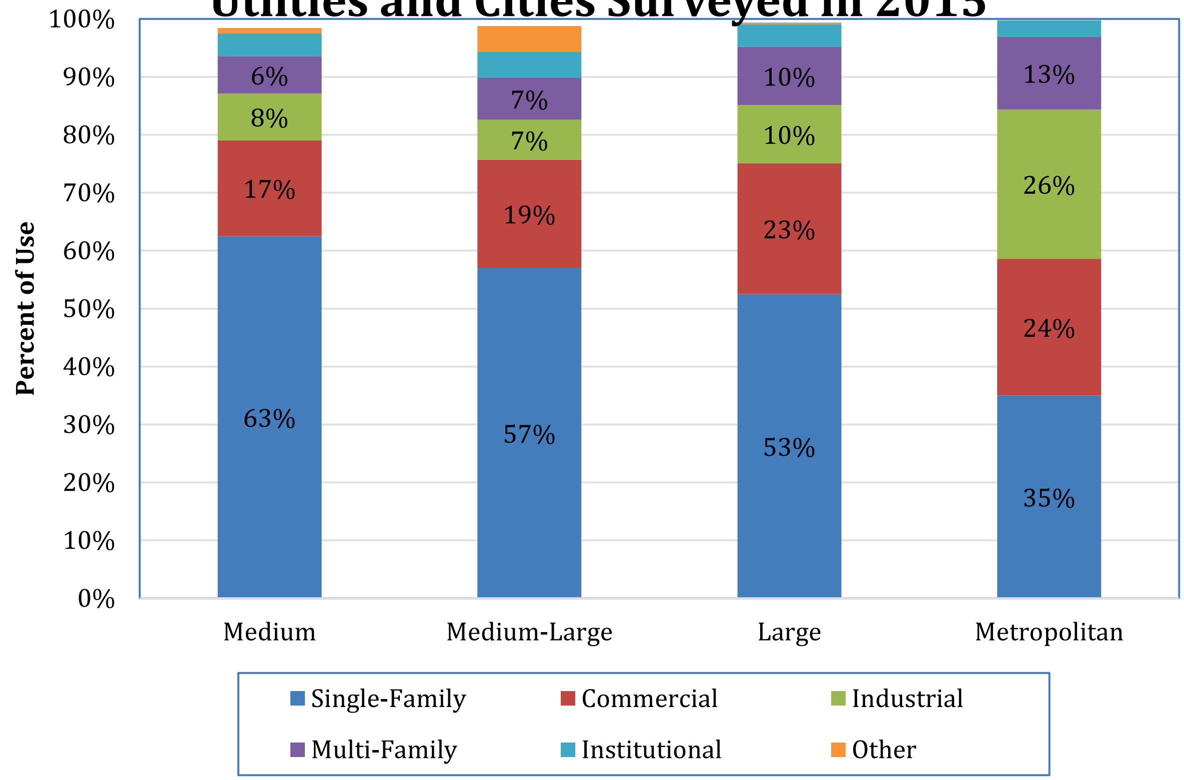


**Figure A-6. Distribution of water use by all utilities and cities surveyed in 2015.**

Since the multi-family category is often included in the institutional, commercial and industrial (ICI) sectors, Figure A-6 shows the breakdown for single family, multi-family and total ICI use. What this illustrates is that ICI use including multi-family use exceeds single-family water use in the utilities surveyed.

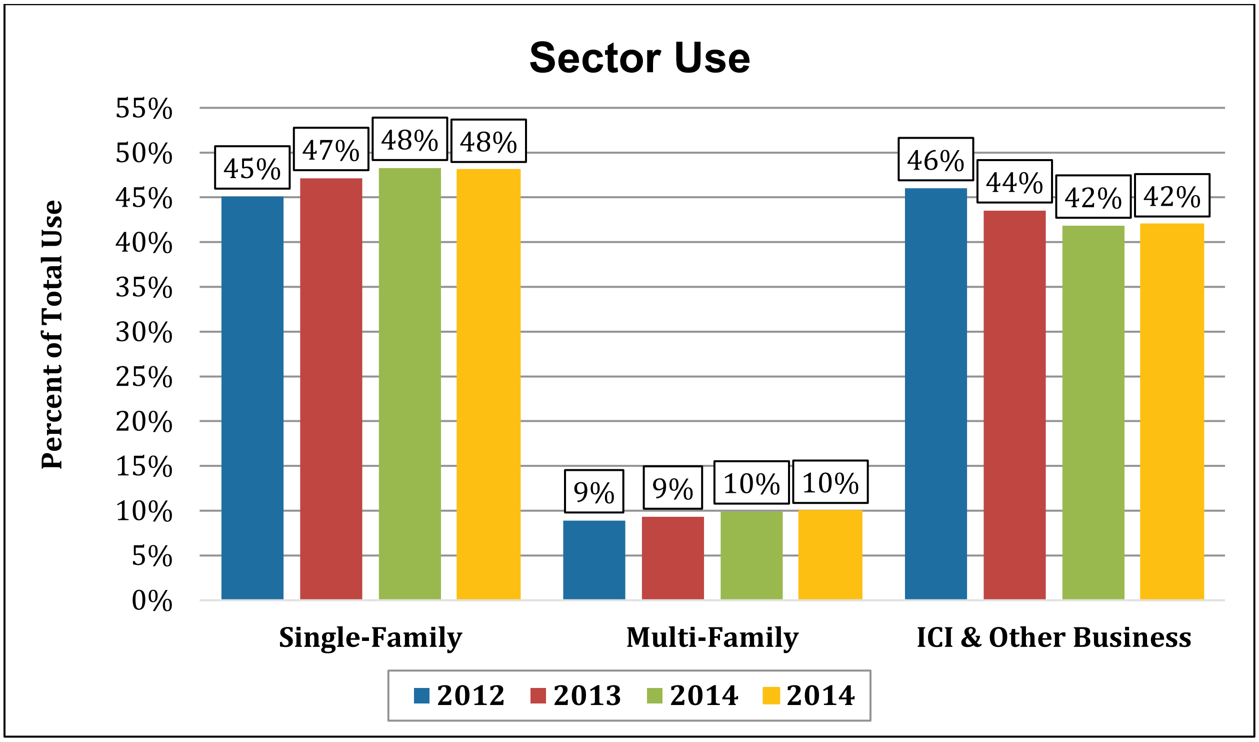



**Figure A-7. Sector use in single-family, multi-family, and total ICI water use.** *(Source: TWDB, 2017)*

Another interesting analysis is how much water is used per day per connection based on user type.

**Table A-2 Summarizes the average water use per day by each category of user in gallons per day.** (*Source: TWDB, 2017)*

| **Average Daily Use of Water by User Category and Size of Utility** *(Gallons per Day)* | | | | | |
|---|---|---|---|---|---|
| **Category of Use and Size of Utility** | **Medium** | **Medium-large** | **Large** | **Metropolitan** | **All analyzed utilities** |
| **Single-family residential** | 228 | 253 | 248 | 207 | 229 |
| **Multi-family residential** | 263 | 260 | 218 | 607 | 345 |

| | | | | | |
|---|---|---|---|---|---|
| **Commercial** | 767 | 1,076 | 1,223 | 1,335 | 1,134 |
| **Industrial** | 27,236 | 19,527 | 9,300 | 10,063 | 10,945 |
| **Institutional** | 1,956 | 2,081 | 2,013 | 5,958 | 2,565 |
| **Agricultural** | 759 | 1,122 | 562 | 0 | 851 |
| **Total water use** | 305 | 348 | 356 | 476 | 383 |

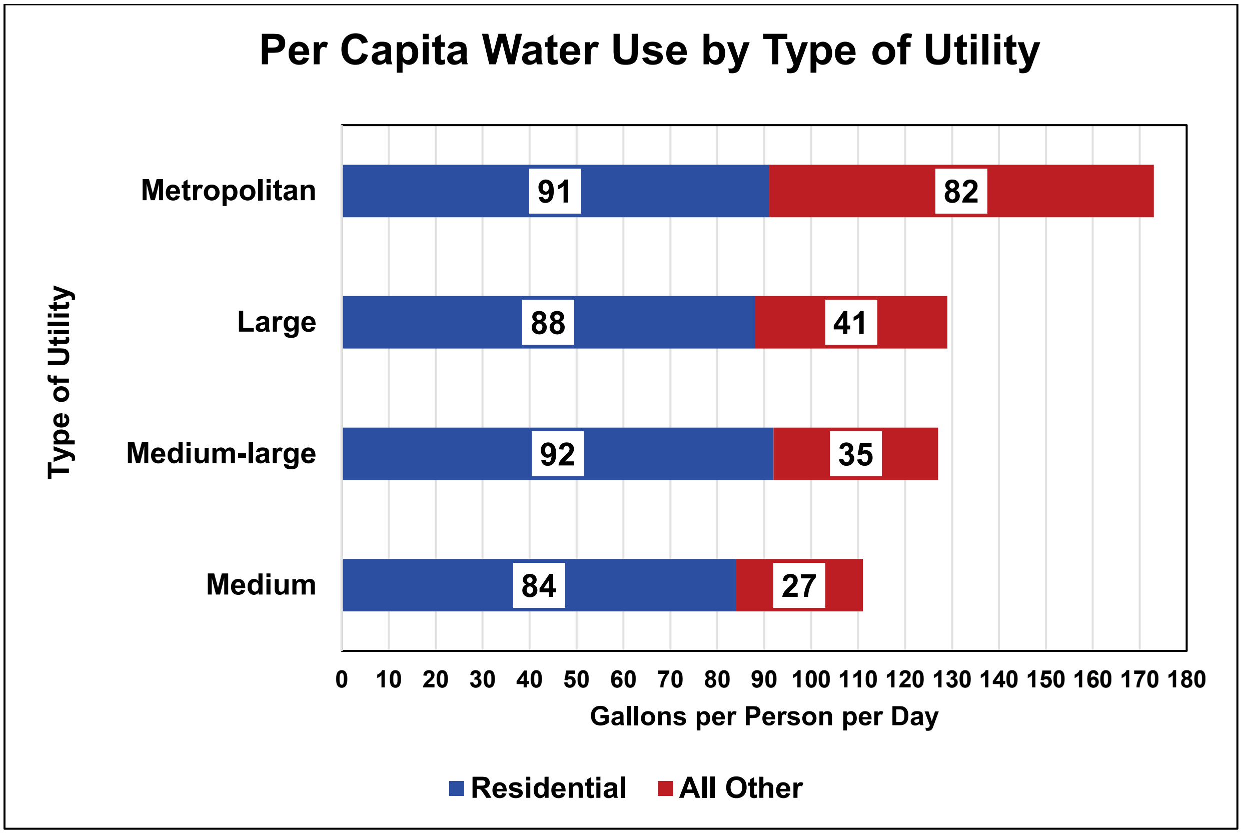



**Figure A-8. Combined multi-family and single-family per capita water use (gallons per person per day) and per capita use for ICI and other uses by utility type.**
*(Source: TWDB, 2017)*

## C&I Water Use Characteristics

Water used by commercial and institutional facilities varies by both type of facility and type of equipment used. Between 2009 and 2015, 173 water conservation audits of commercial and institutional facilities were conducted by the cities of Austin, Dallas and Fort Worth. The following information summarizes the results of these audits. Figure A-9 shows the breakdown of ***indoor use*** at various types of commercial and institutional facilities by restroom, food service and other uses.

