***DRAFT***

Best Management Practices for

Commercial and Institutional Water Users

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**Chapter 1: Introduction and Purpose**

**Background**: 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, expand systems to meet growing population and an expanding economy, and to meet the health and environmental needs of all Texans. The commercial 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, 84 percent, are employed in these two sectors as represented by Figure 1. This segment contains many components as illustrated in Figure 2. In 2014, the latest information from the US Department of Commerce, the Texas economy’s gross domestic product equaled $1.65 trillion of which the commercial and institutional sectors accounted for 71 percent of the total as shown in Figure 3.

Multi-family complexes and public housing facilities are also often included in commercial and Institutional sectors since they represent multiple housing units owned by a business enterprise of governmental entity and operate like a business. The same is true of dormitories and other large complexes that house people. In Texas, based on the National Multi-family Housing Council (http://nmhc.org/Content.aspx?id=4708 ), 3.7 million Texans live in multi-family apartments.

Water and wastewater costs are rising more rapidly than electricity, natural gas, and other "utility" costs and overall inflation. These rising costs will impact the economic viability of these segments of the state's economy. Water efficiency is one of the key methods of keeping these rapidly rising costs under control while contributing to the overall sustainability of Texas' limited and precious water resources.

Figure 1. Commercial and institutional sectors represent a major component of the Texas economy. The majority of Texans are employed in these two sectors. *U.S. Bureau of Labor Statistics – 2015. http://www.bls.gov/eag/eag.tx.htm*

Figure 2. Major components of the Commercial and Institutional sectors in Texas. The majority of Texans are employed in these sectors. U.S. Bureau of Labor Statistics, 2015. *http://www.bls.gov/eag/eag.tx.htm*

Source: US Bureau of Economic Analysis: https://www.bea.gov/newsreleases/regional/gdp\_state/gsp\_newsrelease.htm

**Purpose**: The first 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.

In addition to the commercial and institutional activities mentioned above, many consider public housing, apartments, 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.

The second purpose of this guide is to provide information on technical assistance sources, tax incentives and other technical and financial assistance that is available to the sector.

**Chapter 2: Commercial and Institutional Water Use Patterns**

Currently, Texans use approximately eight million acre feet (7.1 billion gallons) of water a day for urban and industrial activities and approximately 10 acre feet (8.9 billion gallons) for agricultural purposes. However, agricultural uses are projected to continue their long decline while water use in the urban and industrial sectors will continue to increase as population doubles over the next 50 years to nearly 50 million people, all who will need water. Based on the 2012 Texas Water Plan from the Texas Water Development Board (TWDB), total water demand will grow from 18 million acre feet in 2010 (to 22 million acre feet a year or about 19.6 billion gallons per day. Although the next water plan will not be officially public until 2017, future projections of use are slightly lower primarily due to increased water efficiency.

Although the above graph shows the “big picture” of water use in Texas, an examination of the urban and industrial components for utilities with 3,300 connections or above, based on the Texas Water Development Board 2015 report entitled “Water Use of Texas Water Utilities” shows that commercial and institutional use varies by size and type of community, but can be very significant. See Figure XX. (<http://www.twdb.texas.gov/publications/reports/special_legislative_reports/doc/2014_WaterUseOfTexasWaterUtilities.pdf>). The study shows that approximately 52 percent of the water supplied by all utilities in the survey was for institutional, commercial and industrial (ICI) uses or multi-family properties that are operated like a business. Many utilities include multi-family properties in commercial accounts since working with property owners and managers is similar to working with other businesses and industries.

**The Role of Leaks and Other Water Losses must also be taken into account.** What the graph does not show is that based on a survey conducted every five years by the Texas Water Development Board, 13.7 percent of the water distributed by utilities in Texas was lost through leaks and other losses. These “non-revenue water” losses are not reflected in these uses.

Leaks also play a large role in the home and business and these are reflected in Based on an American Water Works Association Water Research Foundation Study in 2014, homes loose approximately 12 percent of their water to leaks. The study also shows that only about ten percent of these homes account for over half of the leak volume. Leaks in multi-family, commercial and institutional facilities have not been so carefully quantified, but certainly do occur. If on assumes an overall on-site or use leakage of 10 percent and a utility loss of 10% to 15%, it is clear that a large amount of water produced by municipalities for use is lost this way. The State now has requirements for utilities to analyze and control their losses. Best management practices to accomplish this in the ICI and multi-family sectors will also be discussed in section XX entitled Metering, Measurement, and Leak Control.

The importance of water use outside of single family residential use is seen when per capita use (gallons per person per day) is examined based on the 2015 Water Use of Texas Water Utilities report cited above. Based on this study, single family residential use average 77 gallons per person per day. As Figure ww shows, per capita residential use can range from 74 to 90 gallons per person per day, but the component added by the institutional, commercial, and industrial sectors and a very small volume of sales to other non-residential users easily overshadows single family use especially in larger cities. These non-residential uses are the target of this guide.

Institutional, Commercial and Industrial water use among the various ICI sectors also varies. One 2010-2011 study for the City of Austin shows the following distribution of water use (See Figure YYY). Each city’s profile will be different, but such an analysis helps direct the utility to which sectors are the largest sectors they serve and therefore where a conservation effort might be mounted.

Although this guide is directed to commercial and institutional users and where applicable, multi-family users, it is worthy to note that industrial water use such as manufacturing, mining and oil and gas recovery and electric power generation account of nearly 40 percent of non-agricultural uses in Texas.

Benchmarking Water Use: Another useful tool to determine how much water any particular type of commercial or institutional entity should use is benchmarking or determining how much water is use per type of activity, square foot of space, or similar denominators. The energy sector has been prolific in gathering this type of data, but the water industry is just now starting the process. The following material represents a compilation of a variety of benchmarking studies that have been conducted across the United States and other countries. The information is intended both as information of what is available and as an indicator of the need for much more work in this area.

One such effort is that of the US Environmental Protection Agency’s Energy Star Portfolio Manager Program which was started many years ago to benchmark energy use in commercial and institutional facilities. Beginning in 2012, a water component was added and several large property holding companies are using the water segment. To date, New York, Philadelphia, Minneapolis, Atlanta, Washington DC and Boston are requiring commercial entities of certain sizes to benchmark both energy and water use and the Texas State Energy Conservation Office is using Portfolio Manager to benchmark water use by Texas State facilities and State supported Universities.

In 2000, the American Water Works Association Research Foundation, Commercial and Institutional End Uses of Water study was conducted and represented the first major national effort of its kind in the water industry. Currently the American Water Works Association has commissioned a study entitled **Methodology for Determining Baseline Commercial, Institutional, and Industrial End Uses of Water** which will be available in 2016. It describes processes that utilities can use for building their local benchmarking efforts. Many studies by consultants are also available in the literature. Both the University of Florida and several cities have conducted specific studies in the United States and Europe, Australia and New Zeeland have been active in benchmarking commercial water use. The Colorado WateWise Council commissioned the Brendle Group to benchmark certain sectors in the State of Colorado.

In all of these studies, determining total water use per facility is the easier part of the task since utility billing information is available. The determination of the type of facility is the next task. Some few utilities has classified user types in some detail. Some even have used the North American Standard Industrial Classification (NAICS) system and its now outdated predecessor SIC codes. The more the detailed the classification is, the better the information. For example, hotel/motel facilities can be broken into three or four categories using the NAICS codes to include resort, full service, limited service, and motel classifications.

Finally, determining the denominator often proves to be problematic. The following table illustrates some of the denominators that have been used for typical commercial and institutional facilities.

|  |  |
| --- | --- |
| **Table dd Examples of Benchmarking Denominators Used by Facility Type in Past Studies** | |
| Facility Type | **Denominators Used** |
| Hotel | Square feet, number of room, number of occupied rooms, number of guests |
| School | Square feet, number of students, number of all adjusted to days open |
| Restaurant | Square feet, seats, meals served (covers), number of employees |
| Hospital | Square feet, beds, occupied beds, total patient load per day including outpatients |
| Shopping Center | Square feet, number of employees, estimates of number of shoppers |
| Office | Square feet, number of employees, estimates of total people hours including workers and visitors. |

The type of water using practices and equipment present is also used to further break down user types. This can include if the facility has landscape that is irrigated, pool and spa facilities, cooling towers, etc.

