California
Department of Water Resources

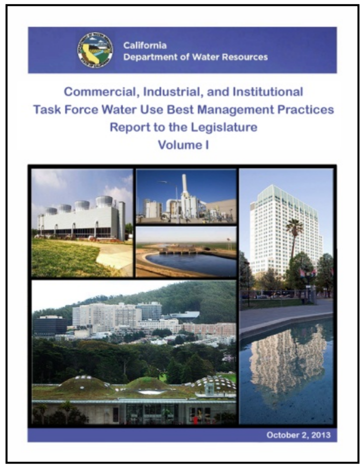
Commercial, Industrial, and Institutional Task Force Water Use Best Management Practices Report to the Legislature Volume II

October 21, 2013

This report to the Legislature pursuant to Section 10608.43 of the California Water Code is displayed in two volumes for the reader's convenience.

Navigating Through this Report

Targeted to the general public, the legislature, and other policy makers and managers



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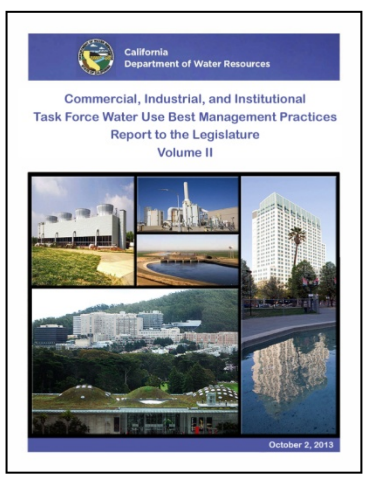

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State of California
The Natural Resources Agency
Department of Water Resources
Division of Statewide Integrated Water Management
Water Use and Efficiency Branch

Commercial, Industrial, and Institutional Task Force Best Management Practices Report to the Legislature VOLUME II

A report to the Legislature pursuant to Section 10608.43 of the California Water Code

October 21, 2013

Edmund G. Brown Jr.	**John Laird**	**Mark W. Cowin**
Governor	Secretary for Natural Resources	Director
State of California	The Natural Resources Agency	Department of Water Resources

Copies of this report are available from:

State of California
Department of Water Resources
P. O. Box 942836
Sacramento, CA 94236-0001

This report is also available on the Water Use and Efficiency web site at: http://www.water.ca.gov/wateruseefficiency/sb7/committees/urban/u1/

State of California
Edmund G. Brown Jr., Governor

California Natural Resources Agency
John Laird, Secretary for Natural Resources

Department of Water Resources
Mark W. Cowin, Director

Laura King Moon, Chief Deputy Director

Gary Bardini
Deputy Director

Carl Torgenson
Deputy Director

John Pacheco
Acting Deputy Director

Katherine S. Kishaba
Deputy Director

Paul Helliker
Deputy Director

Cathy Crothers, Chief Counsel

Nancy Vogel, Assistant Director, Public Affairs Office

This report was prepared under the direction of

Division of Statewide Integrated Water Management
Kamyar Guivetchi, Chief

By

Water Use and Efficiency Branch
Manucher Alemi, Chief

And

Kent Frame, Program Manager II

Assisted by

Spencer Kenner, Assistant Chief Counsel
Rich Mills, Senior Engineer, WR
Jim Lin, Senior Engineer, WR
Martin Berbach, Staff Land and Water Use Scientist
Michael Ross, Engineer, WR
Toni Pezzetti, Engineering Geologist
Sabrina Cook, Environmental Scientist
Andria Avila, Office Technician
Guyla McCurry, Office Assistant

In consultation with members of the

California Urban Water Conservation Council

Assisted by

Chris Brown, Executive Director
Luke Sires, Project Manager
Keir Keightley, Project Manager
Angela Anderson, Project Manager
Elizabeth Betancourt, Project Manager
Marci Flores, Administrative Assistant

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- Richard Bennett, Consultant
- Bill Hoffman, Consultant
- Bill Jacoby, Consultant
- John Koeller, Consultant
- Ken Mirvas, Technical Writer
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The Task Force members and alternates who participated in the development of this report are as follows:

Mr. Manucher Alemi (vice chair)	DWR	Sacramento, CA
Alt: Mr. Kent Frame	*DWR*	*Sacramento, CA*
Mr. David Arrieta	DNA Associates	Sacramento, CA
Mr. Dave Bolland	Association of California Water Agencies	Sacramento, CA
Alt: Mark Rentz	Association of California Water Agencies	Sacramento, CA
Mr Chris Brown (vice chair)	CUWCC	Sacramento, CA
Mr. Ray Cardwell	Contra Costa Water District	Concord, CA
Alt: Mr. Chris Dundon	Contra Costa Water District	Concord, CA
Ms. Heather Cooley	Pacific Institute	Oakland, CA
Alt: Ms. Lucy Allen	Pacific Institute	Oakland, CA
Mr. Dan Cunningham	Metal Finishing Association of CA	Torrance, CA
Mr. Jerry Desmond, Jr.	Plumbing Manufacturers International	Sacramento, CA
Alt: Len Swatkowski	Plumbing Manufacturers International	Rolling Meadow, IL
Ms. Jan Marie Ennenga	Manufacturers Council of the Central Valley	Modesto, CA
Alt: Tim Ruby	Del Monte Foods	Walnut Creek, CA
Mr. Don Fisher	Fisher Nickel Inc., Food Service Tech.	San Ramon, CA
Alt: Mr. Amin Delagah	Fisher Nickel Inc.	Ramon, CA
Ms. Jenny Gain, P.E., QSD	California Urban Water Agencies	Walnut Creek, CA
Alt: Ms. Penny Falcon	Los Angeles Dept. of Water and Power	Los Angeles, CA
Mr. Mark Gentili	Los Angeles Dept. of Water and Power	Los Angeles, CA
Alt: Mr. Enrique Silva	Los Angeles Dept. of Water and Power	Los Angeles, CA
Mr. Richard Harris	East Bay Municipal Utility District	Oakland, CA
Alt: Mr. Charles Bohlig	East Bay Municipal Utility District	Oakland, CA
Mr. Jack Hawks	California Water Association	San Francisco, CA
Mr. Joe Hess	Genentech	Oceanside, CA
Ms. Trudi Hughes	California League of Food Processors	Sacramento, CA
Alt: Mr. Rob Neenan	California League of Food Processors	Sacramento, CA
Lt Col Jeremy N. Jungreis	USMCR	Camp Pendleton, CA
Alt: Mr. Paul Boughman	USMC Western Area Counsel Office	Camp Pendleton, CA
Ms. Randi Knott	California Hotel and Lodging Association	Sacramento, CA
Alt: Mr. Lynn Mohrfeld	California Hotel and Lodging Association	Sacramento, CA
Ms. Patti Krebs (dec.)	Industrial Environment Association	San Diego, CA
Mr. Ken Letwin	BP America	Carson, CA
Alt: Mr. Scott Hawley	BP America	Carson, CA
Mr. Mike McCullough	Northern California Golf Association	Pebble Beach, CA
Mr. Bill McDonnell	Metropolitan Water District of Southern CA	Los Angeles, CA
Mr. Jim Metropulos	Sierra Club	Sacramento, CA
Mr. Mike Mielke	Silicon Valley Leadership Group	San Jose, CA
Mr. Mike Pimentel	Rain Bird Corporation	Azusa, CA
Ms. Tracy Quinn	Natural Resources Defense Council	Santa Monica, CA
Alt: Mr. Ed Osann	Natural Resources Defense Council	Santa Monica, CA
Ms. Toby Roy (Task Force Chair)	San Diego County Water Authority	San Diego, CA
Alt: Ms. Maria Mariscal	San Diego County Water Authority	San Diego, CA
Mr. Tat-Yuen (Jacky) Sang	Bayer Health Care	Berkeley, CA
Mr. Patrick Silvestri	CA Soc. for Healthcare Engineering, Inc.	Ontario, CA
Mr. Dave Smith	WateReuse California	Sacramento, CA
Alt: Ms. Elise Goldman	West Basin Municipal Water District	Carson, CA
Mr. Carlo Tarantola	California School Employees Association	Citrus Heights, CA
Alt: Ms. Sharon Furlong	California School Employees Association	Citrus Heights, CA

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ACWA	Association of California Water Agencies
af	acre feet
af/yr	acre-feet per year
ANSI	American National Standards Institute
APN	Assessor's Parcel Number
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
ASME	American Society of Mechanical Engineers
ASSE	American Society of Sanitary Engineering
ASTM	American Society for Testing and Materials
AWWA	American Water Works Association
B/C	Benefit/cost analyses
BAT	best available technology
BCC	best classification code
BMPs	best management practices
CBSC	California Building Standards Commission
CC	cycles of concentration
ccf	hundred cubic feet
CDCR	California Department of Corrections and Rehabilitation
CDPH	California Department of Public Health
CEC	California Energy Commission
CEE	Consortium for Energy Efficiency
CEQA	California Environmental Quality Act
CIP	clean in place
CII	commercial, industrial and institutional
CIWQS	California Integrated Water Quality System
CLCA	California Landscape Contractors Association
COP	clean out of place
CPUC	California Public Utilities Commission
CUWA	California Urban Water Agencies
CUWCC	California Urban Water Conservation Council
CWC	California Water Code
DE	diatomaceous earth
DI	deionization
DOF	Department of Finance
DWR	Department of Water Resources (State of California)
DX	direct expansion
EBMUD	East Bay Municipal Utility District
EO	executive order
EPAct	Federal Energy Policy Act
ET	evaporation-transpiration
FEMP	Federal Energy Management Program