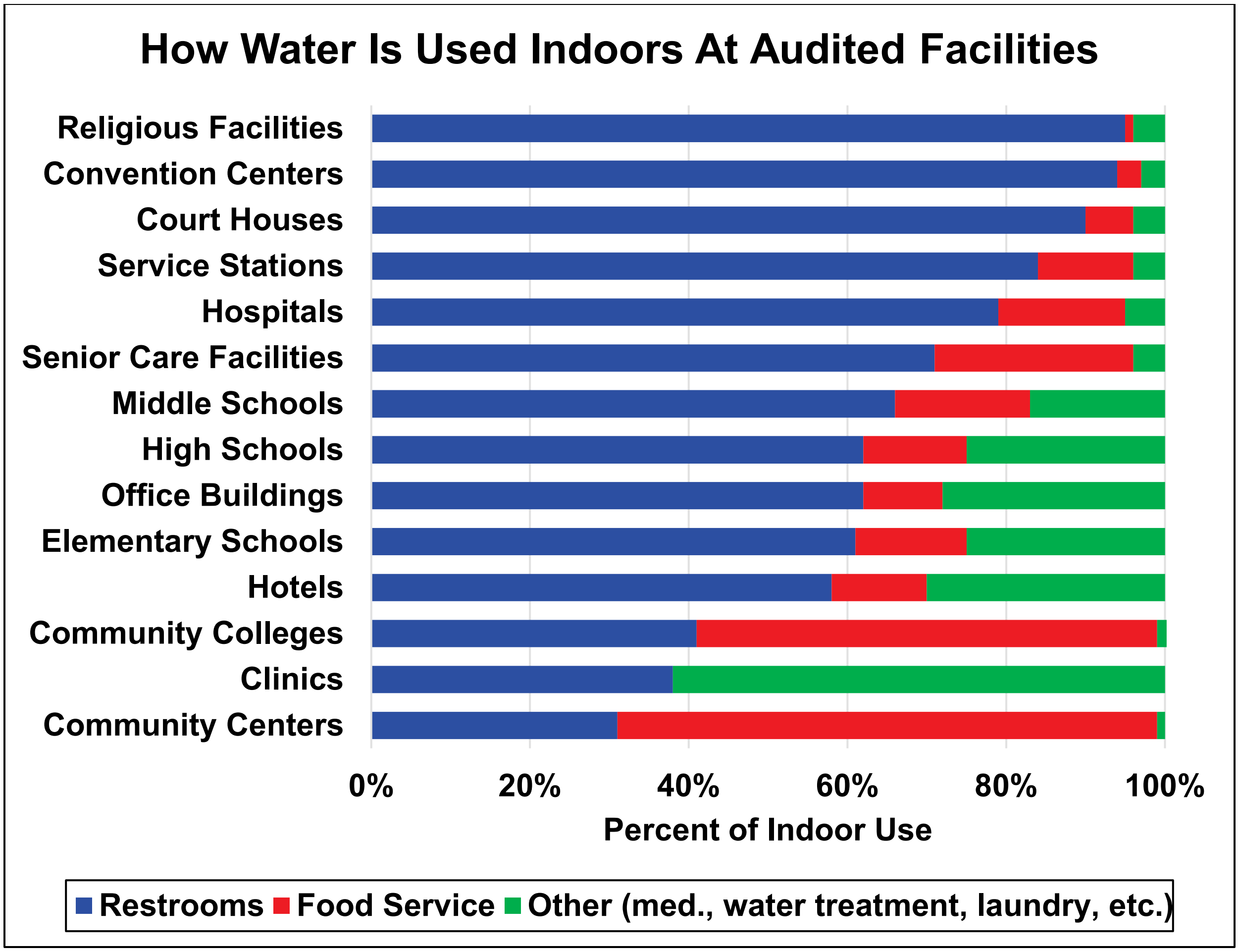



**Figure A-9. Percentage of indoor use for restrooms, food service, and other water uses at various types of facilities between 2009 and 2015.**
*(Source: Unpublished study of audits in Austin, Dallas, and Fort Worth)*

Figure A-10 shows a further breakdown by water use in restrooms. This includes toilet, urinal, shower/bath, faucet and other uses. The other uses include mop sinks and other miscellaneous uses. Not included are uses for floor drain p-trap priming. For all modern facilities built to code, trap-priming use is very low, but if the old continuous flow systems are still in use, huge amounts of water can be used.

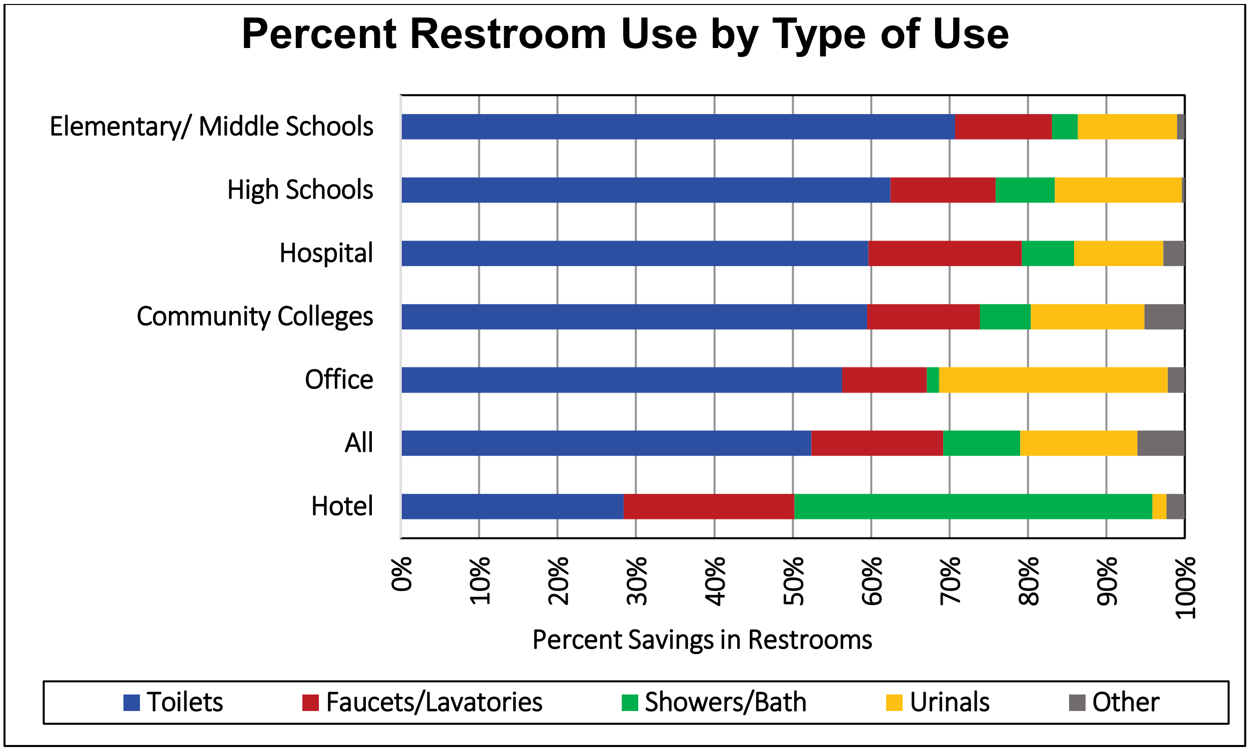



**Figure A.10. Percentage of restroom use in various commercial and institutional facilities broken down by type of use.** *(Source: Unpublished study of audits in Austin, Dallas, and Fort Worth)*

Outdoor use can vary widely. The average irrigation use by the 173 entities included in the audits average 22% or all uses, but varied significantly. An analysis conducted by the city of Austin based on 2010 water use shows that irrigation use varied significantly by type of facility. For example, grocery stores and restaurants as a whole typically do not use much irrigation water. There were, however, notable exceptions. Austin has over 1,200 restaurants. Their monthly water use is shown in figure A-11. As the graph shows, there is little seasonal variation, but for a few restaurants where landscape is predominant, as much as 25% to over 50% of all the facilities water use can be for irrigation. As figure 2.11 shows, only a small amount of total restaurant use is for irrigation by separate irrigation meters.

By contrast, office building water use shows strong seasonal variation as seen in Figure 2.12 for over 3,000 buildings in Austin, Texas. Many office buildings do have landscape and some have extensive landscape. However, many larger office buildings and campuses also have cooling towers that have significantly strong seasonal use pattern corresponding in time to irrigation patterns. Most office buildings of 150,000 square feet or more have cooling towers. The audits conducted in Austin, Dallas and Fort Worth tended to be of the larger type. Likewise, the office building audited tended be in downtown locations where landscape space was limited.

To put irrigation use into perspective, the Hermitte and Mace (2012) report, "The Grass Is Always Greener…Outdoor Residential Water Use in Texas," estimates single-family residential water use at 31 percent of total single-family use. The percent of total water use in multi-family residences (apartment complexes) tends to be lower since there is usually significantly less landscape are per resident than for single family homes. Some Texas studies estimate that a quarter of total apartment water use is for landscape.

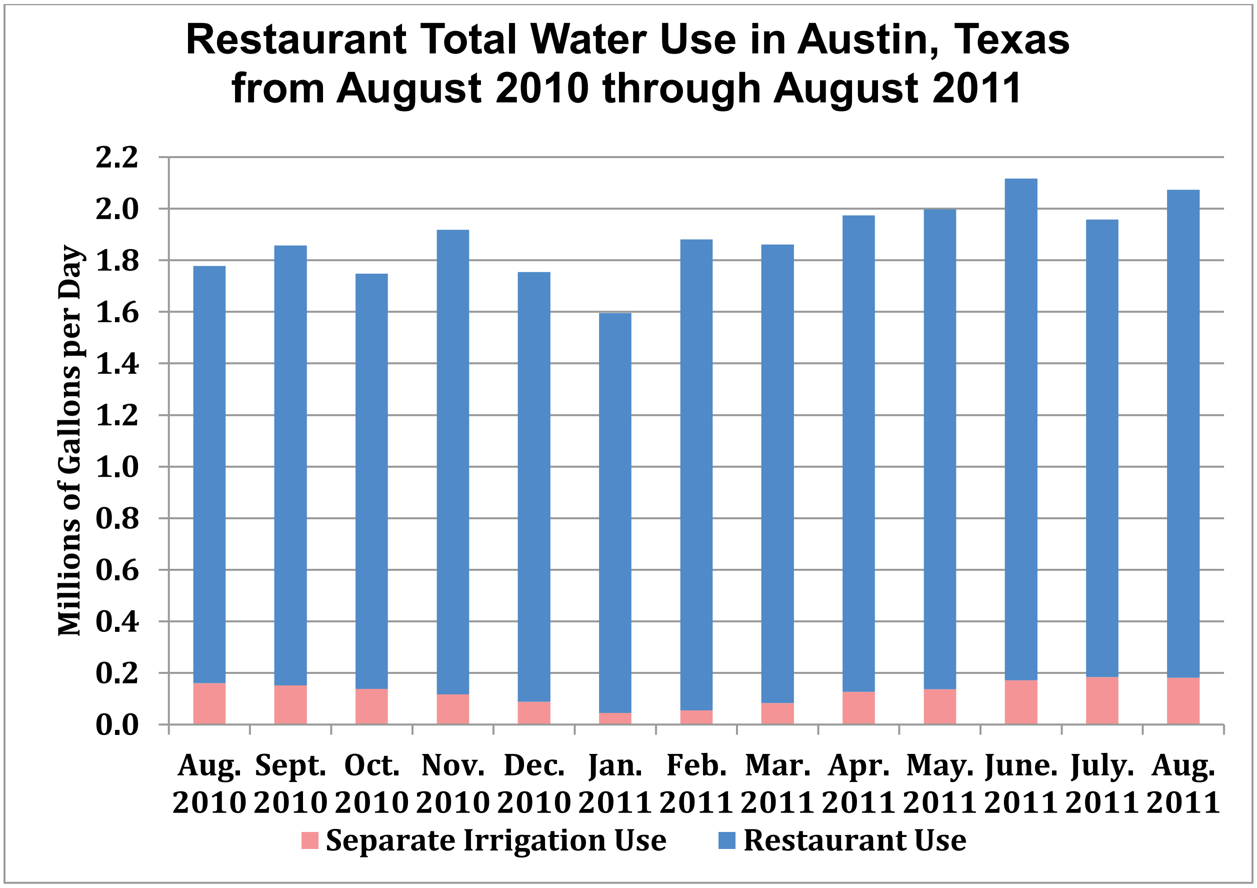



**Figure A-11. Total water use for restaurants in Austin, Texas, August 2010 – August 2011, shown in millions of gallons per day.** *(Source: Unpublished study by Austin Water Utility)*