Four types of information have been derived from these studies, including:

1. Average use or median use by category;
2. Histograms showing how use varies across the sector;
3. Time line trends in benchmarking data; and
4. Seasonal benchmarking.

It is beyond this document to show all available benchmarking data, but examples of each type follow.

**Average Use**

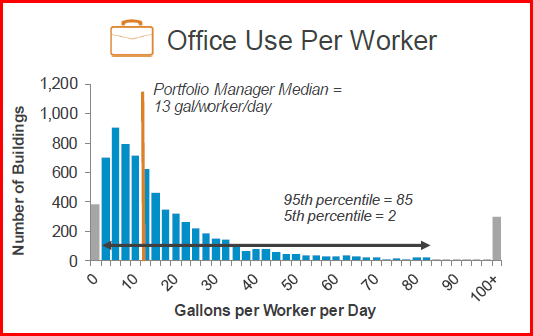
|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Summary of Six United States Studies Reporting Water Use by**  **Gallons per Square Foot of Heated Space per Year** | | | | | | |
| **Type of Facility** | **EPA Portfolio Manager1** | **University of Florida2** | **Santa Fe, New Mexico3** | **Colorado Water Wise – Brendle Group.4** | **AWWA End Use Study 2000 5** | **Austin 20136** |
| ***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 |  |  |
| Hotels | 54 | 85 |  | 79 to 165 | 60 to115 | 72 |
| Hospitals | 52 | 31 |  |  |  | 58 |
| Grocery/Supermarkets | 24 | 95 | 36 |  | 52to 64 |  |
| Medical Offices | 19 | 34 | 49 |  |  |  |
| Offices | 13 | 20 | 26 |  | 9 to 15 |  |
| Banking/Financial | 12 | 89 |  |  |  |  |
| Court House | 11 |  |  |  |  |  |
| K-12 Schools | 10 | 20 |  | 12 to 19 | 8 to 16 |  |
| Houses of Worship | 7 | 15 |  |  |  |  |
| Retail/Shopping Centers | 5 | 32 | 20 |  |  |  |
| Unrefrigerated Warehouses | 3 | 8 |  |  |  |  |
| 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; 3. 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 4. Planning Division, City of Santa Fe, New Mexico, **Water Use in Santa Fe**, 2001 5. The Brendle Group, Inc. **Benchmarking Task Force – Collaboration for Industrial, Commercial & Institutional Water Conservation,** 226 S. Remington St. #3 Fort Collins, CO 80524 6. 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 7. M Jordan, B Hoffman, S Riesenberg**, Benchmarking Commercial and Institutional Water Use in Austin, Texas,** Austin Water Utility, Austin, Texas 2013 | | | | | | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Summary of Restaurant Water Use Coefficients from Various Studies** | | | | | |
|  | | | | | |
| **Source of Information** | **Best Gal./Meal** | **Avg. Gal./ Meal** | **Gal./ sq. ft./ Year** | **Best Gal./ Seat/ Day** | **Avg. Gal./ Seat/ Day** |
|  |
| Florida (Univ. of Fl.) Restaurant |  |  | **270** |  |  |
| Florida (Univ. of Fl.) Fast Food |  |  | **240** |  |  |
| Colorado Study (Brendle Group) |  |  | **192** | **29** | **53** |
| USA (2000 AWWARF) | **9 to 12** |  | **130 to 331** | **20 to 30** |  |
| Bolder Colorado |  |  | **125** |  | **49** |
| Danamark.com (Canada) | **8 to 9** |  |  |  |  |
| U of Kansas (M. Vanschenkhof) |  | **12.8** | **266** |  |  |
| South Australia study and Sydney Water |  | **9 to 12** |  |  |  |
| North Carolina |  |  |  |  | **20 to 40** |
| Austin Study (Full Svc.) |  |  | **173** |  | **31** |
| Austin Study (Fast Food) |  |  | **257** |  | **39** |

**Histograms of Various Types**

The first example of a histogram showing the distribution of use is from the US Environmental Protection Agency (U. S Environmental Protection Agency, Portfolio Manager, Data Trends, Water Use Tracking <http://www.energystar.gov/buildings/tools-and-resources/water-use-tracking>) and shows use per office worker for office buildings. As the figure shows, use can vary widely. Median use of water per worker was only 13 gallons per worker per day, but many facilities used over 100 gallons per worker per day. These would be prime candidates for water efficiency programs.

The second graph shows the result of a benchmarking project for water use in the 2010-2011 time period in Austin, Texas. This graph also contains a breakdown the gallons used per room for hotels based on the type of hotel (M Jordan, B Hoffman, S Riesenberg**, Benchmarking Commercial and Institutional Water Use in Austin, Texas,** Austin Water Utility, Austin, Texas 2013). Again, it shows that there is wide variation.

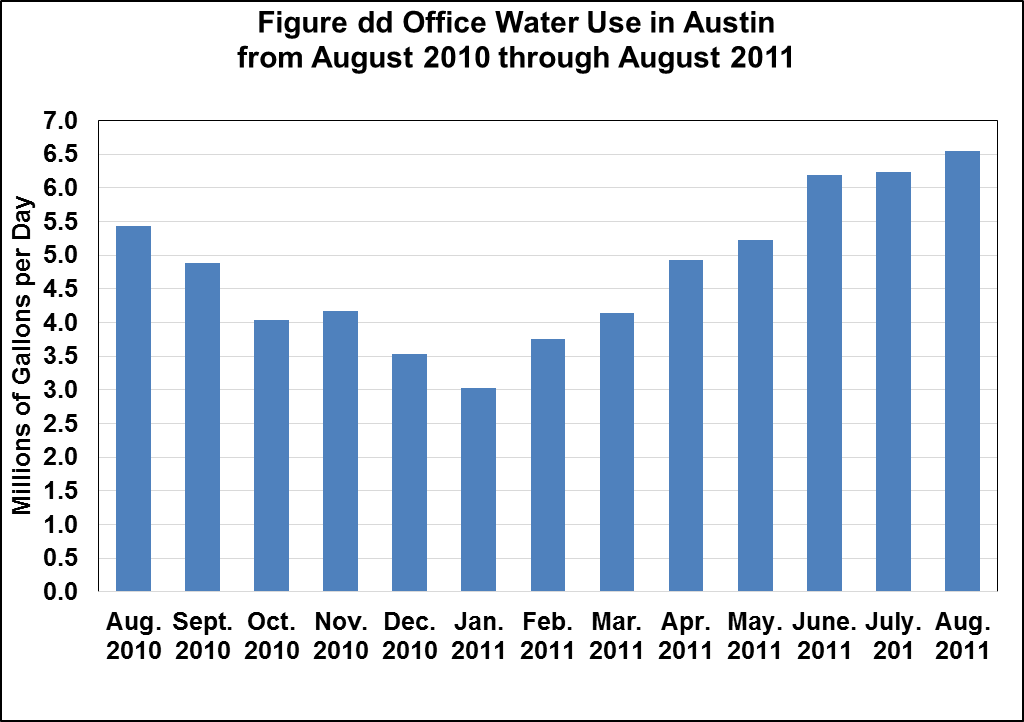


**Time Series Analysis**

Time series analysis of benchmark data shows trends over time. It is often necessary though to account for economic and/or climatic variations to fully understand what is occurring. The following example is from a study of data from a study in Phoenix, Arizona for hotels. It is based on an unpublished study by H.W. (Bill) Hoffman & Associates. It is part of a much larger, yet to be published, study by the City of Phoenix.

**Seasonal Benchmarking**

Seasonal use can be looked at in a number or ways. The most direct is to simply look at volume of use. In the Austin study (M Jordan, B Hoffman, S Riesenberg**, Benchmarking Commercial and Institutional Water Use in Austin, Texas,** Austin Water Utility, Austin, Texas 2013) for example, total monthly use for various sectors was examined. Figure pp shows the results for office use in Austin. Where separate irrigation meters are available, the use of these to determine irrigation use is invaluable, but for many larger facilities, cooling tower use can be even larger. Landscape irrigation, swimming pools, and certainly cooling towers all are part of seasonal use.