GAMA	groundwater ambient monitoring and assessment
GBI	Green Globes' Green Build Initiative
GDP	gross domestic product
gpcd	gallons per capita per day
gpm	gallons per minute
gpv	gallons per vehicle
HCD	Department of Housing and Community Development (California)
HEUs	High-efficiency urinals
HVAC	Heating, ventilating, and air conditioning
IAPMO	International Association of Plumbing and Mechanical Officials
ICA	International Carwash Association
ICC	International Code Council
IPC	International Plumbing Code
IRR	Internal Rate of Return
IRWMP	Integrated regional water management plan
IWIP	Illinois Water Inventory Program
kWh	Kilowatt-hour
LEED	Leadership in Energy and Environmental Design
maf	million acre feet
mcf	thousand cubic feet
MEF	modified energy factor
mgd	million gallons per day
M&I	municipal and industrial
MAWA	maximum applied water allowance
MMWD	Marin Municipal Water District
MS4	small municipal separate storm sewer system permits
MWELO	Model Water Efficient Landscape Ordinance
NAICS	North American Industrial Classification System
NEPA	National Environmental Policy Act
NF	nanofiltration
NGOs	Non-governmental Organizations
NPDES	National Pollutant Discharge Elimination System
NPV	net present value
NSF	National Sanitation Federation
OPL	on-premise laundries
PBMP	Potential Best Management Practice
PCB	Printed circuit board
PG&E	Pacific Gas & Electric Company
psi	pounds per square inch
PRSV	Pre-rinse spray valve
PWSS	Public Water System Statistics Survey
RO	reverse osmosis
ROI	return on investment
RWQCB	Regional Water Quality Control Board (California)

SB	Senate Bill
SIC	standard industrial classification
SWRCB	State Water Resources Control Board (California)
TDS	total dissolved solids
TWDB	Texas Water Development Board
UPC	Uniform Plumbing Code
USEPA	U.S. Environmental Protection Agency
USGS	U. S. Geological Survey
UV	ultraviolet
UWMP	urban water management plan
WF	water factor
WPU	Water Plan Update
WRDA	Water Resources Development Act

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1.0 Introduction

This report, *Commercial, Industrial, and Institutional Task Force Water Use Best Management Practices Report to the Legislature*, identifies specific best management practices (BMPs) and actions to support the commercial, industrial, and institutional (CII) sector's efforts to improve water use efficiency and support California's water supply sustainability. It is intended to provide the CII sectors with information on water-saving technologies and applicable BMPs.

This report is intended for use as a resource for:

- Existing and new businesses, facilities, and institutions.
- Developers, consultants, and designers.
- Water service providers.
- Planning agencies.
- Policy makers.

"Fortunately, there are numerous cost-effective strategies that can be applied to achieve significant water savings in the CII sector. Estimates indicate that this potential ranges between 710,000 and 1.3 million acre-feet per year."

(Quote from Making Every Drop Work: Increasing Water Efficiency in California's Commercial, Industrial, and Institutional (CII) Sectors 2009 NRDC. Efficiency estimate based on 2003 Pacific Institute analysis in Waste Not, Want Not: The Potential for Urban Water Conservation in California.)

Since technology and practices change over time, the information in this report is intended and recommended to be updated periodically.

This report provides the CII sector to capture the multiple benefits of reduced costs for water, energy, wastewater, and onsite water and wastewater treatment facilities. Water efficient landscape BMPs are also included because outdoor water use may represent a significant percentage of CII water use.

Recommendations include BMPs, actions for implementation, metrics and the use of alternate water sources for certain applications.

1.1 Background and History

The CII sector is fundamental to California's economy and structure. It employs residents, provides goods and services, and maintains the state's position as a center for technology and innovation. Though California's economy has grown, the water used in the state has remained generally consistent (see Figure 1.1). Increasing water use efficiency is critical to growing and protecting the state's economy and to reduce pressures on California's water resources and environmental health.

Growing population, climate change, and the need to protect and grow California's economy, while protecting and restoring our fish and wildlife habitats, make it essential that the state manage its water resources as efficiently as possible.

The California Department of Finance (DOF) estimates that California's population will continue to grow from 37 million people (2010 census), surpassing 40 million by 2020 and 50 million in 2050. The 2009 California

Water Plan Update (Update 2009) addressed the variability of population, water demand patterns, environmental patterns, climate, and other factors that affect water use and supply. Incorporating consideration of uncertainty, risk, and sustainability, Update 2009 estimates that in 2050, urban sector water use will be between 1.5 and 10 million acre-feet per higher than the 2009 annual use.

To address increasing demands on the State's water supply, Governor Schwarzenegger issued an executive order in February of 2008 that called for a 20 percent reduction of per capita water use in the urban sector by 2020. In November 2009, Senate Bill (SB) X7-7 (Steinberg) made that order a state law by amending the California Water Code (CWC). This report meets one of the requirements of this law.

> Future increases in air temperature, shifts in precipitation patterns, and rising sea level could affect California's water supply by changing how much water is available, when it is available, and how it is used (DWR Climate Change Effects, Update 2009).

SB X7-7 recognizes that:

- Reduced water use through conservation achieves significant energy and environmental benefits and can help protect water quality, improve stream flows, and reduce greenhouse gas emissions.
- Diverse regional water supply portfolios will increase water supply reliability and reduce dependence on the Sacramento - San Joaquin Delta.
- The success of state and local water conservation programs to increase efficiency of water use is best determined on the basis of measurable outcomes related to water use or efficiency.

SB X7-7 contains specific actions requiring water conservation, measurement, and reporting activities for urban and agricultural water suppliers. One of the SB X7-7 actions directs the Department of Water Resources (DWR), in coordination with the California Urban Water Conservation Council (CUWCC) to "convene a Task Force consisting of academic experts, urban retail water suppliers, environmental organizations, commercial, industrial, and institutional water users to develop alternative best management practices for the commercial, industrial, and institutional water users" (CWC10608.43).