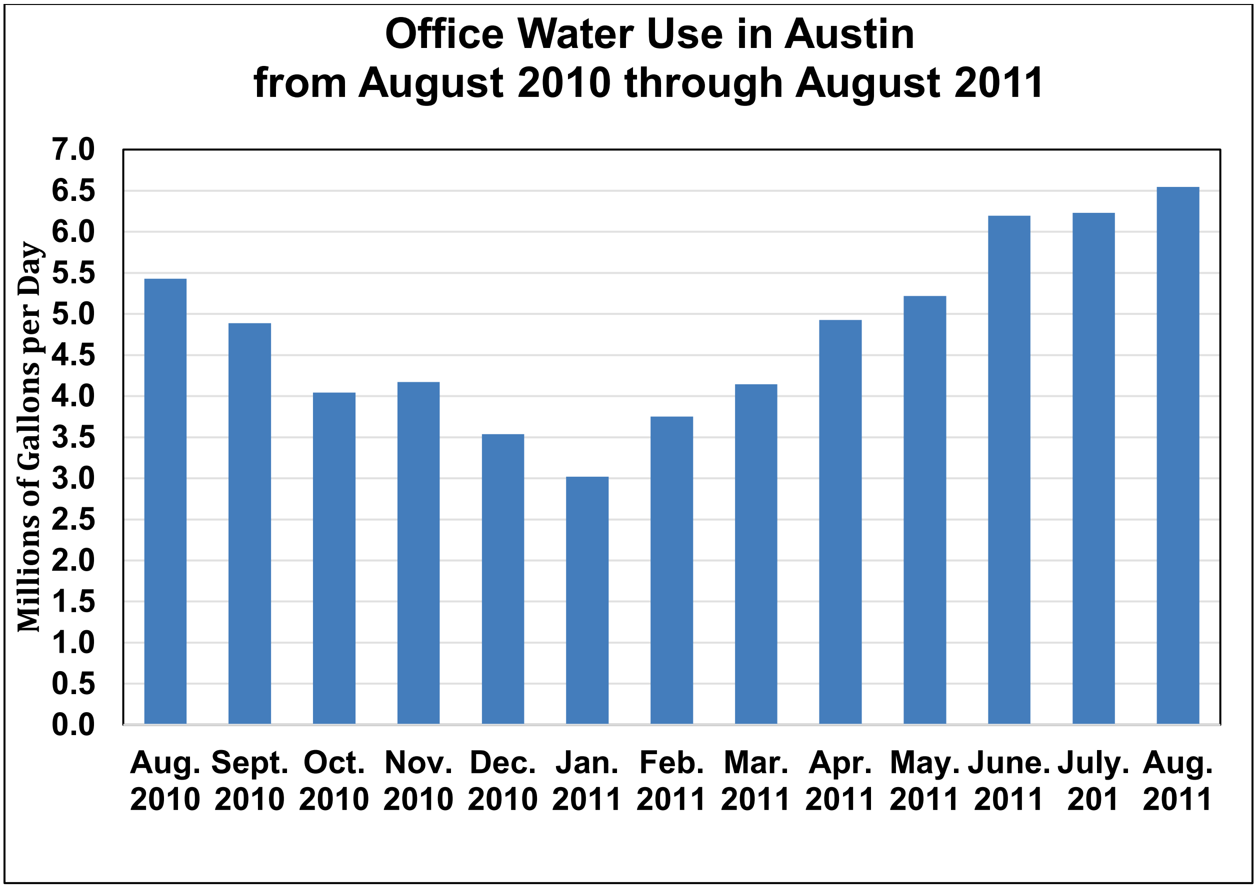



**Figure A-12. Seasonal variations for office building water use in Austin, August 2010 – August 2011, shown in millions of gallons per day.** *(Source: Unpublished study by Austin Water Utility)*

The analysis of commercial and institutional facilities' audits with cooling towers shows that cooling tower water use can be significant. Figure A-13 shows the results.

Each facility is unique and its water use patterns will vary. For example, many elementary school campuses in Texas only irrigate landscape immediately around the building. It just so happens that the six elementary schools in this sample that also had cooling towers were in districts where much of the campus is irrigated.

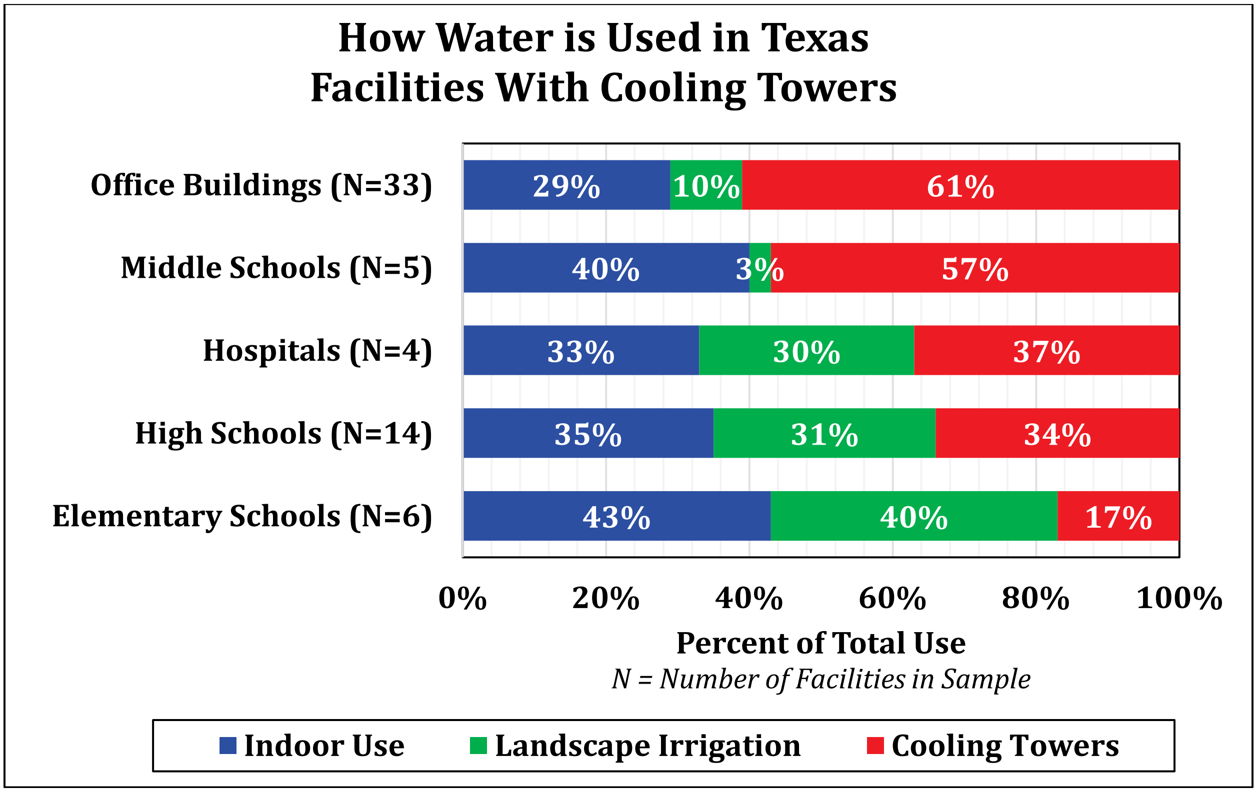



**Figure A-13. Percentage of total water use in Texas facilities with cooling towers.**
*(Source: Unpublished study of audits in Austin, Dallas, and Fort Worth)*

# APPENDIX B - The Cost of Water and Cost Effectiveness Considerations

Water and wastewater costs are increasing at a rapid rate. Although the development of new water sources and conservation have played a role in these rising costs, it is the need to both repair and replace aging infrastructure and the need for new infrastructure to meet growing population that have been the major drivers. Nationally, the American Water Works Association (2012) estimates the infrastructure needs of the United States for water alone to exceed one trillion dollars over the next quarter decade (See Exhibit B.1).

**Buried No Longer:**
**Confronting America's Water Infrastructure Challenge**
**Investment needs for buried drinking water infrastructure total more than $1 trillion nationwide over the next 25 years.**

**Exhibit B.1-Estimated investment needed for infrastructure in the United States for water projects.** *(Source: American Water Works Association, 2012)*

Water rates have been rising dramatically over the last several decades, information from Black and Veatch (Multiple reports on the water and sewer rates for the largest 50 cities in the USA) and from Dr. Janice Beecher (2016), Director of the Institute of Public Utilities at Michigan State University. Figure 3.1 presents a long-term history of utility consumer price indexes for all major utilities used in the United States. This figure dramatically shows that waste and sewer costs are escalating much faster than other utilities.

Based on the Black and Veatch (2016) study, "50 Largest Cities Rate Survey 2016: Building Financial Resilience," since 2001, water and wastewater rates for commercial customers have increased at an average of 5.85 percent per year. Figure 3.2 shows water costs for Texas' six largest cities in 2016. The average combined water and sewer cost is $9.91 per thousand gallons. If these costs continue to rise at the historical rate of 5.85 percent a year, fifteen years from now, combined water and sewer costs will have risen to almost $24 per thousand gallons (See Figure 3.3). Again, these costs are for commercial customers. Residential customer prices are even higher.

By contrast, the U.S. Department of Energy's Energy Information Administration (EIA) projects much slower growth for electricity and natural gas cost for commercial customers. Figure B.1 shows the EIA projections of cost for commercial users for both electricity and natural gas. In Texas in 2016, commercial customers pay 7.5 cents to 8.5 cents per kilowatt-hour (kWh) for electricity and $8.20 to $8.50 per thousand cubic feet (MCF) for natural gas.

The net result is that water and sewer rates will continue to increase much faster than energy rates. This will have significant implications to calculating the benefit/cost ratios for projects.

E r

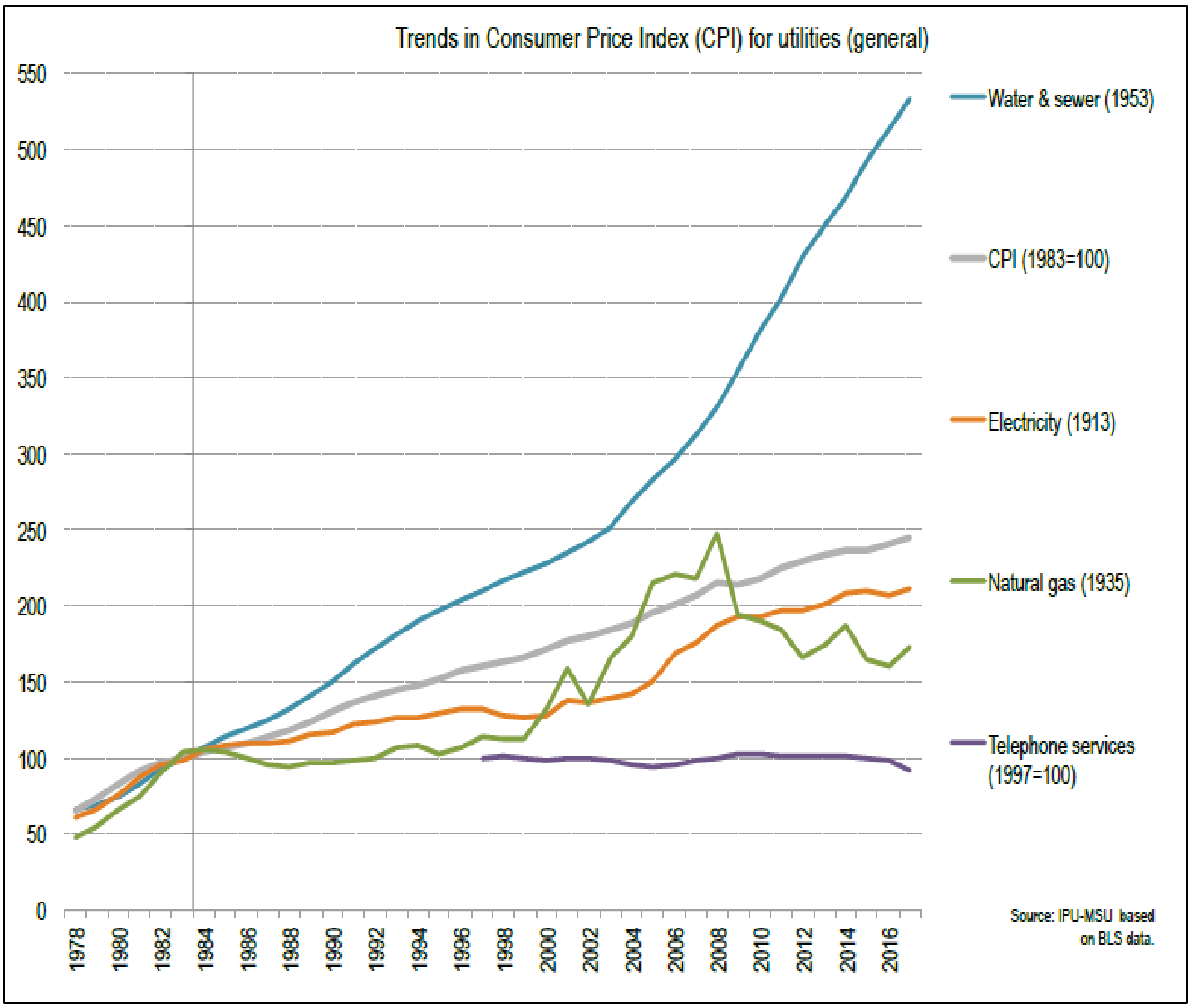



**Figure B-1. Consumer price index trends for utilities in the United States, 1978 – 2016.**
*(Source: Beecher, 2018)*

*Putting Cost Into Perspective*

Figures B-2, B-3 and B-4 detail the commercial water and waste water rates for Texas' six largest cities (in 2016). The combined water and wastewater costs are in the range of ten dollars per thousand gallons.