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**How Commercial and Institutional Entities Use Water**

How businesses use water includes uses familiar to residential users, as well as equipment and processes that are not so familiar. Table XX illustrates the many types of water use commonly found in commercial and institutional operations.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Table xx Examples or Water Using Technologies in the Commercial and Institutional Sectors | | | | | | | | | | | | |
| Type of  End-Use Operation | **Water Using Technology** | | | | | | | | | | | |
| Restrooms and Plumbing | Wash-down &Sanitation | Pools, Spas, and Fountains | Water Treatment Systems | Thermodynamic Processes | Laundry Equipment | Medical & Lab Equipment  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 |

The amount of water used for each of these activities depends on the type of facility and the operational characteristics of that activity. Many cities and facility groups have had water use surveys (audits) of their facilities performed to determine how water is used and where savings were possible. The following summarizes some of these findings.

This is where the audits from the stakeholder group will be summarized once all are gathered.

Here are some examples for starters. In the end, I hope to have a much better data set to share, based on stake holder utility inputs.

**Chapter 3: Cost Effectiveness Considerations**

Water and sewer rates have been increasing rapidly over the last two decades. In a 2015 Circle of Blue report available on the web, they state that water rates have increased by 41 percent since 2010 in the top 30 cities in the United States (<http://www.circleofblue.org/waternews/2015/world/price-of-water-2015-up-6-percent-in-30-major-u-s-cities-41-percent-rise-since-2010/>).

Based on a 2014 Black and Veatch report entitled *50 Largest Cities Water/Wastewater Rate Survey 2012-2013* (<http://www.saws.org/who_we_are/community/rac/docs/2014/50-largest-cities-brochure-water-wastewater-rate-survey.pdf>) the average population weighted rate for water and wastewater combined for commercial facilities using 100,000 gallons a month was $9.81 per thousand gallons. Assuming a six percent increase per year since 2013, by 2015, these cost will have increased to approximately $11 per thousand gallons or 1.1 cents per gallon. Figure 5. Shows the change in the national cost of water and wastewater between 2001 and 2013. Figure 6. Shows what future cost of water and wastewater will be if inflation remains at the average over the last 13 years of 5.87% a year.

Figure 7. shows the rates for commercial water users for Texas’ six largest cities, Houston, San Antonio, Dallas, Austin, Fort Worth and El Paso. Although Texas rates have not risen as fast as national rates, the Texas Water Development Board predicts that over the next 50 years, the cost to modernize and upgrade water and wastewater treatment capacity as well as develop new supplies will over of $230 billion.

By contrast, the cost of electricity for commercial customers has actually decreased in Texas since 2008. Current commercial establishment electric rates in Texas are around 9 cents per kilowatt hour, while nationally commercial rates are in the range of 10 cents to 11 cents per kilowatt hour. The Energy Information Administration (<http://www.eia.gov/electricity/data/browser/#/topic/7?agg=2,0,1&geo=g&freq=M>**)** predicts that electric power rates will increase at 1.8% to 1.9%.

Natural gas prices for commercial in 2014 establishments average $9.17 per thousand cubic feet (MCF) nationwide and $8.44 per MCF in Texas, but by the middle of 2015, prices had declined to $8.54 per MCF in the USA and $6.52 per MCF in Texas based on US Energy Information Administration data. <http://www.eia.gov/dnav/ng/hist/n3020us3m.htm> where natural gas price will trend to is dependent on both recovery technologies such as fracking and market forces.

By contrast, water and sewer rates are projected to increase at their historic rates of five to six percent as infrastructure costs, more stringent quality requirements, development of more costly water sources, and other factors continue. Based on the 2012 Texas Water Plan and projections by the Texas Water Development Board, over the next 50 years, Texans will have to invest $231 billion for mainly infrastructure for water and wastewater facilities.

The true cost of water also includes the energy used to heat or move water, chemical and other treatment that must be provided on site, and any pretreatment of wastewater prior to discharge. The example in Figure 8. assumes a combined water and sewer cost of $10 per thousand gallons.

Calculate the Unit Value of Water Used: To determine the cost of water, first obtain the unit cost of water. This is usually expressed in dollars per thousand gallons or dollars per 100 cubic feet. Do the same for wastewater if it is charged based on the volume of use. Add these together to obtain the total cost of water. If costs are expressed in 100's of cubic feet (CCF), it can be converted to gallons by multiplying by 0.748. In simplified terms CCF x 0.748 = Use in thousands of gallons.

*EXAMPLE 1:*

Question - A small facility used 52 CCF in a month. How many gallons of water did they use?

Answer - 52 X 0.748 = 38.9 thousand gallons or 38,900 gallons a month

(To convert the cost of water or wastewater in dollars per CCF, divide the cost by 0.748.)

*EXAMPLE 2:*

Question - Water cost $2.50 per CCF. What is that cost in dollars per thousand gallons?

Answer - $2.5/ 0.748 = $3.34 per thousand gallons

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, dollars per therm, or dollars per MCF [thousand cubic feet] of natural gas, etc.) Figures 4 and 5 show the cost of heating one thousand gallons of water with either electricity or natural gas for water which has it temperature raised either 55oF or 120oF, typical of water heated either for domestic use (Figure 4) or for high temperature use in a commercial dishwasher (Figure 5) in Texas.

If the gas is billed in therms, the cost can be converted to dollars per MCF of gas by multiplying the cost of the gas in therms by 10 to convert it to dollars per MCF.

If propane is used, one MCF of gas contains approximately one million BTU's, which is equivalent to approximately 11 gallons of propane. Therefore, if propane costs $2.00 per gallon, it would be equivalent to natural gas costing $22.00 per MCF!

*EXAMPLE 3:*

Question - Natural gas cost $0.60 per therm. What does it cost to heat water by 55oF?

Answer - $0.60 X 10 = $6.00 per MCF, from Figure 4, that is equal to approximately $3.50 per thousand gallons.

Figure 9. Energy costs for heating water by 55°F. Assumes 55°F temperature increase, 95% efficiency for electric and 75% efficiency for gas.

Figure 10. Energy costs for heating water by 120°F. Assumes 120°F temperature increase, 95% efficiency for electric and 75% efficiency for gas.

Additional costs for softening the water or other treatment must also be estimated. For example; for water softening, the cost of the salt per month can be divided by the amount of water treated by the softener.

*EXAMPLE 4:*

Question - Water cost $2.50 per CCF and wastewater cost $3.00 per CCF. The water is used for domestic hot water. The water is heated with electricity at 10 cents a kilowatt hour. What does it cost to heat water by 55oF?

Answer - The water cost a total of $5.50 per CCF ($2.50 + $3.00). This is equal to $7.35 per thousand gallons ($5.50 / 0.748 = $7.35).

Using Figure 4, the cost of heating the water by 55oF is approximately $14.20 per thousand gallons. Therefore, total water costs include energy costs plus water and wastewater costs.

Total Cost = $7.35 + $14.20 = $22.55 per thousand gallons or 2.255 cents a gallon [($22.55 x 100 cents a dollar) / 1,000 gallons = 2.255 cents a gallon]. This can be rounded off to 2.3 cents per gallon for use in estimating savings.

If natural gas were used from Example 3, the total cost would be $7.35 + $3.50 = $10.85 per thousand gallons. That is 1.085 cents per gallon.

*EXAMPLE 5:*

A small facility uses 52 CCF per month. It was determined that 70 percent of the water is cold water and 30 percent is hot water. The water is heated with gas. Hot water is used to wash equipment along with a two percent (2%) chemical cleaning solution by weight that costs $18.00 per pound.

Question - How much does it actually cost to use hot water?

Answer - From example 4, hot water costs $10.85 per thousand gallons. Thirty percent of the total use of 52 CCF is hot water with chemicals added. Hot water use = 52 X 748 gallons per CCF = 11,668.8 gallons a month. It costs $10.85 per thousand gallons so the cost per month = (11,668.8/1,000) x 10.85, which is $126.60.