The CII Task Force was also directed to assess the potential statewide water use efficiency improvements in CII sectors that would result from implementation of the alternative BMPs. The CII Task Force, in conjunction with DWR, was ordered to submit a report to the Legislature by April 1, 2012.

The CUWCC played a key role in the CII Task Force formation and implementation. The CUWCC is a non-governmental organization created in 1991 by urban water agencies and environmental groups. The CUWCC was created to "increase efficient water use statewide through partnerships among urban water agencies, public interest organizations, and private entities." The CUWCC's goal is to integrate urban water conservation BMPs into the planning and management of California's water resources. It has adopted water use BMPs that its 389 member agencies have agreed to implement.

1.2 Scope of the Commercial, Industrial, and Institutional Task Force

The scope of the CII Task Force is defined by statute §10608.43 as outlined below. It was tasked with:

- Developing alternative BMPs for CII businesses and an assessment of the potential statewide water use efficiency improvement in the CII sectors that would result from implementation of these BMPs.

- Conducting a review of multiple sectors within CII businesses and recommended water use efficiency standards for CII businesses among the various water use sectors.
- Developing appropriate metrics for evaluating CII water use.
- Evaluating water demands for manufacturing processes, goods, and cooling.
- Evaluating public infrastructure necessary for delivery of recycled water to the CII sectors.
- Assessing the institutional and economic barriers to increased recycled water use within the CII sectors.
- Identifying of the technical feasibility and cost and benefit of the BMPs to achieve more efficient water use statewide in the CII sectors that is consistent with the public interest and reflects past investments in water use efficiency.

1.3 CII Task Force Members, Meetings, and Report

DWR and the CUWCC project management team assembled the CII Task Force to develop BMPs, metrics, recommendations, and this report to the legislature. The Task Force consisted of key CII leaders with strong expertise in water-related issues, representing "academic experts, urban retail water suppliers, environmental organizations, commercial water users, industrial water users, and institutional water users," as specified in the CWC §10608.43. CII Task Force members were invited to participate or were recommended. Participation was voluntary and, in several cases, a member or alternate served only once because of scheduling conflicts.

At the CII Task Forces initial meeting in March 2011, subcommittees were formed to review, assess, and develop new BMPs, as necessary. The subcommittees included:

- Food and Beverages - Trudi Hughes/California League of Food Processors, chair
- High Tech - Mike Mielke/Silicon Valley Leadership Group, chair
- Commercial Landscape - Mike Pimentel/Rain Bird, chair
- Metrics – Jeremy Jungreis/US Marine Corp Reserve, chair
- Petroleum Refining and Chemicals – Ken Letwin/British Petroleum, chair
- Water Recycling – Dave Smith/WateReuse, chair

Subcommittees were comprised of CII Task Force members and non-member subject matter experts with interest and expertise in the subcommittee topic. Subcommittees met regularly to implement the BMP mission and prepare relevant portions of the Task Force Report. Subcommittee actions and status were reported at each CII Task Force meeting.

Agendas were posted ten days prior to meetings on the CUWCC's CII Task Force and on the DWR's Water Use Efficiency websites.[1] Meetings of the CII Task Force were open to the public and were subject to the Bagley Keene 2004 Open Meeting Act. The public and other interested parties were given an opportunity to comment throughout the process.

The Task Force members provided technical information, reviewed technical material and documents, and provided comments, data, and supporting information to the DWR and CUWCC project management team which prepared

[1] http://www.cuwcc.org/2column.aspx?id=16620 and www.wateruseefficiency/sb7

this report as stipulated under the CWC §10608.43. The recommendations in this report reflect a consensus of the Task Force members.

The CUWCC and their contractors, under the direction of DWR, drafted the initial documents for the first draft of this report. DWR then assembled and edited the first and subsequent drafts.