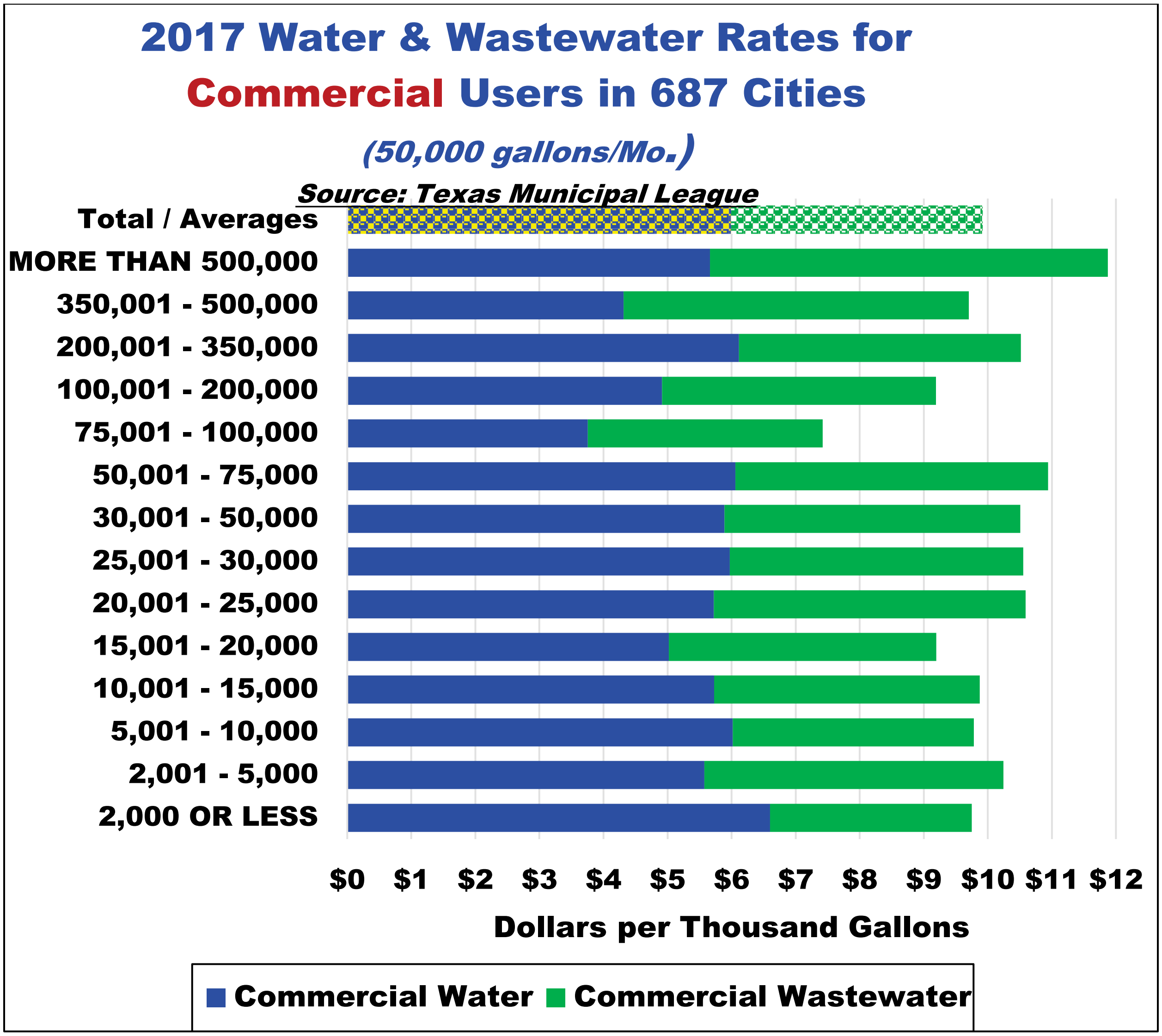



Figure B-2 Commercial Water and Wastewater Rates in Texas in 2017 (Texas Municipal League)

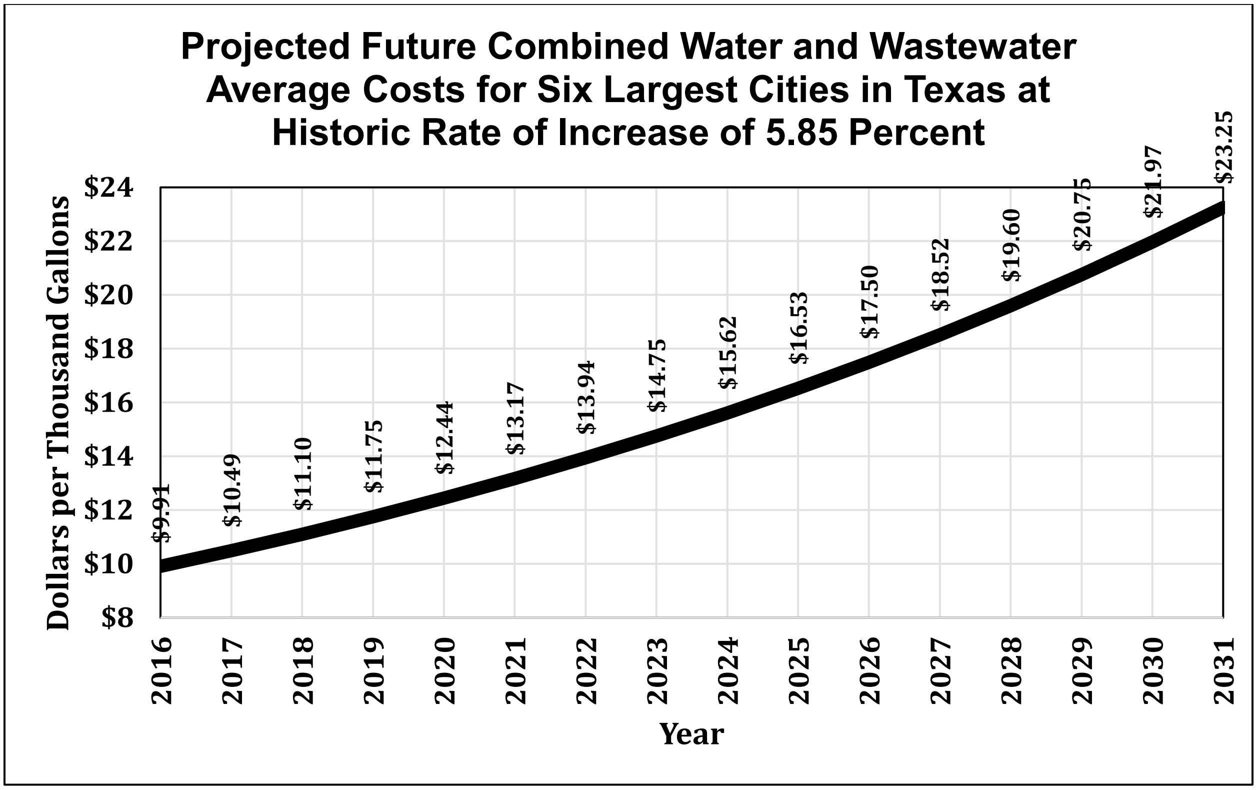



**Figure B-3.** **Projected future water and wastewater costs if increases continue at historical rate of 5.85 percent annually.**

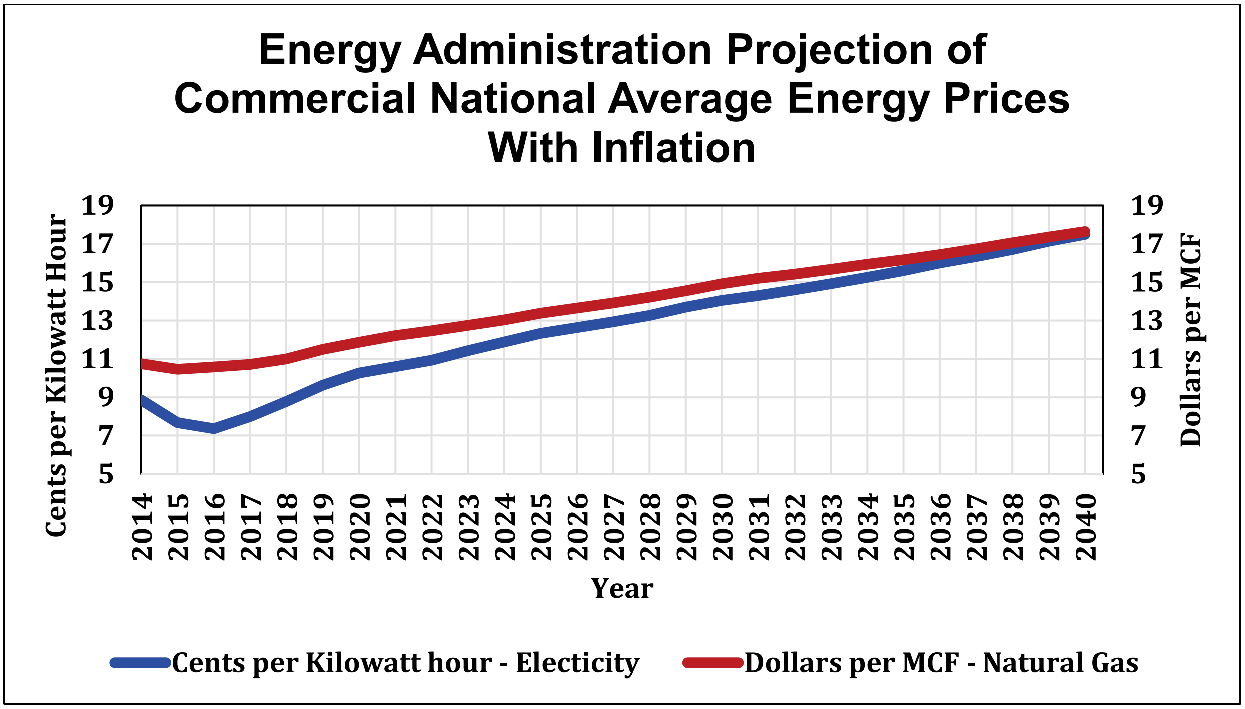



**Figure B-4. The U.S. Department of Energy's Energy Information Administration (EIA) projects a slower growth for energy costs. Note that MCF equals per thousand cubic feet.** *(Source: U.S. Energy Information Administration, U.S. Department of Energy, 2017)*

Figure B-5 shows how much energy costs for heating water add to the cost of water expressed in dollars per thousand gallons based on how much the temperature of the water must be raised and that depends on the temperature of the tap water being heated and the desired temperature of the hot water. In Texas, ground water (well water) temperatures typically range from 60 °F to 75 °F unless the water is from a geothermally heated source. Groundwater temperatures vary little throughout the year. By contrast, surface water temperatures (lakes and rivers) are strongly influenced by seasonal temperatures and location. To use Figure B-5 to estimate the cost of water heating, the tap water temperature and desired hot water temperature must be known. For example, if the tap water is at 65 °F and the desired hot water temperature is 135 °F, the difference in temperature is 70 °F.

Using Figure B-5, the cost to heat water by 70 °F with natural gas is $6.62 per thousand gallons of water and $13.96 for electricity. If the combined water and wastewater costs are $9.65 per thousand gallons at the facility location, the energy cost per thousand gallons of water would be added to this to obtain the total cost of water. For example, if the facility uses an electric water heater, ***the combined water, wastewater, and electricity cost per thousand gallons would equal $23.61 per thousand gallons or 2.361 cents per gallon.***

These costs vary from one service area to another, so the user of this guide should use their local energy costs. Also, inflation of energy cost should be considered when estimating the utility costs over life of the equipment to be considered.

When working with commercial and institutional facility staff, water rates are often difficult for them to visualize, but they certainly can visualize the cost of one gallon of water. Figure B-2 illustrates what the combined water and wastewater costs are in the range of ten dollars per thousand gallons. At ten dollars a thousand gallons, the cost of one gallon of water is one cent. Therefore, it costs ***five cents each time a five gallon per flush toilet is used*** and only 1.28 cents when a modern toilet meeting current Texas plumbing fixture standards are used.

When hot water is considered, the cost of the energy to heat the water must be added to the cost of the water and wastewater. The method to calculate energy costs associated with hot water is detailed in Example 3 of the cost of water calculations. Four factors must be considered:

1. How much do you need to raise the temperature?
2. Is your water heater electric, natural gas, or other?
3. What is its efficiency? and
4. How much does the energy cost?

Most facilities use either natural gas or electricity to heat water. As described in Figure B-5, the cost of natural gas in Texas for commercial users is in the range of $8.50 per thousand cubic feet (MCF) and electricity cost about eight cents per kilowatt-hour (kWh). The efficiency of the equipment for heating water can vary significantly. For electric heaters, the heating elements are almost 100% efficient in transferring energy to the water, but there are convective and radiant thermal losses through the heater walls. For natural gas, in addition to thermal losses, some of the heat is lost to the flue gas. Electric heaters operate in the 90 to 98 percent range depending on condition of insulation, while gas water heater efficiency varies from 60 percent for older, poorly maintained equipment to 95 percent plus for condensing, tankless water heaters. Most conventional water heater efficiencies are in the range of 75 percent.