Another way to look at cost is to compare annual cost for use of fixtures with different flow rates. Table 2 shows a comparison of annual cost to operate a toilet in various settings over a 365 day year.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Table 9. Dollars per Year for Toilet Flushing** | | | | |
| **$10 per 1,000 gallons or $7.48 per CCF** | | | | |
| **Gallons per Flush** | **Cents per Flush** | **Type of Facility** | | |
| **Home: 6 flushes per day & 365 days per year** | **Office: 35 flushes per day & 250 days per year** | **Restaurant: 75 flushes per day & 365 days per year** |
| **5** | 5 | $110 | $438 | $1,369 |
| **3.5** | 3.5 | $77 | $306 | $958 |
| **1.28** | 1.28 | $28 | $112 | $350 |

Developing the Benefit/Cost Estimate

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

Costs are typically calculated for each recommended best management practice within a comprehensive CI 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 to be 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%. If the payback is in 1.6 years the ROI is equal to ($100%/1.6) or 62.6% 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 metrics used when performing a life cycle analysis. It sums all of the 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 making a decision 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.

Finally, if one considers future costs, the average life of equipment and appliances commonly found in commercial and intuitional facilities, cost of replacement and future energy, chemical, treatment, water and wastewater costs should be considered.

**Chapter 4: Financial Incentives and Technical Assistance for Water Efficiency**

Water utilities can offer a number of incentives. A number of water utilities offer various forms of incentives ranging from rebates to either partial funding for or actual free water conservation audits. 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 kind 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:

* Sources of Technical Assistance;
* Tax Incentives;
* Sources of Financial Assistance, Water and Energy Rebates, and Tax Incentives;
* Codes, Standards, and Rating Systems

**Sources of 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 web site 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 type often have web sites, publications, webinars and other sources of information on ways to reduce all forms of water utility costs including water.
3. Water conservation specific web sites that by prove useful include:

* The Alliance for Water Efficiency: The site contains a wealth of information and guides for commercial and institutional entities. The site can be found at <http://www.allianceforwaterefficiency.org/>;
* The US Environmental Protection Agencies publication entitled ***WaterSense for Business*** guidebook and the Water Sense program which can be found at <http://www3.epa.gov/watersense/>;
* The Texas Water Conservation Advisory Council web site that contains this guide at <http://www.savetexaswater.org/bmp/CIBMPindex.htm>,
* The State Energy Conservation Office’s ***Water Conservation Design Standards*** for State facilities at <http://seco.cpa.state.tx.us/tbec/waterconservation.php>;
* Green Plumbers at http://www.greenplumberstraining.org/Pages/default.aspx
* The Maximum Performance Testing web site 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.

1. 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 the energy efficiency has, so commercial and institutional water users are cautioned to choose these firms carefully.

**Financial Assistance, Water and Energy Rebates, and Tax Incentives**

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 web sites:

* [Texas Water Development Financial Assistance](https://www.twdb.texas.gov/financial/programs/index.asp)
* [State Energy Conservation Office Loan Star Program](http://www.seco.cpa.state.tx.us/ls/)

Beginning in 2015, Texas now has a new program available called PACE (Property Assessed Clean Energy) was passed by the Texas Legislature to promote both WATER and energy efficiency financing.   
PACE is an innovative financing program that enables owners of commercial and industrial properties to obtain low-cost, long-term loans for water conservation, energy-efficiency improvements, and renewable retrofits. The PACE statute, SB 385, 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. 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 web site at: <http://www.keepingpaceintexas.org/pace-in-a-box/>

Water and Energy Rebates are can help finance the replacement or retrofit of 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 efficiency are also energy efficient. One should check with their electric and gas service providers. There is also a national web site that lists energy efficiency programs called Desire. 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. They are described below.

* + [Texas Sales Tax Exemptions for Water Related Equipment with Application](https://www.twdb.texas.gov/conservation/municipal/commercial-institutional/doc/SalesTaxExemption.pdf) (A sales tax exemption was created in 2001, to encourage water conservation.)
  + [Application for Water Conservation Initiatives Property Tax Exemption](http://www.window.state.tx.us/taxinfo/taxforms/50-270.pdf) (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](https://www.twdb.texas.gov/conservation/municipal/commercial-institutional/doc/WastewatertaxExemption.pdf)

**Codes, Standards, and Rating Systems**

In Texas, two plumbing codes are allowed to be used as the basis for local adoption by cities and local jurisdictions. These are the International Associations of Plumbing and Mechanical Official’s (IAPMO) Uniform Plumbing Code (UPC) and the International Code Council’s International Plumbing Code (IPC). 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.

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.

A side-by-side of all of these codes, standards and rating systems can be found on the Maximum Performance web site 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 and often make local amendments. Therefore, the above sites may contain more up-to-date information.

**Chapter 5: Implementation, Scope, and Scheduling**

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.

Utility Implementation Plan

For the utility, the following steps are needed to develop and implement a water conservation program for their CI customers:

1. 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, submetering 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.
2. 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.
3. 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.

1. 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.
2. Program Development: Stakeholder input will significantly benefit the development of the program. 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.
3. Implementation:The final step is implementation. The reader is referred to the municipal best management practices for additional input.

Commercial and Institutional Implementation Plan

Developing a water conservation program at the facility level is a multi-phase process. The first steps to take are to ask what the goals are. 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, labor costs, and needs associated with operations that 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).

**Chapter 6: Best Management Practices and Procedures to Reduce Water Use**

In this section the following practices and activities are described. It is important to realize that no two facilities are alike. The technical and economic feasibility of each activity will need to be examined on a case by case basis. In this chapter, the following practices and activities are described and the determination of economic feasibility, the benefits and impacts on other resources, and related topics, are identified.

1. Metering, Monitoring, and Measurement
2. Plumbing Fixtures, Fittings, and Equipment
3. Food Service Operations
4. Laundry Operations
5. Water Treatment
6. Laboratory and Medical Facilities
7. Cooling Towers, Boilers, and Other Thermodynamic Operations
8. Swimming Pools, Spas, and Fountains
9. Vehicle Washes
10. Landscape Practices
11. Alternate Sources of Water

Commercial and institutional operations use water in a variety of ways. Table3 illustrates some of the more common water uses found in these various sectors. This chapter contains best management practices and activities for the commercial and institutional sectors to reduce water use and cut operating costs.

1. **Metering, Monitoring, and Measurement**

The axiom of “if you don’t measure it, you can’t management” is very true. Perhaps no area in the water utility and the facility management arenas is undergoing more fundamental change. Currently, most utility meters must be manually read and readings are typically done only once a month for billing purposes. Automatic Meter Reading is a newer system where the utility operator simply needs to drive by the meter and electronically download the information, but again this is typically only done once a month. Few smaller commercial and institutional facilities have access to the information except when a bill comes. Likewise, the one meter serves all of the purposes for which water is used. Some cities do require separate irrigation and sometimes cooling tower makeup meters, but again, most of these meters have required that they be manually read.

This old way of metering is undergoing significant change. For water utilities, a new technology called Advanced Metering Infrastructure (AMI) is being adopted and will, based on water industry experts, become common place in the next two decades. It provides for meters to be read remotely and can be set to provide these readings in a near-real-time manner. This allows for the utility to monitor use and help customers identify when leaks or other anomalies occur. Current systems typically can provide hourly water use readings is desired and even shorter intervals where needed. Many utilities are making provisions to provide this information on a real-time basis to the customer if desired.

The second revolution is the use of the customer’s on-site meters to measure and manage use. This includes sub meters for major water using activities and for separate buildings on a campus served by one water utility meter. Following the trend for energy monitoring, these meters are also being connected to central monitoring sites along with the energy monitoring systems such as a “dashboard” or similar monitoring devices. These systems provide real time information to the facility manager and help them manage utility costs.

One major water waste that they can help control are leaks and water losses of all types. As discussed in section 2., leaks in distribution systems loose significant amounts of water and American Water Works Association studies show that residential leaks account for approximately 12 percent of residential use, but that approximately only 10 percent of the homes accounted for over half of the volume lost through leaks. (W. DeOreo, P. Mayer, E. Caldwell, B. Gauley, J. Kiefer, B. Dziegielewsk- Some Key Results from REUWS2 - Single Family Residential End Uses of Water Study Update - Water Research Foundation Project 4309 Presented at WaterSmart Innovations 2014 – presentation 2014-T-1458, <http://watersmartinnovations.com/sessions/2014>). Leaks are a significant problem for commercial and institutional users alike and the new metering and monitoring technologies offer a way to significantly reduce these losses by timely identification.