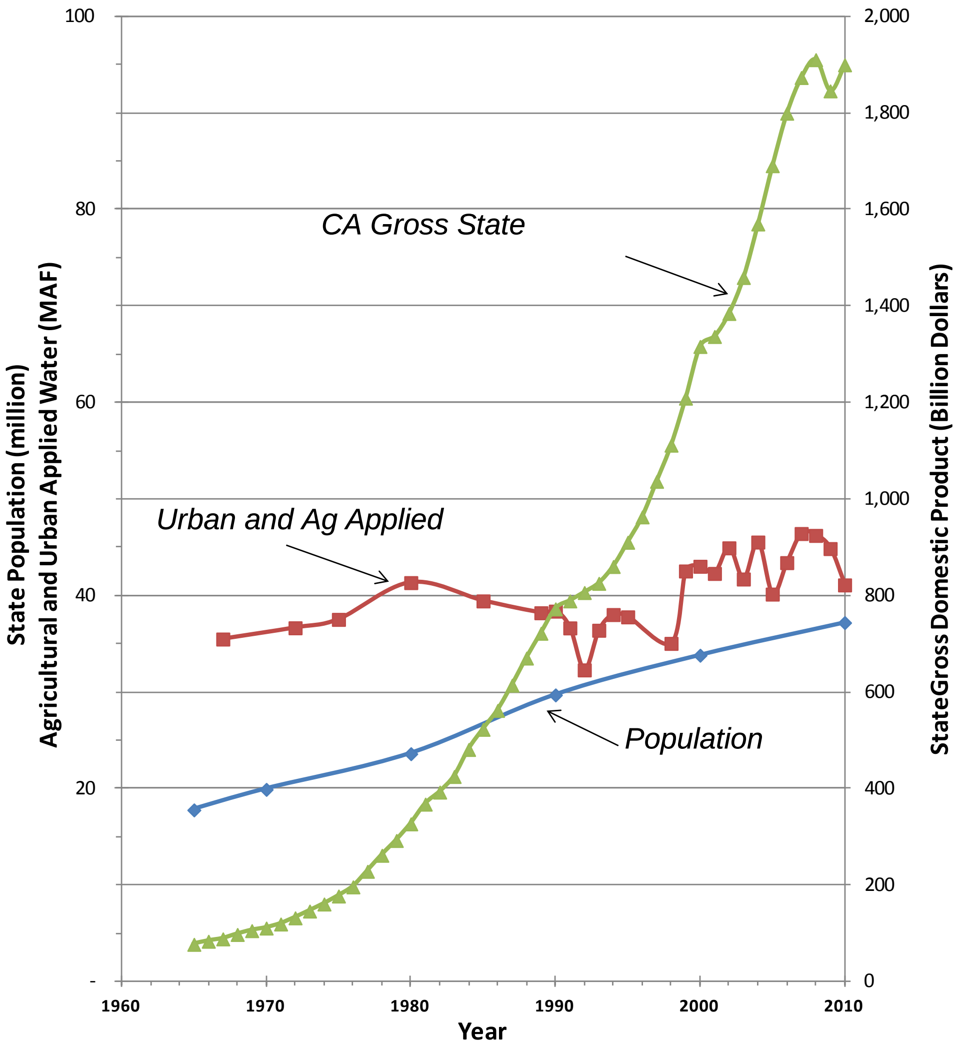

Figure 1.1 - California Population, Gross Domestic Product (GDP) and Water Use Comparison.

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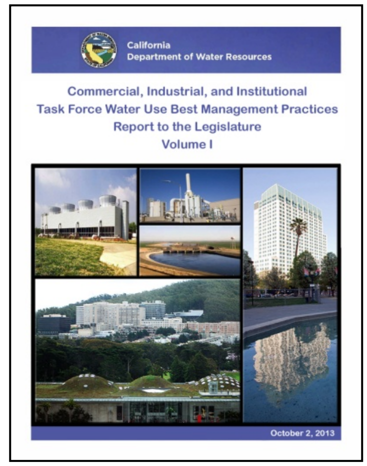
2.0 Report Organization

This report is organized on multiple levels to support its use for diverse purposes. It provides a general overview for those interested in the commercial, industrial, and institutional (CII) best management practices (BMPs) concepts, as well as detail for those implementing them. Recommendations also include the use of alternate water sources for certain applications, and many of the BMPs can be applied to other business types not specifically addressed herein.

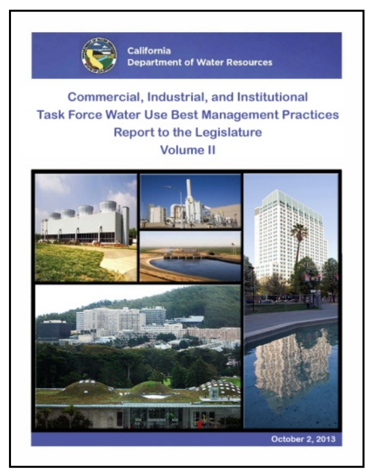


This report includes the following:

- **Executive Summary** – Report highlights.
- **Volume I: A Summary** – This volume contains summary of the in-depth information provided in Volume II. The targeted audience for Volume I is the general public, the legislature, and other policy makers and managers.
- **Volume II: Recommendations, BMPs, and Technical Background –** This volume contains the fully-developed, technical report prepared by the CII Task Force team and the full recommendations of the CII Task Force. Volume II also includes the report appendices, which contain supplemental information, the glossary, case studies, and references. This volume is targeted to those who would implement the BMPs and are interested in a more technical discussion.

For the reader's convenience, this report is displayed in two volumes. Volume I provides a summary of the material presented in greater detail in Volume II, which includes the Appendices and Case Studies.

Both Volumes I and II are prepared as stand-alone documents; however, references and appendices are only included in Volume II. Each volume contains the same sections, but the technical sections are only briefly summarized in Volume I.



The introductory sections are the first four sections of each volume. They are the same in both volumes except for references, and provide information critical to any reader of this report. The introductory sections include:

1.0 Introduction
2.0 Report Organization
3.0 Current Water Use and Demand in the Urban Sector
4.0 Recommendation Summary

The technical sections (Sections 5.0 through 10.0) follow the introductory sections in both volumes. However, the level of detail in the technical sections differs between the two volumes. In Volume I, each section is a brief summary of the more detailed information contained in Volume II. The technical sections are:

5.0 Water Use Metrics and Data Collection
6.0 Technical and Financial Feasibility of Implementing the BMPs
7.0 Commercial, Industrial, and Institutional Sector BMPs

8.0 Standards and Codes for Water Use Efficiency
9.0 Public Infrastructure Needs for Recycled Water
10.0 Evaluation of Institutional and Economic Barriers to Municipal Recycled Water Use

The BMPs are the highlight and focus of the CII Task Force Report. They are presented in three locations:

- Volume I – A brief overview of how the BMPs were developed and what BMPs are included
- Volume II – A fully developed, detailed discussion of each BMP, including relevant information for implementation.
- Appendix A – A BMP list and description only, without background information.