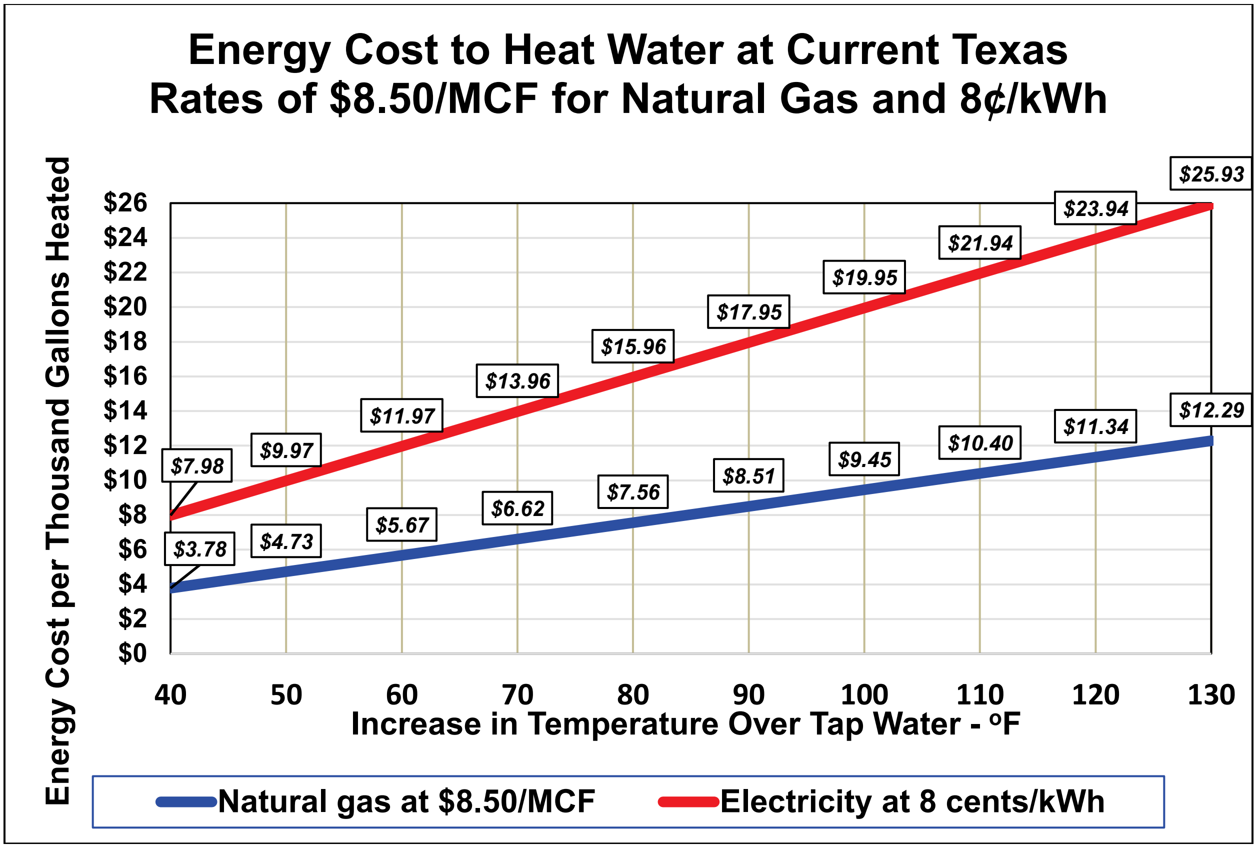



**Figure B-5. The cost, in dollars, to increase water temperatures based on 2017 electric and natural gas rates. The chart assumes an efficiency of 98 percent for electricity and 75 percent for natural gas.**

# APPENDIX C - Water Use Technologies in the C&I Sectors

**Table C-1. Illustrates some of the more common water uses found in various commercial and institutional sectors.**

| Examples or Water Using Technologies in the Commercial and Institutional Sectors | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Type of End-Use Operation** | **Water Using Technology** | | | | | | | | | | | |
| | **Restrooms and Plumbing** | **Wash-down and Sanitation** | **Pools, Spas, and Fountains** | **Water Treatment Systems** | **Thermodynamic Processes** | **Laundry Equipment** | **Medical Laboratory Equipment** | **Photo and Film Processing** | **Food Service Equipment** | **Process and Special Uses** | **Vehicle Wash** | **Landscape Irrigation** |
| **Office Buildings** | X | X | X | X | X | | P | | X | | | X |
| **Schools** | X | X | X | X | X | X | X | X | X | X | X | X |
| **Restaurants and Other Food Service** | X | X | X | X | X | X | | | X | | | X |
| **Retail** | X | X | X | X | X | X | | P | X | | X | X |
| **Lodging** | X | X | X | X | X | X | | | X | | | X |
| **Grocery** | X | X | | X | X | X | | X | X | | | X |
| **Hospitals and Medical Clinics** | X | X | X | X | X | X | X | X | X | X | | X |
| **Laboratories (research and medical)** | X | X | P | X | X | X | X | X | P | X | | X |
| **Dental Clinics** | X | | | P | | | X | | | P | | X |
| **Universities** | X | X | X | X | X | X | X | X | X | X | X | X |
| **Coin and Card Laundries** | X | X | | X | X | X | | | | X | | P |
| **On-Premise and Industrial Laundries** | X | X | | X | X | X | | | P | X | | X |
| **Military Facilities** | X | X | X | X | X | X | X | X | X | X | X | X |
| **Arts and Crafts** | X | X | | X | X | X | | X | | X | | X |
| **Stadiums, Sports and Entertainment** | X | X | X | P | X | X | | | X | | P | X |
| **Parks and Recreation (outdoor and indoor)** | X | X | X | | P | P | | | P | | | X |
| **Zoos and Aquariums** | X | X | X | X | X | X | X | X | X | X | X | X |
| **Printers** | X | X | | X | X | | X | X | P | X | | X |
| **Vehicle Washes** | X | X | | X | X | | | | | X | X | |
| **Other Equipment Not Listed** | P | P | P | P | P | P | P | P | P | P | P | P |
| **X = technology used; P = technology possibly used** | | | | | | | | | | | | |

# APPENDIX D - Water Benchmarking Information

**Benchmarking Considerations**
While the energy efficiency community in the United States has benchmarked energy use for decades, the water efficiency community has a much less intense record.

Australia, Canada, New Zealand, and many European countries have benchmarking information for their commercial buildings, including information on what constitutes an efficiency operation versus the average or median use. This appendix summarizes both Texas specific information gathered from a review of over 170 water conservation audits conducted in Austin, Dallas and Fort Worth as well as other information available in the literature.

To this end, it is important to point out that median and mean values are useful, but the range of water use per unit – square foot, person, room, etc., is important in understanding the water saving potential. The following two graphs illustrate this point.

**Examples of Types and Use of Benchmarking**
The first graph shows office water use per square foot from four cities that have requirements that commercial entities use the US Environmental Protection Agency's Energy Star Portfolio Manager Process to benchmark both energy and water use.

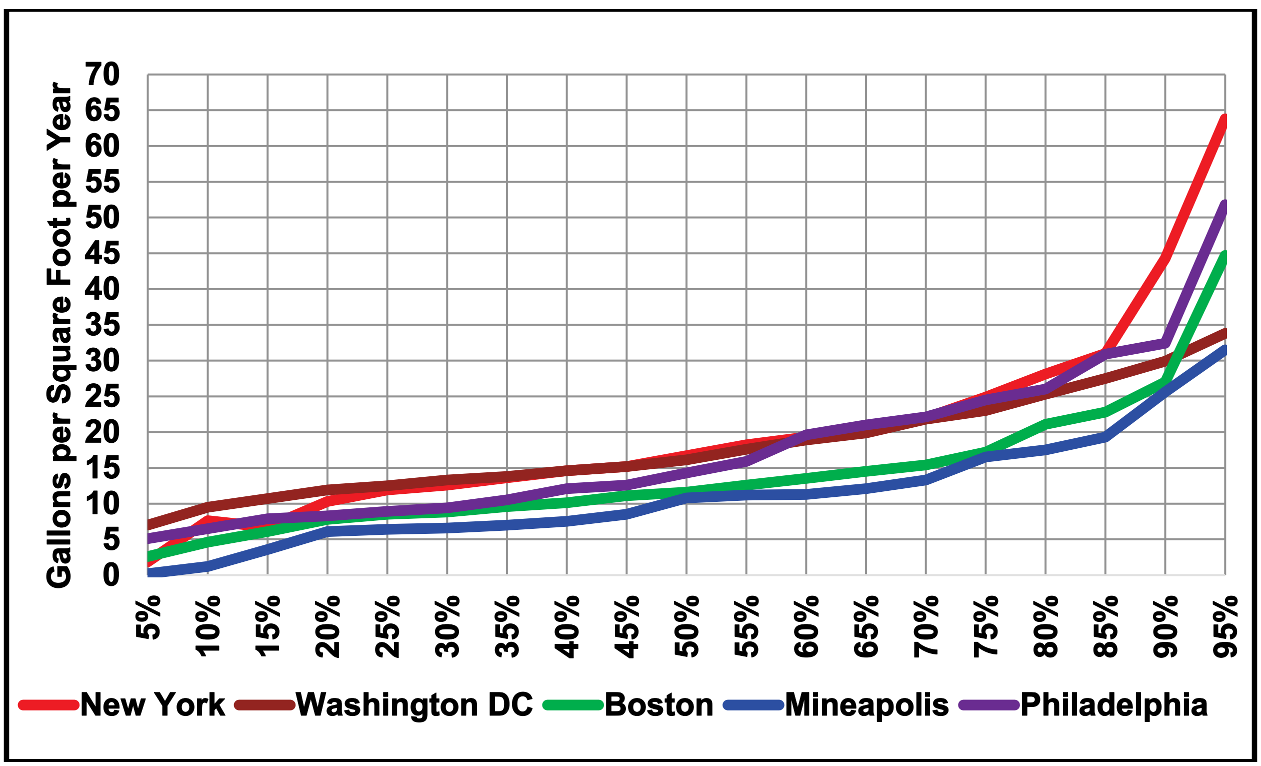


**Figure D-1. Office building water use based on U.S. EPA's Energy Star Portfolio Manager.**

As Figure D-1 shows, the median value is only part of the picture. The buildings in the 85 percent plus range show significantly higher water use per square foot compared to the median. This pattern is seen for most types of commercial activity.

The second graph, Figure D-2, is taken from the U.S. Energy Information Administration's report, "Energy Characteristics and Energy Consumed in Large Hospital Buildings in the United States in 2007" (2012), for water use in hospitals. The purpose of this benchmark information is to show that there is high variability in water use based on geography. Hospitals in the South have much higher air conditioning loads and therefore much higher cooling tower water use.

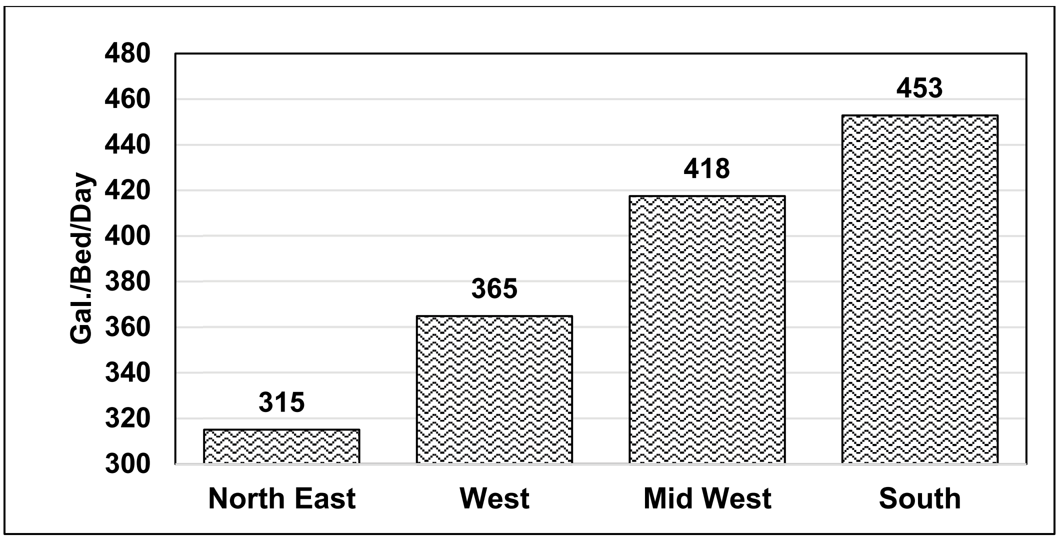



**Figure D-2. CBECS 2007 hospital use using gallons per bed per day.** *(Source: U.S. Energy Information Administration, U.S. Department of Energy, 2012)*

Another example of benchmarking comes from Australia (Sydney Water, 2017). Again, it shows the range of use based on a "Fair, Efficient, and Best Practices" designation. It also illustrates the impact that the use cooling towers has on water use in large commercial facilities (See Table D-1).