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 m2).
* 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).
* Cold water make-up to water heating boilers of more than 500,000 Btuh
* Cold water make-up to steam boilers that draw more than 100,000 gallons annually or having a capacity greater than 500,000 Btuh
* Make-up water to closed loop hydronic, chilled water greater than 50 tons or hot water recirculation system used for space heating (500,000 Btuh)
* 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 m2).
* A makeup water supply to a swimming pool.
* The makeup water supply to an evaporative cooler having an air flow exceeding 30,000 cubic feet per minute (ft3/min) (14,158.2 L/s).
* Any single-use or equipment that consumes more than 20 percent of the total water use at a facility or does not produce wastewater
* Car washes, aquariums or equivalent projects within a building using more than 1,000 gpd
* Aquaculture and fish research facilities and systems using more than 500 gallons of potable water per day
* All green roof systems or roof spray systems regardless of the water source.

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 sub meters 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.

1. **Plumbing Including Fixtures, Fittings, and Equipment**

Plumbing fixtures, fittings and appurtenances, and related equipment includes the following:

* Water closets of all types used to remove human waste,
* Urinals of all types used to remove human liquid waste,
* All sink, handwashing, and indoor faucets of all types,
* Showers,
* Bathtubs,
* Bidets ,
* Wash fountains,
* All trap primers,
* Pumps, and
* Pressure reducing valves.

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. However, newer codes contain some slightly more efficient types of fixture volumes. Again, this is a guide as to what should be or is recommended to be used. The user must though keep in mind that they must choose fixtures and fittings that comply with State and local codes.

Table 4 follows the TCEQ 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 4. 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/flusha |
| Water closets - flush valve | 1.28 gallons/flush(1.6 gpf in remote locations)c |
| Urinals | 0.5 gallons/flushb |
| 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. | |

**Water Closets (toilets)**

There are five major types of water closets (toilets) available on the American market. These are:

1. Gravity toilets – Toilets commonly found in homes, restaurants and smaller businesses. They have a water reservoir (toilet tank) that supplies water to the bowl by gravity.
2. Dual flush toilets – These toilets are capable of using a smaller volume of water when only liquid waste is flushed and full flush when solid waste is present too.
3. Pressure assist toilets – These have a pressure tank located inside what is typically the toilet tank. They work off of pressure supplied by the water supply.
4. Vacuum assist tank type toilets – These work using a combination of a gravity flush assisted by a vacuum created as water exits a special container in the toilet tank thus creating a vacuum.
5. Flushometer or flush valve toilets – These are the most common type of toilet found in commercial and institutional settings. A valve attached to the toilet by a pipe of about two inches in diameter (depending on the model) is attached directly to the water supply.

Current TCEQ regulations require that water closets use no more than 1.28 gallons per flush. The US Environmental Protection Agency’s Water Sense Program lists over 2,200 models of toilets available in the United States that have passed a “Maximum Performance” test to prove that the fixture will flush well. This means that, unlike when the 1.6 gpf standards were promulgated in the early 1990.s, these fixtures have been proven to perform well. All must pass 350 grams of simulated human waste, well above normal use conditions. A listing of test results for almost every combination of toilet and flush valve can be found on the MaP web site at <http://www.map-testing.com/>.

Flushometer-valve include both diaphragm and piston type valves. Both work well, but piston valves tend to have closer tolerances in operation. Typically they produce a flush which is within plus or minus 5 percent of that stated while diagraph flush volumes can vary more by 15 percent or more. The user is encouraged to discuss the two types of valves with the vendor to determine which will work best in their application. A discussion of flushometer toilets can be found on the US EPA web site at: http://www3.epa.gov/watersense/products/flushometer-valve-toilets.html

Water closets with flush-o-meter valve or tank-type toilets shall have a flow rate no greater than 1.28 gallons per flush (gpf). It is recommended that all toilet fixtures should be rated for 1,000 grams or 1.28 gpf as certified by the latest Maximum Performance Test. The web site referenced above list over 300 valve and bowl combinations of which over 200 are rated at 1,000 grams of more and another 100 are rated at 800 grams to 1,000 grams.

Flush valves, if not properly maintained can be huge water wasters. Diaphragms, as they become old, tend to not close as quickly as they should. Many will recognize the symptom of the 20 second flush. Piston valves have O-rings for sealing that also need to be maintained. At peak flow, flushometer toilets can flow at 20 gallons a minute! In fact timing the time for a flush cycle to occur can help determine both what volume the toilet is flushing at and if repair in needed. The following can be used to determine both the type of toilet flushometer volume is being used by the toilet and if repair is needed

* + 1-3 seconds 1.28 to 1.6 gal/flush
  + 2-3.5 seconds 1.6 gal/flush
  + 4-5 seconds 3.5 gal/flush
  + Over 5 seconds over gal/flush, or the diaphragm needs replacing.

For example, if a 1.28 gpf toilet takes five seconds to flush, either the valve needs maintenance or in the case of diaphragm valves, the wrong diaphragm may have been used. In fact “**diaphragm confusion**” is a major cause of water waste. A urinal diaphragm flushing at 0.5 gpf will also fit a 5.0 gpf valve and vice versa. There are many examples of 1.28 or 1.6 gpf flushometer diaphragms being replaced with 3.5 or 5.0 gpf diaphragms by mistake turning a 1.28 gpf toilet into a water waster. Piston valves cannot be so easily confused. For this reason, some facilities now specify piston valves.

Flush Urinals

Flush urinals shall have a flow rate no greater than 0.5 gpf based on TCEQ regulations. However, 0.25 gpf urinals and one pint per flush urinals are also available. Older urinals have used between 1.0 and 1.5 gpf for years, so this measure offers significant savings.

Non-potable water may be used for flushing in new buildings in compliance with plumbing codes and/or ordinances as applicable.

Non-water Urinals

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. Both major plumbing codes recommend that 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 Kitchen Faucets

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.

For three compartment sink faucets used primarily for filling the sink, specially designed pot filler valves are sometimes used. They are designed to have higher flow rates that faucets with aerators. Many restaurant and food service operators remove aerators from three compartment sinks since they need to fill the sink or large pots quickly. This common practice should only be used where filling of the sink or vessels is the primary function. However, this very common practice does not meet code.

Lavatory Faucets

The most important component of a lavatory faucet is the aerator. Aerators, and laminar flow restrictors for hospital use, are what controls the volume of water that a faucet produces. If an aerator has been removed or the flow restrictor removed, the faucet will flow at 3 gpm to 6 gpm depending on design and line pressure. Maintenance of aerators is a ***VERY KEY*** element of any water efficiency program.

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.

Faucets in public lavatories shall be fitted with aerators that have a flow rate no greater than 0.5 gpm where the pressure is greater than 25 psi. Lavatory faucets in public restrooms shall be self‐closing or shall be equipped with automatic shut‐off devices.

Signage requesting that leaks and other plumbing problems be promptly reported to the appropriate building management authority shall be placed in each restroom, locker room, kitchen, laundry, pool and other high water-use area. The signage shall be labeled with a phone number to report such problems.

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 m2). For each increment of 1,800 square inches (1.161 m2) 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.

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. …shall have self-closing valves?

Emergency Safety Showers and Eye Wash Stations

Emergency safety showers and emergency eye wash stations should not be limited in their water supply flow rates.

Water Supplied Trap Primers

The p-traps in floor drains in public restrooms and commercial kitchens should have water in them at all times to ensure that a seal between the space and sewer is maintained. If this water seal dries out, sewer gasses will enter the space. IN older facilities, it was common practice to have a small usually copper tube run to the drain in the floor. This pipe was attached to a faucet with an air gap and left to run continuously, thus wasting significant volumes of water. Only a table spoon of water a day is needed to replace evaporative loss and therefore maintain the seal in most traps. The faucet type primers have been band from code for decades and should be replaced if found.