A glossary of terms is included in Appendix B. Selected case studies describing water savings efforts currently being implemented in California are in Appendix C. These, and each of the other appendices, are located in Volume II.

3.0 Current Water Use and Demand in the Urban Sector

California's water demands have begun to reach and, in some circumstances, exceed the available water supply. Although the State has a vast supply of water resources, competing demands from agricultural, residential, commercial, industrial, and institutional (CII) businesses, and the environment are placing a strain on that supply. Yet water is vital in California, as this state is the 8th largest economy in the world and the most populous state in the nation, with 37 million residents according to the 2010 census.

DWR estimates that the CII sector accounts for approximately 30%, or roughly 2.6 million acre-feet (maf), of total urban water use in California (Update 2009).

The 2009 California Water Plan Update (Update 2009) estimated that the annual average water demand is 33.2 million acre feet (maf) for the agricultural sector and 8.8 maf for the urban sector based on the average uses during the 1998 to 2005 time period (Update 2009). Long-term variability (1967 to 2010) in these annual demands is shown in Figure 1.1. These estimates do not include additional state developed water that is allocated, mitigated, legislated, designated, or otherwise used to support the environment.

The Update 2009 estimated that the CII sectors use approximately 30 percent, or roughly 2.6 maf[2], of total urban water use. Figure 3.1 shows how CII water use relates to California's overall water use, excluding environmental use, as well as the proportion of the three components of CII water use measured by the WPU 2009 – industrial, commercial and institutional, and large landscape (golf courses, parks, etc.).

Reductions in CII water use would contribute to the urban sector meeting its 2020 targets. Water conservation and efficiency benefits the CII sector by reducing costs as well as physical, regulatory, and reputational water-related risks.

The CII sector obtains water from numerous sources, including:

- Delivered water from external suppliers, including both surface and groundwater supplies.
- Self-supplied water, primarily groundwater.
- Municipal recycled water, supplied from an external supplier.

In addition, the CII sector frequently internally reuses its process water to maximize water supply benefits. This internal reuse has not been quantified because such practices may involve proprietary information.

[2] This number does not include self – supply, but does include recycled water.

Seawater, or saline water, is an additional source of water supply available to some coastal CII facilities providing an estimated 14.5 maf primarily to the mining and steam electric power plants sectors (USGS 2009). Saline water use is not included in the Update 2009, as illustrated in Figure 3.1. Figure 3.2 shows the total estimated CII annual water sources and use, considering both saline and freshwater use.

Reductions in CII water use would contribute to the urban sector meeting its 2020 targets. Conservation and efficiency benefits the CII sector by reducing costs as well as physical, regulatory, and reputational water-related risks.

Within the CII Task Force Report, BMPs are generally considered applicable to any CII water sources, with the exception of municipal recycled water. Because of the uniqueness of municipal recycled water relative to the ranges of water quality and its dependence on the local supplier, as well as infrastructure and process issues, recycled water is addressed separately in Chapters 9.0 and 10.0 of this report.

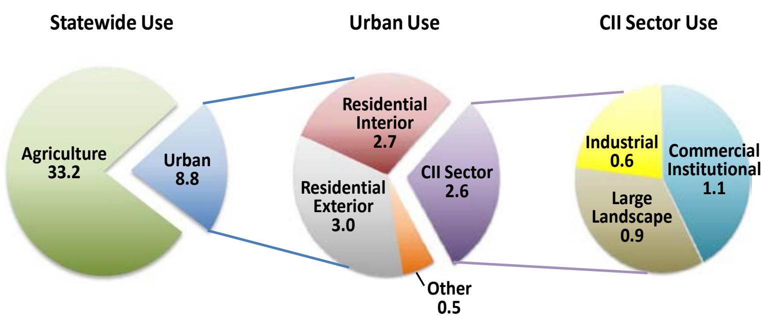


Figure 3.1 Volumetric Breakdown of California Non-Environmental Developed Water Use

Note: Based on 1998-2005 CWP averages. Volumes shown are in millions of acre-feet per year.

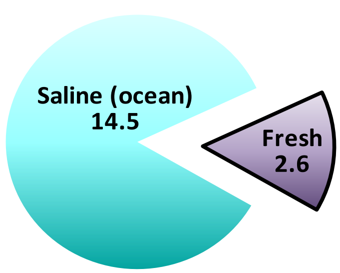


Figure 3.2 Sources of CII Water in California

4.0 Task Force Recommended Actions Summary

This report explores a range of issues associated with water use and efficiency opportunities within the CII sector and recommendations including:

- Best Management Practices (BMPs)
- Best Available Technology (BAT)
- Recommendations for actions
- Metrics for evaluating water use
- Recycled water and alternative supplies

> The "Task Force Recommended Actions Summary" section of this report provides direction on how noted tasks can be accomplished, plus a list of potential recommended legislative actions and next steps.