**Table D.1. Example of benchmarking from Sydney, Australia for office buildings and shopping centers.**

| Ratings | Gallons per Square Foot of Cooled Space per Year | |
|---|---|---|
| | With Cooling Towers | Without Cooling Towers |
| Best Practice | 18.9 | 9.8 |
| Efficient | 20.7 | 11.6 |
| Fair | 24.8 | 15.7 |

*Note that these values have been converted for the original metric values. To convert from kiloliters/cubic meter/year to gallons per square foot per year, multiply kiloliters/$m^2$/Year by 24.54. *(Source: Sydney Water, 2017)*

## National Benchmarking Studies Expressed in Gallons per Square Foot per Year

The Table D-2. contains the benchmarking information from eleven studies where the benchmark is expressed in gallons per square foot of indoor space per year. Values are median and average values as reported in the studies.

**Table D-2. Summary of 11 studies reporting water use by gallons per square foot of space per year (using median or mean as reported).**

| Type of Facility | EPA Portfolio Manager[1] | University of Florida[2] | Santa Fe, New Mexico[3] | Colorado Water Wise - Brendle Group.[4] | AWWA End Use Study 2000[5] | Austin 2013[6] | Boston Benchmark Law 2015[7] | New York Benchmark Law[8] | Washington DC Bench - mark Law[9] | Philadelphia Benchmark Law[10] | Minneapolis Benchmark Law[11] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Gallons per Square Foot of Heated Space per Year* | | | | | | | | | | |
| **Restaurants** | | 221 | | 173 to 211 | 130 to 330 | 215 | | | | | |
| **Senior Care Facilities** | 61 | 106 | | 62 to 101 | | | | 86 | | | |
| **Hotels** | 54 | 85 | | 79 to 165 | 60 to115 | 72 | 55 | 71 | 55 | 100 | |
| **Hospitals** | 51 | 31 | | | | 58 | | | | 68 | |
| **Grocery/ Supermarkets** | 24 | 95 | 36 | | 52to 64 | | | | | 24 | |
| **Medical Offices** | 19 | 34 | 49 | | | | | 33 | | 35 | |
| **Offices** | 13 | 20 | 26 | | 9 to 15 | | 12 | 13 | 15 | 17 | 11 |
| **Banking/ Financial** | 12 | 89 | | | | | | | | | |
| **Court House** | 11 | | | | | | | | | | |
| **K-12 Schools** | 10 | 20 | | 12 to 19 | 8 to 16 | | | 7 | 10 | 13 | |
| **Houses of Worship** | 7 | 15 | | | | | | | | 11 | |
| **Retail/ Shopping Centers** | 5 | 32 | 20 | | | | | 10 | | 16 | |
| **Unrefrigerated Warehouses** | 4 | 8 | | | | | | 3 | 2 | 4 | |
| **Colleges/ Universities** | | | | | | | 23 | 14 | 24 | 75 | |
| **Residence Halls/ Dormitories** | | | | | | | 31 | 50 | 41 | | |
| **Multi-Family** | | | | | | | 35 | 54 | 40 | | |

1. U. S Environmental Protection Agency, Portfolio Manager, Data Trends, Water Use Tracking http://www.energystar.gov/buildings/tools-and-resources/water-use-tracking
2. M. A. Morales and J. P. Heaney, **Estimating Non-Residential Water Use with Publicly Available Databases,** Conserve Florida Water Clearinghouse, Department of Environmental Engineering Sciences, University of Florida, P.O. Box 116450, Gainesville, FL 32611;
2. M. A. Morales, J. P. Heaney, K.R. Freidman, J.M. Martin, **Estimating Commercial, Industrial, and Commercial Water Use on the Basis of Heated Building Area**, AWWA Journal, June 2011
3. Planning Division, City of Santa Fe, New Mexico, **Water Use in Santa Fe**, 2001
4. The Brendle Group, Inc. **Benchmarking Task Force - Collaboration for Industrial, Commercial & Institutional Water Conservation,** 226 S. Remington St. #3 Fort Collins, CO 80524
5. American Water Works Association Research Foundation, **Commercial and Institutional End Uses of Water,** 2001, 6666 Quincy Avenue, Denver Colorado, http://ufdc.ufl.edu/WC13511002/00001/5j
6. M Jordan, B Hoffman, S Riesenberg**, Benchmarking Commercial and Institutional Water Use in Austin, Texas,** Austin Water Utility, Austin, Texas 2013
7. Energy Disclosure for City of Boston Municipal Facilities - May 15, 2015 https://www.**cityofboston**.gov/eeos/reporting
8. Energy Disclosure for City of New York - http://www.nyc.gov/html/gbee/html/plan/ll84_scores.shtml
9. Energy Disclosure for Washington DC - http://doee.dc.gov/page/energy-benchmarking-disclosure
10. Energy Disclosure for City of Philadelphia - http://www.phillybuildingbenchmarking.com/wp-content/uploads/2015/09/MOS_BnchMrkRprt_R5fin_FINAL.pdf
11. Minneapolis 2014 Private and Public Building Energy Data


## Other Benchmark Information from Various Sources

Table D.3.a, b, and c are compiled from studies of literature by H.W. (Bill) Hoffman & Associates, LLC. They show information for hospitals, and hotels.

**Table D.3.a. Summary of hospital water use coefficients from various studies.**

| Study | Gal/Bed/Day | Gal/Sq. Ft./Yr. | |
|---|---|---|---|
| | | Average | Best |
| Federal Facilities Average | | 125 | |
| Univ. of Florida Study | | 31 | |
| United Kingdom -Large Teaching | | 41 | 34 |
| UK Small Acute or Long Stay | | 29 | 22 |
| UK Small Acute or Long Stay with Laundry | | 39 | 31 |
| North Carolina Rule of Thumb | 300 | | |
| ASHE 2002 Study | 471 | | |
| Energy Star Portfolio Mgr. | 315 | | |
| Victoria Public Health Service - Australia | | 39 | 17 |
| Health Estate Journal - United Kingdom | | 87 | |
| US Energy Information Adm. 2007 study | 395 | 68 | |
| City of Austin (9 largest medical Facilities) | 335 | 58 | 18 |

**Table D.3.b. Summary of school water use coefficients from various studies.**

| Study | Description | Gal./Sq.-Ft/Year | Gal./Person/Day |
|---|---|---|---|
| Brendle Group (Colorado) | High School | 12 | 16 |
| Brendle Group (Colorado) | Middle School | 12 | 11 |
| Brendle Group (Colorado) | Elementary School | 11 | 12 |
| 2000 Water Research Foundation | All Schools | 8-16 | 3-15 |
| British Environment Agency | All Schools | | 19 |

| | | | |
|---|---|---|---|
| Austin 2000-2001 | High Schools | | 32 |
| | Middle Schools | | 22 |
| | Elementary Schools | | 18 |
| Austin 2004-2005 | High Schools | | 34 |
| | Middle Schools | | 19 |
| | Elementary Schools | | |
| Austin 2010-2011 | High Schools | | 34 |
| | Middle Schools | | |
| | Elementary Schools | | 15 |

**Table D.3.c. Summary of hotel water use coefficients from various studies.**

| **Table D.3.c. Summary of Hotel Water Use Coefficients from Various Studies** | | |
|---|---|---|
| **Study** | **Gal./Sq.-Ft/Yr.** | **Gal./Room/Day** |
| Univ. of Florida Study | **89** | |
| Energy Star Portfolio Mgr. | | **102** |
| Sydney Australia Study | | **99-132** |
| 2000 Water Research Foundation | | **60-115** |
| Colorado Study (Brendle Group) | **120** | **95** |
| Water Mgt. Inc. Study | | **75-175** |
| 2006 CIRIA London England Study | | **7-123** |
| Austin median | **72** | **90** |
| New York – Portfolio Manager | **75** | |
| New York – Mayors Challenge | **69** | **129** |

Federal facilities are also benchmarking their facilities. Figure D-3 shows the results of this effort. It is worthy to note that prisons (Justice) has very high use per square foot. This is also true of other prisons and jails.

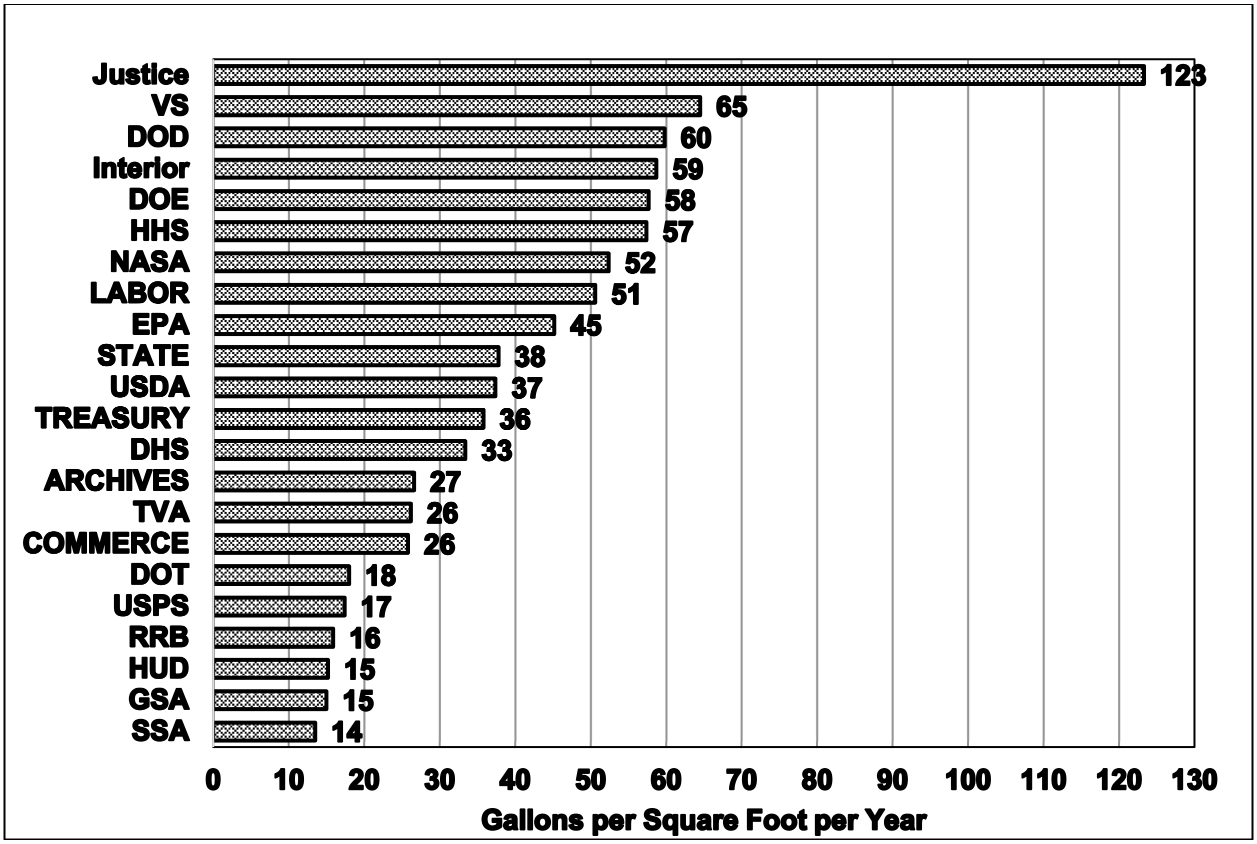



**Figure D-3. Water coefficients for federal facilities in 2012.**

**<u>CBEC benchmarking studies</u>**

The following two graphs (Figures D.4a and b) are based on the Commercial Buildings Energy Consumption Survey completed in 2016 (U.S. Energy Information Administration). It has the year 2012 as its base year. They show average operating by type of facility and the number of workers per square foot of facility. Where such information is not available from the audit process, these data can be used to develop estimates.