The primary types of primers available today include:

* Flush activated primers that are connected to a flush valve usually for a water closet. When the toilet is flushed, a very small volume of water is discharged through a tube into the drain.
* Pressure activated primers sense a pressure change such as when a toilet or urinal is flushed. When this occurs, a valve allows a very small volume of water is discharged through a tube into the drain.
* Electronic systems that are set to activate usually once a day and are some of the most water conservative types of drain primers.
* Lavatory P-trap primers are simply drain tubes that connect to the p-trap of a lavatory in the restroom. When one washes their hands or runs water, a “dribble of water” that would normally be discharged directly to the sewer is diverted and flows by gravity to the floor drain. Although these are the most water efficient, many have reported that the tubes tend to clog easily requiring maintenance.

The following table summarizes the types of primers available on the market.

|  |  |  |
| --- | --- | --- |
| **Common Floor Drain Primer Technologies** | | |
| **Primer Type** | **Actuations per Day** | **Water Use** |
| **Continuous** | **Continuous** | ***Extremely High!***  ***These do not meet code.*** |
| **Flush-activated** | **Depends on Flush Valve Use** | **Very Low** |
| **Pressure-Sensitive** | **Depends on Fixture Use** | **Very Low** |
| **Electronic** | **1** | **Very, Very Low** |
| **P-trap Primer** | **Depends on Fixture Use** | **0** |

Floor drain seals made of rubber like materials are now approved to help retard evaporation. These are effective in reducing evaporation from floor drain p-traps. Facilities can take advantage of this to reduce the volumes of water needed. However, codes still requires a water seal to protect the health and safety of the users.

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. 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 be kept in proper working order to accomplish this. One specific type of backflow preventer is the reduced pressure zone device (RPZ). By IAPMO 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.

1. **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

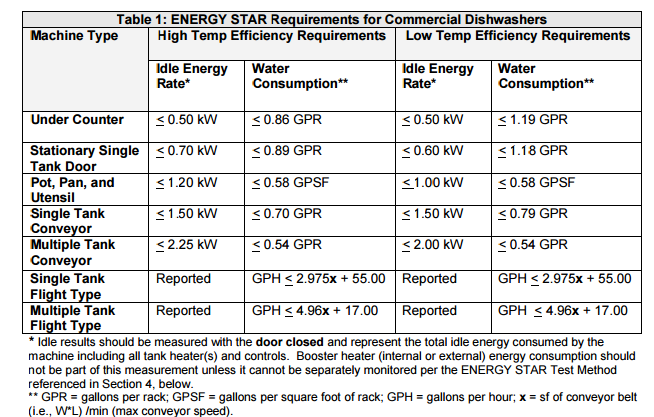
All kitchens must clean plates, pots, pans, utensils, and equipment used in the preparation of food. The following lists equipment commonly found in scullery operations and provides guidance for their purchase and use.

1. Commercial Pre-Rinse Spray Valves: 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. Once the U.S. Environmental Protection Agency's WaterSense program issues its guidance on pre-rinse spray valves, WaterSense flow rates should replace those recommended in this section.
2. 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. Both heat and chemical sanitizing type machines. Heat sanitizing machines heat the final rinse water to 180oF to sanitize the dishes while chemical sanitizing equipment uses chorine chemicals.

There are four basic types of machines. These include:

1. **Under-counter type.** Under-counter type equipment is generally heat sanitized and is found in mainly in bars and very small restaurants serving under 60 meals a day.
2. **Door or hood type.** Door or hood type equipment is primarily found in restaurants that serving fewer than 150 meals a day. Dishes are placed in racks typically 20 inches by 20 inches in size. However, racks for dishes, glasses and cups, cooking utensils and other configurations are available. Both heat and chemical sanitizing equipment is available.
3. **Conveyor-type.** The C-Line or conveyor-type machine is designed for food service facilities serving over 150 customers. This machine pulls the racks through at a rate that is set by the operator. Conveyor speed is a major factor in how much water the equipment uses per rack,
4. **Flight-type.**  Flight-type machines are designed for large operations such as hospitals, large hotels, prisons, and other facilities serving thousands of people. Dishes and other utensils are placed on a continuously moving conveyor with many “fingers” to hold the items being washed. This equipment is very expensive and should only be used in large facilities.

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 recommends the following:



https://www.energystar.gov/ia/partners/product\_specs/program\_reqs/Commercial\_Dishwasher\_Program\_Requirements.pdf



Another equally important consideration is the selection and operation of the dish washer. The capacity of the machine must be matched to the washing load expected by the facility. If too large of a machine is chosen, both lease or purchase price is wasted as are water and energy. The vendor or lessor can help with selection. The above efficiency standards and the water use stated by both the US EPA and other sources such as the National Sanitation Federation International and other sites are for ware washers set properly, operating at the shortest dwell – (wash) time and set at the proper pressure. In practice, settings for dwell time are longer, nozzles ware, and higher than recommended pressure settings are all too common. This leads to water waste and energy loss. Operators should be aware of how to properly set pressure and understand the functions of the equipment. Most machines will work well at 20 psi to 25 psi. Choosing the chemical formulation for the machines is another way to reduce water use. The vendor can be of assistance in this regard.

Rack type dishwashers typically are limited to use in institutional and commercial settings where a large number of people are fed. The U.S. Environmental Protection Agency has stated that they plan to rate such equipment in the future. In the interim, it is recommended that flight type machines use no more than 170 gallons per hour as specified by the manufacturer for single width machines. In all cases, fill and dump warewashing equipment should not be used.

1. Disposal for Food Waste: In recent years, all have realized that food wastes are actually "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.

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 6 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 6. Summary of Four Waste Disposal Methods | | | | |
| Parameter | **Grinder** | **Mechanical Strainers** | **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 Efficiency Standards for State Buildings and Institutions of Higher Education Facilities](http://www.seco.cpa.state.tx.us/tbec/docs/SECO_Water_Standards.pdf) and several national "green plumbing" codes, the following recommendations are made:

1. If applicable, manual scraping and scrapping baskets should be used instead of garbage grinders and disposals.
2. All garbage disposals should be air-cooled.
3. Manual pre-wash units should have shut-off valves that turn water off when nozzle is not in operation.
4. All garbage food waste grinders' (disposals) water flow rates should not exceed the minimum water flow rate specified by the manufacturer. A flow restrictor shall be installed on the water supply to limit the water flow rate to the minimum flow as specified by the manufacturer.
5. 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.
6. Pulpers and mechanical strainer systems shall have potable water flow rates that do not exceed 2.0 gallons per minute.

Cooking Equipment

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

One major development by the latest Uniform Plumbing Code is that steamers and combination ovens, including boiler type DO NOT need to be equipped with tempering water capability. This helps reduce water use substantially. Note that various jurisdictions use either the Uniform or International code as a basis for local codes. Always check with the jurisdiction having authority.

1. 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. 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 140oF. 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. The recommendations for steamers are as follows:
   1. Use a boilerless steamer wherever possible. Most institutional facilities can use boilerless steamers.
   2. Boilerless steamers should not use more than 2.0 gallons of water per hour per pan.
   3. Boiler type steamers should not use more than 5.0 gallons of water per hour per pan.

All Boiler type steamers shall consume not more than 1.5 gallons per pan per hour.

1. Combination Ovens: Combination ovens, as the name implies, can cook in several modes including baking, broiling, and steaming or a combination of the three. Combination ovens should not use more than 3.5 gallons of water an hour.

Combination ovens shall 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 shall not exceed a half a gallon per hour per oven cavity. When operating in the steamer mode, combination ovens shall use no more than 1.5 gallons per hour per pan.

1. 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. 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.
2. 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 necessary, it should be connected to a chilled water or cooling tower loop.

Once through cooling is discouraged in the use of water cooled ice machines. 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.