The recommendations found in this report provides direction, procedures or actions to formalize and assure implementation, verify and report on implementation, and adopt changes as practices and technologies improve. Recommendations also include next steps and a list of potential legislative actions.

The Task Force, furthermore, recommended that throughout the BMP implementation process, participation by the state legislature, state agencies, industry groups, CII businesses, water service providers, wastewater agencies, environmental groups, and other stakeholders should be included.

While stakeholders in the implementation process have been identified, their continued support and specific roles must be confirmed. An assessment of the resources needed for implementation must be completed and sources of additional support, both financial and technical, must be defined. The implementation process should include state legislation, regulations, and stakeholder buy-in. Also, a mechanism for verification of progress will need to be defined, implemented, and monitored.

Throughout the implementation process it is important to remember that each CII site is unique and needs to be treated as such. Accordingly, the approaches to implementing BMPs, determining metrics, the technical feasibility, and cost-effectiveness need to consider that uniqueness. Finally, water use comparisons between various business sectors or between individual customers may not be helpful in determining metrics and selecting benchmarks, and are best applied within an individual business or customer due to unique site-specific characteristics.

The following discussion summarizes actions that can be implemented regarding metrics, the technical and financial feasibility of implementation, BMPs and recycled water. Specific BMPs and recommendations for metrics and recycled water can be found in the corresponding sections of Volumes I and II.

4.1 Metrics and Measuring Progress

The purpose of this section is to provide a conceptual understanding and approach to establish appropriate metrics for evaluating water use, efficiency, and productivity in the CII sectors, and to identify the savings potential from implementation of the CII BMPs in California. The usefulness and feasibility of metrics are tied to the availability and reliability of data. This section summarizes objectives and introduces the need for consistent and reliable water use data collection, reporting, and monitoring. Volume I, Section 5.0 Metrics summarizes Volume II Section 5.0 and includes recommendations, while Volume II contains the full discussion and recommendations.

> The applicability and feasibility of metrics are tied to the availability, consistency, and reliability of data collection, reporting, and performance monitoring.

It should be noted, however, that water use metrics require further evaluation, especially for the industrial sector.

The objectives identified for water use metrics and data collection include:

Metrics:

- **Providing a framework** for understanding water use metrics and their applications.
- **Discussing who uses** metrics and why.
- **Presenting criteria** for selecting appropriate metrics.
- **Providing examples** of metrics in use and potential new metrics.
- **Providing recommendations** to improve the use of metrics that will encourage water use efficiency and demonstrate the effectiveness of BMP implementation.

Data Collection and Reporting:

- **Providing context** perspectives to address CII water use data collection and reporting at the water service provider and state level.
- **Providing recommendations** to evaluate options for data collection and reporting across end use, water service provider, subsector, state, and sector levels.

4.2 Technical, Financial Feasibility and Potential Water Use Efficiency Improvements for BMPs and Audits

The Legislature called upon the CII Task Force to develop “an assessment of the potential statewide water use efficiency improvement in the commercial, industrial, and institutional sectors that would result from implementation of these best management practices” (CWC Section 10608.43). A statewide assessment was challenging, as described in this section, but examples of water savings accomplished in specific applications are presented in this section along with an approach based on penetration rate for a BMP.

Finally, water audits have been found to be effective in assisting managers of CII entities to identify areas of inefficient water use within facilities and appropriate BMPs to reduce water use. A discussion of audits concludes this section.

> This section is more completely summarized in Section 6.0 of Volume I with a more detailed description in Section 6.0 of Volume II and begins with CII Task Force recommendations.

Recommendations

The CII Task Force has the following recommendations based on the background information provided in Section 6.0 of Volume I and II.

- CII entities should perform water audits to identify opportunities for implementation of BMPs.
- Following audits, CII entities should evaluate the technical and financial feasibility of BMPs to determine whether to implement BMPs.
- Water and energy service providers should incorporate water audits into their efficiency programs, consider financial incentives for BMP implementation, and provide other technical assistance as appropriate.
- Organizations representing businesses and industry, water service providers, CUWCC, and DWR should educate CII businesses on the BMPs and approaches to doing audits and performing a cost-effectiveness analysis.
- All new water users should consider implementing the recommended BMPs at the time of installation or construction.
- When replacing equipment, CII business should evaluate the equipment and the maintenance and operational practices needed to achieve an industry standard of water use efficiency for the new equipment being purchased.

4.3 Best Management Practices

A wide range of BMPs have been developed that focus on technical advancements and improved management practices that will increase the efficiency of water use in the CII sectors. A detailed discussion on specific BMPs that could be implemented for the various CII sectors and their financial feasibility and potential water efficiency improvements are described in Volume I, Sections 6.0 and 7.0 and Volume II, Sections 6.0 and 7.0 and Appendix A.

> It is recommended that an advisory group or committee be formed to further analyze and make recommendations regarding the development, use, and capture of pertinent metrics and BMPs.