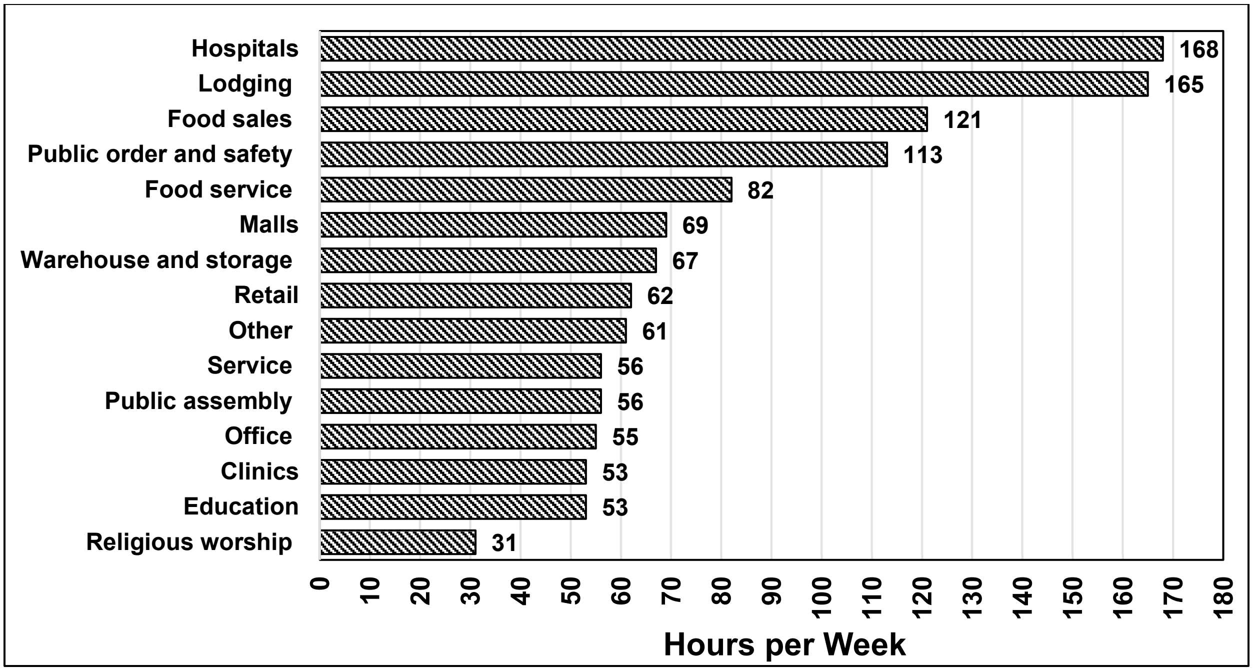



**Figure D-4a. Average operating hours per week.** *(Source: U.S. Energy Information Administration, 2016)*

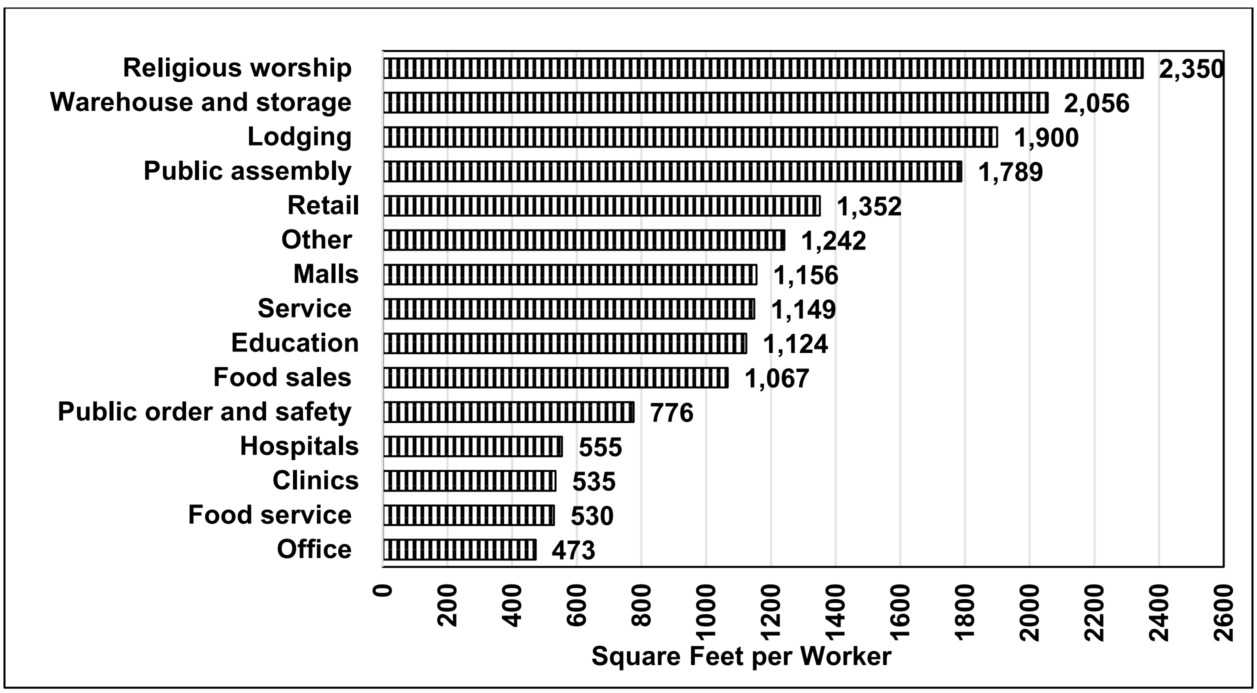



**Figure D-4b. Square feet per worker.** *(Source: U.S. Energy Information Administration, 2016)*

## <u>Texas Specific Information</u>

The following is information taken from Texas Water Development Board studies and special investigation by H.W. (Bill) Hoffman & Associates, LLC. Table D.4 shows the percent of water use by Texas Cities by category of use based on the TWDB's (2015) "Water Use of Texas Water Utilities: Biennial Report to the Texas Legislature," completed for the 84th Legislative Session.

**Table D.4. Average categorical percentage of metered water use.**

| **Description** | **Total Residential** | Single-Family Residential | Multi-Family Residential | **Institutional** | **Commercial** | **Industrial** | **Agricultural** | **Other[1]** |
|---|---|---|---|---|---|---|---|---|
| **All Utilities (344)** | **58%** | 48% | 10% | **4%** | **21%** | **15%** | **<1%** | **2%** |
| **Significant ICI[2] Utilities (34)** | **35%** | 25% | 10% | **4%** | **30%** | **31%** | **<1%** | **1%** |

*(Source: TWDB, 2015)*

**Table D.5. Audit savings identified regardless of payback, based on audits conducted in Austin, Dallas, and Fort Worth, Texas.**

| Type of Facility | Percent Savings Identified and Sample Size | | | | |
|---|---|---|---|---|---|
| | Low | High | Average | Median | Sample Number |
| Elementary Schools | 33% | 61% | 41% | 34% | 6 |
| Middle Schools | 15% | 42% | 27% | | 5 |
| High Schools | 11% | 38% | 27% | 26% | 12 |
| Community College | 3% | 29% | 12% | 15% | 6 |
| Universities | 20% | 82% | 27% | | 3 |
| Recreation Centers | 3% | 19% | 5% | | 4 |
| Convention Centers | 18% | 31% | 20% | | 3 |
| Hospitals | 8% | 22% | 16% | 13% | 6 |
| Hotels | 11% | 82% | 23% | 22% | 11 |
| Office Buildings | 1% | 65% | 15% | 17% | 43 |
| Libraries | 3% | 34% | 24% | | 3 |

| Simple Payback for Water Savings in Years for Entities Audited | | | | | |
|---|---|---|---|---|---|
| Range of Pay Back on Measures in Years | Low | High | Average | Median | Sample Number |
| | 0.1 | 26 | 3.9 | 2.7 | 157 |

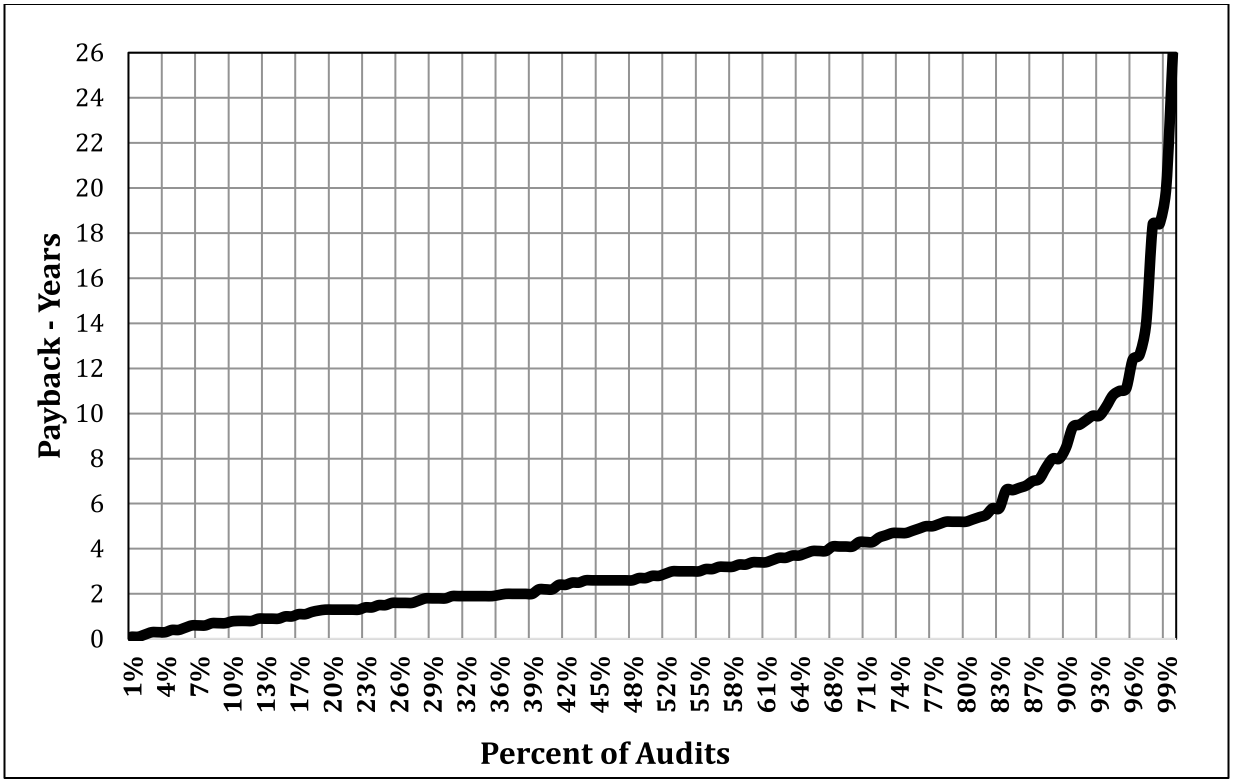



**Figure D-5. Simple payback, in years, for 157 commercial water audits in Austin, Dallas, and Fort Worth, Texas.**

The seasonality of use for office buildings that have cooling towers is shown to illustrate the impact that cooling towers have on overall water use at a facility. Figure D.6 shows the cooling tower use impact.