Even at a combined water and sewer cost of $2.50 per thousand gallons, water and wastewater costs far outweigh the energy savings for making ice with water cooled machine. Table 7 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. Average water and sewer cost for the six largest cities in Texas is over $9.00 per thousand gallons. This means that air cooled ice making equipment is always much less costly to operate that water cooled equipment with once through (pass through) cooling.

|  |  |  |  |
| --- | --- | --- | --- |
| Table 7. 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 with Water Cooled Equipment at 10 Cents per kWh*.***  (Cents/100 Pounds) | **Net Savings per 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

Other Equipment

1. 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.
2. Grease Interceptors: Grease interceptor maintenance procedures shall not include post-pumping/cleaning refill using potable water. Refill shall be by connected appliance accumulated discharge only.
3. Dipper Well Faucets:Where dipper wells are installed, the water supply to a dipper well shall have a shutoff valve and flow control. The flow of water into a dipper well shall be limited by at least one of the following methods:
4. Water flow shall 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 shall 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 shall be the maximum amount of water that the fixture can hold before water flows into the drain.
5. The volume of water dispensed into a dipper well in each activation cycle of a self-closing fixture fitting shall not exceed the water capacity of the dipper well, and the maximum flow shall not exceed 2.2 gpm (0.14 L/s) at a supply pressure of 60 psi (414 kPa).

Dipper wells shall be equipped with flow restrictors and shall have a flow rate no greater than 0.2 gpm.

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](http://www.watermiser.com/) 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](http://www.sustainablefoodservice.com/cat/fog.htm) handling best practices.
* Serve water to guests only on request.

1. **Laundry Operations**

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

* Self-Service (coin or card operated) laundry equipment found in facilities such as laundromats, dorms, self-serve hotel laundry rooms, and apartments.
* 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.
* 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. For single load self-service equipment, the U.S. Environmental Protection Agency Energy Star program recommends a Water Factor (WF) of 4.5 gallons per load of clothes per cubic foot of capacity and an Energy Factor (EF) of 2.2 cubic feet per kilowatt-hour (kWh) per load. Many laundromats now have multi-load equipment able to wash more than the standard 20 pounds of laundry per load. Equipment meeting a WF of 4.5 or less is available. At a minimum, a WF of 5.5 or less is recommended. 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 4.5 or less.

**Retrofit of a Hotel Laundry System**

A hotel in Austin, Texas installed an ozone system for its laundry with four 275 pound washer-extractors. The systems savings, based on metered water use was reduced by 25 percent. The system cost was $32,325 and the savings in water and wastewater costs was estimated to be $39,500. The ozone system also reduced both energy and chemical use. The payback was less than one year. In addition, the peak day savings was 9,744 gallons. Based on this, the water conservation rebate was $9,744 making the payback slightly over two thirds of a year.

On-Premise laundry equipment 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. It is imperative that the facility work with their laundry chemical vendor to select 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.

Industrial laundries 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. Clothes washers that have double dump valves and equipment of 150 pounds capacity or greater shall be equipped so that the final rinse water can be reused in the first flush wash.

One of the most important considerations is the selection of the vendor of chemicals and the settings for the on-premise and industrial laundries.

Lint capture systems should use dry capture or wet systems that minimize water use by only using reclaimed or other on-site water sources.

**Retrofit of a Hotel Laundry System in San Antonio, Texas for Recycle**

A 475 room hotel in San Antonio retrofitted its laundry systems by installing a high efficiency, 240 pound washer and an extractor/recycler system that recycles a portion of the final rinse water for the first wash cycle. Water System, the hotel’s in-house laundry facility was transformed through a series of modifications and retrofits, reducing its overall water consumption by 65 percent.

Retrofitting from older washer models to high-efficiency machines reduced water consumption by 45 percent. Averaging seven loads per day at 240 pounds per load, the hotel laundry facility also took advantage of installing a new high efficiency washer and a extractor/recycler equipment, which recycles a portion of the final rinse water for use in the first wash cycle. This method gave the facility extra water savings of another 20 percent, with total water consumption reduced by 65 percent. Westin’s water usage dropped from 2.82 gallons per pound of laundry to 0.99 gallons per pound.

Estimated water savings are 2.24 million gallons a year. The project cost was $79,967 and rebate was $27,563. Annual energy, water and wastewater savings are estimated to be $19,893 for a payback of 2.6 years.

Water Recycle, Reuse, and Ozone Addition

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.

1. **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 8 shows examples of water treatment used in commercial and institutional operations.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Table 8. Examples of Water Treatment | | | | | | | | |
| Operation | Sediment Filtration | Activated. 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.

1. 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.

1. 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 shall be by demand initiation. Water softeners shall 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 shall 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.
2. 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.
3. Distillation systems for water purification should have at least an 85 percent recovery rate for distillated water and not be cooled by once-through-cooling.
4. All other treatment devices 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.
5. **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:

1. Vacuum systems
2. Sterilizers
3. Instrument and glassware washers
4. Vivariums
5. Exhaust hood scrubbers
6. Large frame X-ray film developers
7. Water treatment equipment to produce ultra-pure water
8. 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.

1. 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.

1. 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 sterilizers shall be equipped with a mechanical vacuum instead of a Venturi-type vacuum that uses water.

Sterilizers shall be installed with a re-circulating cooling system or the condensate shall be recovered for other on-site uses.

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:

1. Installing water tempering devices (since 2000 most all systems contain these devices).
2. Using a chilled water loop to cool the condensate prior to discharge.
3. Install sterilizers with self-contained boilers that return all steam jacket condensate.
4. Capture waste heat for other uses.
5. Returning the steam jacket condensate to the high purity boiler.

Vacuum Sterilizer Systems:

1. Eliminate the use of venturi type vacuum systems.
2. Use dry vacuum pumps and systems for all non-medical vacuum needs.
3. For medical sterilizers, use liquid ring vacuum systems until dry vacuum systems are approved for use.
4. 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 new 2012 Draft for the U.S. Green Building Council's LEED report recommends that washer-disinfectors use no more than 0.35 gallons of water per standard U.S. instrument tray.

1. 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*.*

1. 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.

Dry hood scrubber systems shall be used where applicable.

Perchlorate and fume hood wash-down systems shall be installed with self-closing valves.

1. 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.

1. 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 is 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 management practices discussed in that section.

1. 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.

1. **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 VRV 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.

Steam condensate return systems shall be installed for all steam boilers.

Steam boilers shall be fitted with blowdown heat exchangers to transfer heat to feed water. Where heat recovery can be used beneficially to heat boiler make-up water or for other purposes, boiler blowdown from steam boilers exceeding 15 psi and 3.4 million BTU’s per hour (100 HP) shall be directed to a heat recovery system that reduces the temperature of the blowdown discharge to below 140 degrees Fahrenheit without using tempering water.

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 shall 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 shall be mediated by conductivity or basin water temperature-based controllers.
* Systems with continuous blowdown/bleedoff, and systems with timer-only mediated blowdown management, shall not be used.
* Cooling systems shall 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 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.

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, microbial growth, biocide, and corrosion inhibitor levels.

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

1. 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.
2. 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.
3. Install automated chemical feed systems or treatment equipment. These systems minimize water and chemical use while protecting against scale, corrosion, and biological growth.
4. 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.
5. 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.
6. A biocide shall be used to treat the cooling system recirculation water where the recycled water may come in contact with employees or members of the public.
7. The U.S. Green Building Council's draft 2012 LEED report for new buildings recommends the following maximum concentration parameters for cooling tower water quality.

**Using LEED to Promote Efficiency in Two Office Buildings**

Two large existing office buildings in Houston, Texas obtained LEED Gold Certification under the existing building criteria as part of major renovations. This included major plumbing retrofits, cooling tower water treatment improvements, sub-metering of water use for better control, and landscape irrigation systems renovations. The two buildings were able to reduce water use by 30 percent to 45 percent respectively.

|  |  |
| --- | --- |
| Table 9. 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.

1. **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.
7. 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 loose even more water to evaporation as the following table illustrates.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Table 10. 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, Cedarburg, WI

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.

1. 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.

1. 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.

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.

The operation of any of these filter devices will determine how much water is needed for filter operations. Dirt in the air, pool use, water quality, and other factors all impact when a filter must be backwashed or cleaned. For most filter operations, cartridge and coated media filters use less water, but that factor is dependent on the operator. The following figure compares water use with different filter types for a hypothetical case. The graph represents relative water use characteristics.

1. 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.

1. 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.

1. 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.

STANDARDS FOR SPECIAL WATER FEATURES

1. Water used for start-up and make-up water in new ornamental fountains or other new ornamental water features shall be supplied by alternate water sources or municipally reclaimed water. If alternate on-site sources of water or municipally reclaimed water are not available within 500 feet of the building project site, potable water is allowed to be used for water features with less than 10,000 gallon capacity.

2. New ornamental fountains or other new ornamental water features shall be equipped with meters and leak detection devices that shut water feature off if a leak greater than one gallon per hour is discovered.

3. New ornamental fountains or other new ornamental water features shall be installed with a re-circulating system.

1. **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

Deionizing equipment shall be used for water softening instead of reverse osmosis treatment.

* 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

In bay and conveyor car and large vehicle wash facilities shall be provided with equipment to recycle and reuse at least 50 percent of the water recirculated for washing the vehicles.

Reject water shall be piped to a reclamation system and used for pre-soak, undercarriage, and/or initial wash.

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

Conveyor and drive‐through type washes shall use no more than 15 gallons of make-up water per vehicle washed for automobiles, pickup trucks and small vans and shall have water recirculation systems.

Conveyor and drive-through type washes shall have a flow rate no greater than 40 gallons per vehicle washed for buses and tractor-trailer rigs.

* 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.

1. **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)

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 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

In 2011 the Texas Legislature passed , House Bill 1073, Senate Bill 1073, and House Bill 3391directs that:

1. Financial institutions may consider making loans for developments that will use harvested rainwater as the sole source of water supply.
2. New state buildings with a roof measuring at least 10,000 square feet must incorporate an on-site reclaimed system into its design.
3. 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.

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.

TCEQ regulations for reclaimed water (treated municipal effluent) and for gray water (water from shower, bath tub, hand washing lavatories, and laundry water only) are found in 30 TAC 210. Water quality criteria for reclaimed water is summarized in Table 12 and summarized in Table 13 for gray water.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Table 12. TCEQ Chapter 210 Water Quality Requirements for Reclaimed Water | | | | |
| Parameter | **Comments** | **Type I** | **Type II without pond** | **Type II with pond** |
| **BOD5 or CBOD5** | Mg/l – 5 day biochemical oxygen demand for carbonaceous BOD | 5 | 20 BOD or 15 CCOD | 30 |
| **Turbidity** | NTU – nephelometric turbidity units | 3 | n/a | n/a |
| **Fecal Coliform (E. Coli)** | CFU/100 ml – 30 day geometric mean | 20 | 200 | 200 |
| **Fecal Coliform (E. Coli)** | CFU/100 ml – maximum single grab sample | 75 | <800 | <800 |
| **Enterococci** | CFU/100 ml – 30 day geometric mean | 4 | 35 | 35 |
| **Enterococci** | CFU/100 ml – maximum single grab sample | 9 | 89 | 89 |

|  |  |  |  |
| --- | --- | --- | --- |
| Table 13. TCEQ Chapter 210 Water Quality Requirements for Gray Water | | | |
| Parameter | **Comments** | **Units Applied Where Public Has Access** | **Units Applied Where Public Not Present** |
| **Fecal Coliform (E. Coli)** | CFU/100 ml – 30 day geometric mean | <20 | <200 |
| **Fecal Coliform (E. Coli)** | CFU/100 ml – maximum single grab sample | <200 | <800 |

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

* International Association of Plumbing and Mechanical Officials (IPMO) Green Plumbing and Mechanical Code Supplement, 2012
* International Association of Plumbing and Mechanical Officials (IPMO) Green International Code Council (ICC), International Green Constriction Code, 2012
* 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 14 summarizes some of the water quality characteristics that the various sources may have.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Table 14. 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** 2. **Medium level and may need additional treatment depending on end use** 3. **High concentrations are possible and additional treatment likely**   **? 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 15 summarizes treatment methods that may be employed for various end uses of these sources.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Table 15. 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.

**XI. Rainwater Harvesting**

1. Structures connected to the public water supply and containing a rainwater harvesting system for indoor use shall comply with 30 Tex. Admin. Code § 290(d) and all local requirements.

2. An economic feasibility study shall be conducted to assess whether harvesting and delivery can be accomplished through gravity drainage or pumping, or if rainwater would need to be treated before reuse, as well as any other cost impact.

3. Monthly rainfall rates and expected run-off capture shall be analyzed to size the catchment area and the storage capacity to meet water demand through the longest expected interval without rain. Reference: TWDB’s The Texas Manual on Rainwater Harvesting, Third Edition, Chapter 4: Water Balance and System Sizing to determine storage capacity and Appendix B: Rainfall Data for average precipitation rates.

4. Plumbing and installation guidance for installing a rainwater harvesting system can be found in “Rainwater Catchment Design and Installation Standards”, from the American Rainwater Catchment System Association and the American Society of Plumbing Engineers.

**XII. Reclaimed Water, Recycled Water and Reuse**

1. On‐site reclaimed, recycled and reuse water systems shall be designed, installed and implemented according to 30 Tex. Admin. Code § 210 and shall comply with local requirements.

2. On‐site graywater reuse systems shall be designed, installed and implemented according to 30 Tex. Admin. Code § 285 (h), and shall comply with local requirements.

**Chapter 7: Determination on Other Resources**

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 a number of organizations and governmental agencies that have excellent resources available on their web sites. Examples of these web sites include:

* H2O Conserve - [*www.h2oconserve.org*](http://www.h2oconserve.org/)
* Water – Use it Wisely - [*http://www.wateruseitwisely.com/*](http://www.wateruseitwisely.com/)
* Food Service Technology Center - [*www.fishnick.com*](http://www.fishnick.com/)
* Consortium for Energy Efficiency - [*www.cee-1.org*](http://www.cee-1.org/)
* Bureau of Reclamation - Water Conservation - *http://www.usbr.gov/waterconservation/*
* Arizona Department of Water Resources - [*www.azwater.gov/conservation*](http://www.azwater.gov/conservation)
* Food Service Technology Center - [*www.fishnick.com*](http://www.fishnick.com/)
* Consortium for Energy Efficiency - [*www.cee-1.org*](http://www.cee-1.org/)
* Bureau of Reclamation - Water Conservation - *http://www.usbr.gov/waterconservation/*
* Alliance for Water Efficiency - [*www.allianceforwaterefficiency.org*](http://www.allianceforwaterefficiency.org/)
* EPA Water Sense and Energy Star Programs - [*www.epa.gov/watersense*](http://www.epa.gov/watersense)[*www.energystar.gov*](http://www.energystar.gov/)
* California Urban Water Conservation Council - [*www.cuwcc.org*](http://www.cuwcc.org/)
* Texas Water Development Board - [www.twdb.state.tx.us](http://www.twdb.state.tx.us/)
* Texas Commission on Environmental Quality -*www.tceq.state.tx.us/*
* [**Save** Texas Water](http://www.savetexaswater.org/) - *www.savetexaswater.org/*
* [Texas Water Foundation](http://www.google.com/url?sa=t&rct=j&q=texas%20water%20foundation&source=web&cd=1&sqi=2&ved=0CF4QFjAA&url=http%3A%2F%2Fwww.texaswater.org%2F&ei=Z5e_T4OdHrKHsAKBucDtCQ&usg=AFQjCNEfZMxhd0RQ0EDZLtuWi3oIdDzr-Q) - *www.texaswater.org/*
* Conserve Florida Water Clearinghouse - http://www.conservefloridawater.org/

Professional organizations can also provide assistance. Examples include:

* American Society for Healthcare Engineering (ASHE)
* 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](http://www.twdb.state.tx.us/conservation/municipal/commercial-institutional/doc/SalesTaxExemption.pdf) (A sales tax exemption was created in 2001, to encourage water conservation.)
* [Application for Water Conservation Initiatives Property Tax Exemption](http://www.window.state.tx.us/taxinfo/taxforms/50-270.pdf) (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](http://www.twdb.state.tx.us/conservation/municipal/commercial-institutional/doc/WastewatertaxExemption.pdf)

**Chapter 8: 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.

***CI (Institutional and Commercial l)*** are non-residential customers. Commercial customers range from car washes to hotels and restaurants, and institutional customers include schools, hospitals, and governmental buildings.

***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.

**Chapter 9: References for Additional Information**

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3. American Water Works Association, Commercial and Institutional End Uses of Water, AWWA Research Foundation, 6666 West Quincy Avenue, Denver Colorado, 80235, 2000
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* 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
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