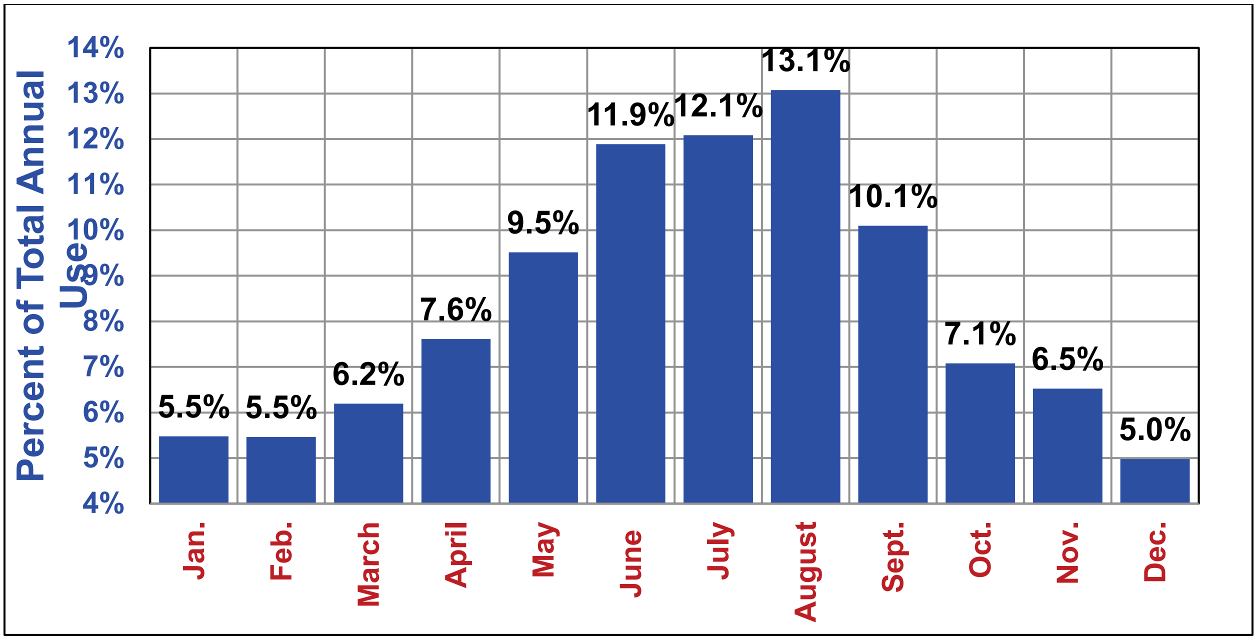



**Figure D-6. Distribution of monthly water use by 44 office buildings in Texas with cooling towers.**

# APPENDIX E - Determination of the Impact on Other Resources

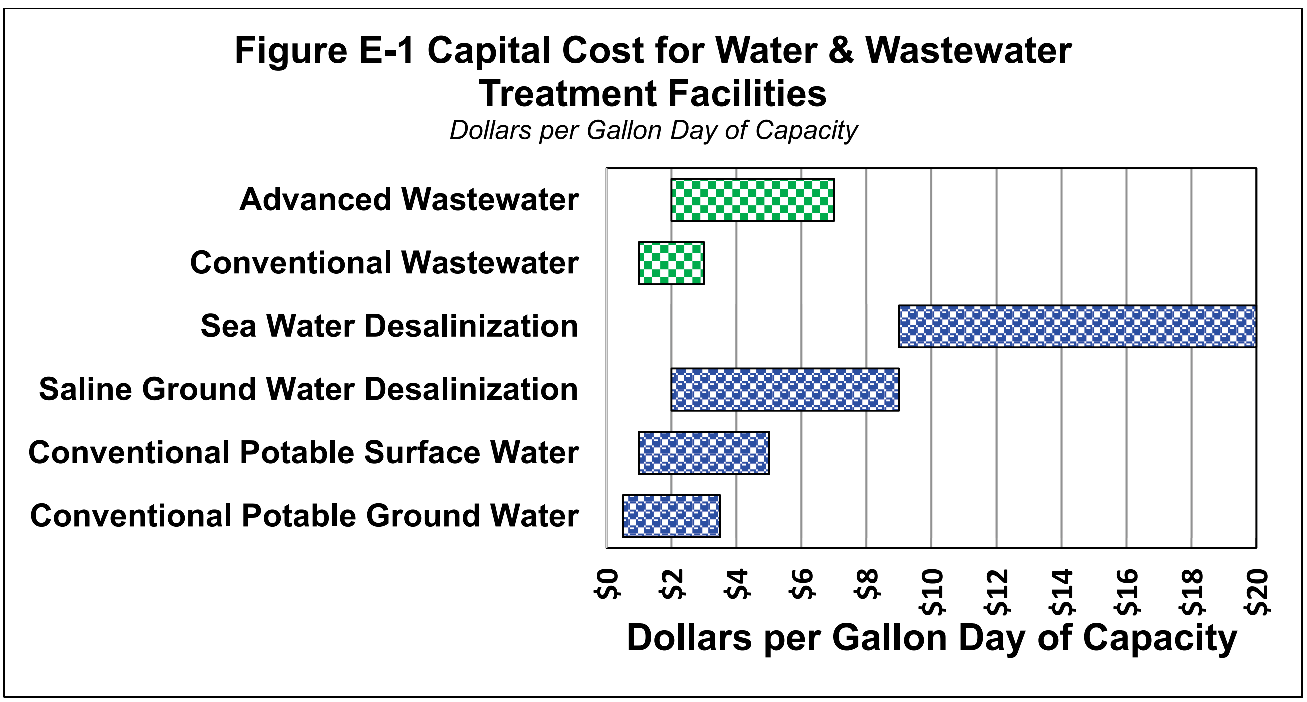
The commercial and institutional (CI) water using sector accounts for approximately one third of municipal, non-industrial water use including leak loss and 38 percent on non-industrial water sales. Reducing water use in the CI sector both reduces these users operating costs and reduces future demand on water and wastewater treatment facilities. Impacts associated with the reduction of water use in the CI sector include

- Savings for Water and Wastewater Utility Operations;
- .Reductions in energy use both to the utility and by the end user; and
- Potential reductions in pollution loading.

## Savings for Water and Wastewater Utility Operations

By reducing water demand through conservation, the need to add water and wastewater treatment to accommodate growth is extended. Reducing demand allows for more economic growth per unit of treatment capacity and more economy on the same water resource. The following figure E-1 shows the range of cost for treatment capacity in dollars per gallon day of capacity.

Based on the 2017 Texas Water Plan, **Water for Texas**, conservation and conventional reuse are the least costly forms of new water supply.



## Energy and Water Relationships

There are many energy and water relationships, often called the energy – water nexus. Conventional thought looks at the energy used to produce, pump and treat water and wastewater on the water needed to produce energy in its various forms. With respect to the end user, there is also a significant energy – water nexus. There is the energy used to heat water and produce steam and the water used in cooling towers and other cooling and heat processes.

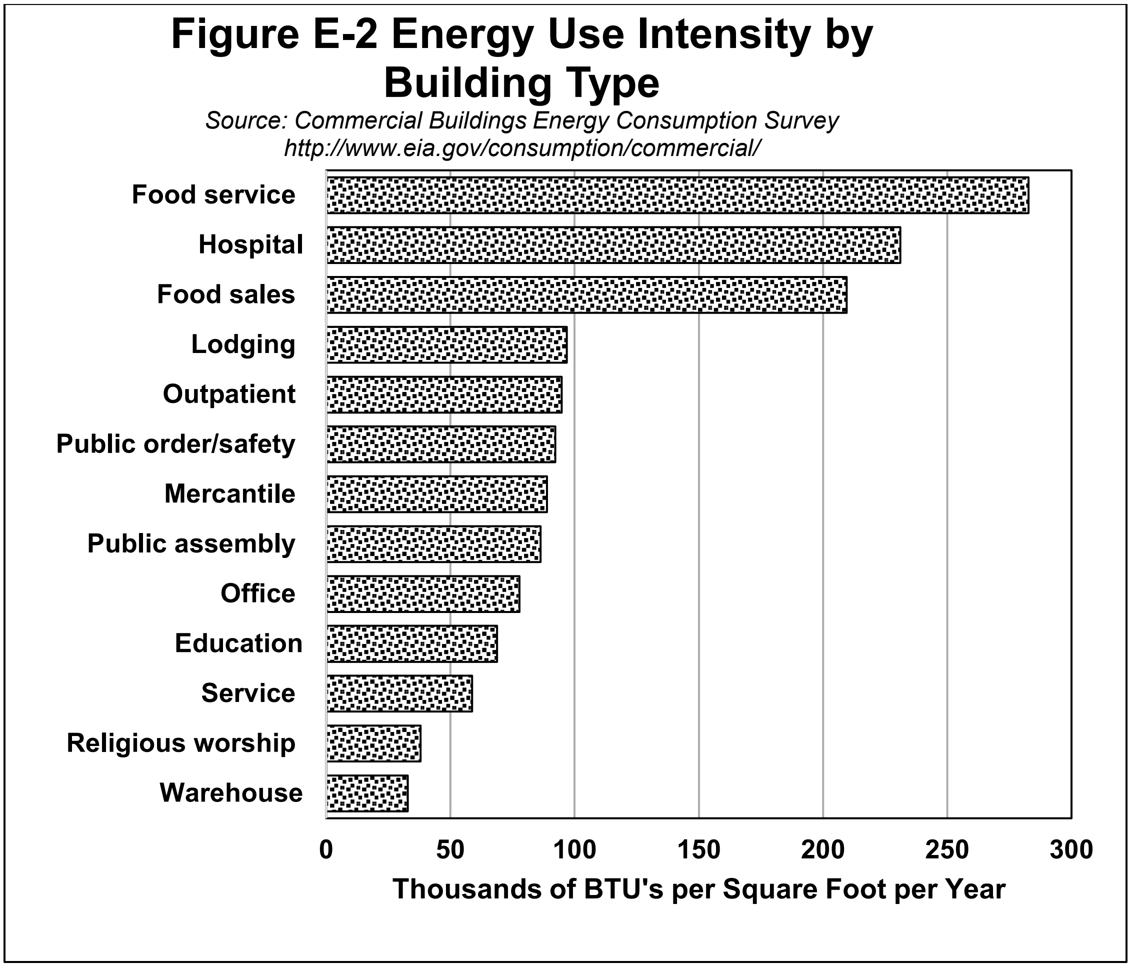
*Water and Wastewater System Energy Use*

At the water and wastewater utility level, it takes some 0.2 to 0.6 kilowatt hours to treat potable water with conventional systems and as much as 10 to 16 kilowatt hours per thousand gallons to desalt sea water, but this is only the beginning. The US Environmental Protection Agency estimates that on average, treatment energy use accounts for only about 15 percent of total energy needed to get water to the end user. Water is heavy and must be pumped at pressure for very long distances. This means that for a typical utility, from 1.5 to as much as 4.0 kilowatt hours must be used to provide a thousand gallons of water to the end user. Wastewater treatment is also energy intensive. For conventional activated sludge operations, from 1.0 to 2.0 kilowatt hours of energy is used for every thousand gallons treated and for advanced wastewater treatment energy use can approach 3.0 kilowatt hours per thousand gallons. The US Environmental Protection Agency estimates 30% to 40% of all energy used by a typical municipality (street and traffic lights, building operations, etc.) is used pump and treat water and wastewater. This means that for every thousand gallons or water used by the end user, some 1.5 to as much as 5.0 kilowatt hours of energy is needed to provide that water to the end user. If seawater desalination is used, total water/wastewater energy use can approach twenty kilowatt hours per thousand gallons.

The other side of this is the fact that with conventional gas, coal and nuclear power plants, from 0.3 to 0.5 gallons of water is evaporated per kilowatt hour in the generation process.

*Energy – Water Relationships for the Commercial and Institutional End User*

For commercial and institutional operations energy and water meet at many junctions. Heating water, cooling tower operations, cooking equipment and steam boilers are the most common junctions and the more of the junctions there are, the more energy intensive the operation becomes as seen in the following graph (Figure E-2) of energy use intensity by building type.




Cooling tower are commonly used for larger facilities for air conditioning and their water use is in the range of 2.0 to 3.5 gallons per ton hour of cooling. The following figure, Figure E-3 shows the breakdown of water use by certain commercial and institutional user by facilities with cooling towers based on actual water audits of facilities in Austin, Dallas and Fort Worth.

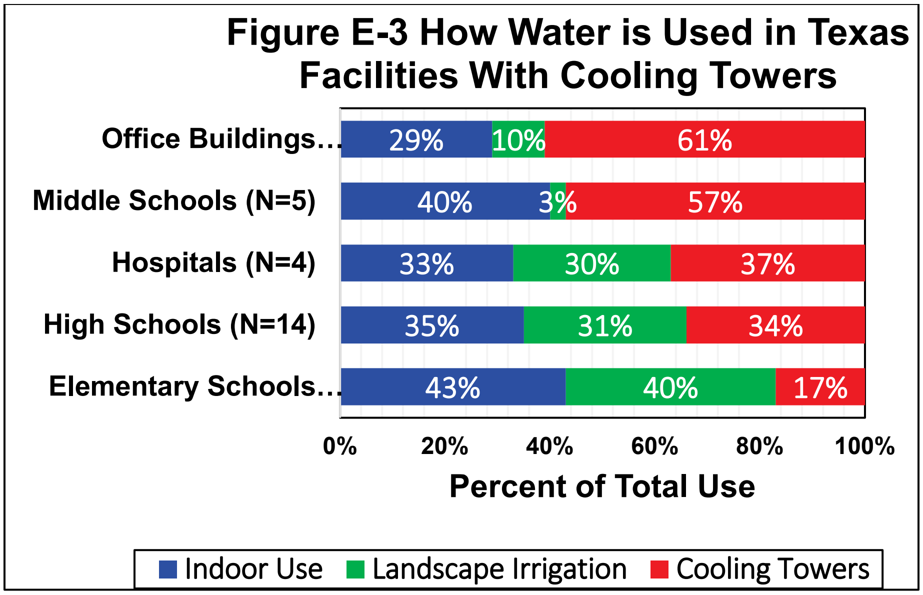


Figure E-3 How Water is Used in Texas Facilities With Cooling Towers
Office Buildings…
Middle Schools (N=5)
Hospitals (N=4)
High Schools (N=14)
Elementary Schools…
29%
10%
61%
40%
3%
57%
33%
30%
37%
35%
31%
34%
43%
40%
17%
0%
20%
40%
60%
80%
100%
Percent of Total Use
Indoor Use
Landscape Irrigation
Cooling Towers

## Potential Reductions in Pollution Loading

The type and characteristics of wastewater produced by commercial and institutional operations depends on the type of facility. Pretreatment programs examine the most common types of operations that produce “high strength” wastewaters. Printing operations, photograph development, plating of metals, and related operation all can produce effluents with high toxic metals contents. In a similar manner, restaurants and food service operations can produce effluents with high fat, oil and grease content. The US Environmental Protection Agency requires that utilities develop pretreatment programs to manage these pollutants at the source. Reducing water use in these operations can lead to increase concentrations in the waste streams. However, smaller volumes can make pretreatment more manageable.

For many operations, dissolved salts content is significantly increased by water softening and cooling tower operations. Pretreatment normally does not address these increases for most facilities, but these salts do increase the total dissolved solids (salts and minerals) of the utility’s effluent. This impacts the usability of the effluent for water reuse and can cause the “Total Maximum Daily Load” concentrations of the effluent for dissolved salts to be exceeded. Water conservation reduces the amounts of water that need to be softened this decreasing salt input. As for cooling towers, energy conservation reduces the amount of water that is evaporated, thus decreasing salt loading. Alternatives to cooling towers both reduce salt loading and eliminate this huge water use, thus saving significant volumes of water. The section on costs examines this in more detail.