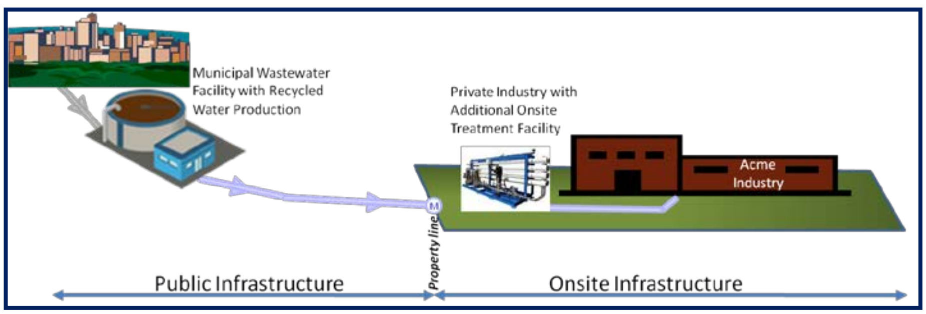
Implementation of the BMPs could be facilitated by all stakeholders doing the following:

- Endorse and adopt a formal process and commit to ongoing support for CII water conservation measures to address issues identified in this report.
- Share and promote the importance of BMP implementation with CII businesses and the general public.
- Conduct state-wide BMP workshops in coordination with industry organizations to implement the recommendations of this report;
- Provide technical and financial assistance and advice to those implementing the BMPs.
- Develop a mechanism for reporting progress that could include:
    - Periodic reports to the Legislature through DWR or other designated entities
    - Inclusion of progress reports in CUWCC reports to the State Water Resources Control Board (SWRCB)
    - Inclusion of progress reports in urban water service supplier Urban Water Management Plans (UWMPs)
- Develop local, sector specific, and state wide approaches to track the success and effectiveness of BMP implementation efforts and water savings results.
- Develop a mechanism to update the CII BMPs as practices and technologies improve.
- Identify assurance mechanisms that recommendations of this report are addressed.

> Water service providers (and energy utilities) should incorporate audits into their efficiency programs, consider financial incentives for BMP implementation, and provide other technical assistance as appropriate.

Financial Feasibility and Potential Water Use Savings for BMPs:

- CII businesses should perform audits to identify opportunities for implementing BMPs. Following audits, they should calculate the cost-effectiveness of various measures, factors such as:
    - Projected water and wastewater cost savings over time
    - Energy savings and changes in operation and maintenance costs including changes in water, wastewater, energy, waste disposal, pre-treatment, chemical, and labor costs
    - Implementation cost
    - Potential incentives available
    - Water supply reliability benefits
- Water service providers (and energy utilities) should incorporate audits into their efficiency programs, consider financial incentives for BMP implementation, and provide other technical assistance as appropriate.



The CUWCC should continue to update their BMPs for water service providers' CII conservation programs and technologies to incorporate the CII BMPs, audits, and cost-effectiveness assessments. All new water users should also consider and re-evaluate implementation of recommended BMPs at the time of equipment installation or construction improvements.

4.4 Recycled Water and Alternative Supplies

Key issues in the CII Task Force Report address how non-potable water sources can be obtained and incorporated into CII applications. These issues are considered in Sections 7.0 (alternate water supplies and specific BMPs), Section 9.0 (infrastructure limitations for obtaining municipal recycled water), and Section 10.0 (barriers and solutions for CII use of municipal recycled water). Overall these recommendations include legislative, financial, regulatory, and operational mechanisms for increasing non-potable water use in CII applications.

The following actions should be taken to encourage more aggressive use of recycled water and alternative water supplies by CII water users:

- Improve regulatory and statutory requirements to overcome barriers to potable and non-potable recycled water use in a manner that is protective of public health and water quality.
- Encourage the California Building Standards Commission (CBSC) to consider national and international codes and to:
  - Periodically update and expand the plumbing code.
  - Address alternative water supplies.
- Encourage financial and technical assistance to increase recycled and alternative water use.

> Overall these recommendations include legislative, financial, regulatory, and operational mechanisms for increasing non-potable water use in CII applications.

The California Energy Commission (CEC) should consider allowing offsets for the use of recycled water at power plants. Under an offset program, where it is not feasible to use recycled water at a power plant, a power plant operator would be allowed to provide funding to expand recycled water at another location.

4.5 Legislative Opportunities

Opportunities for state legislation in assisting in implementation of the CII Task Force BMPs and recommendations include:

- Provide the state with a mechanism and the authority for collecting detailed water use data in the private and public agency sectors for the purpose of tracking the progress of statewide CII sector water use and to implementation of the CII BMPs and recommendations of this report. This information can be reported back to the legislature and used to assist DWR in quantifying urban water use for the California Water Plan Update.
- Provide support and state funding for the implementation of recommendations in this report, including those water conservation programs and recycled water projects with benefits to the state and overcoming financial barriers toward expanded use of recycled water.
- Improve statutory requirements where appropriate to overcome barriers to potable and non-potable recycled water use in a manner that is protective of public health and water quality.
- Promote updates to the plumbing code that encourage alternative water supplies and implementation of cost-effective BMPs.

> Some of the opportunities for State legislation in assisting implementation of the CII Task Force BMPs and other recommendations include: providing additional funding to implement the recommendations of this report, providing authority to collect water use data, and improving statutory requirements to overcome barriers to recycled water.

4.6 Next Steps

To help assure that the work of the CII Task Force benefits the State of California, CII water users, water service providers, wastewater agencies, energy utilities, climate action plans, the environment, CII stakeholders, and others, DWR and CUWCC should:

- Commit to ongoing support for CII water conservation measures.
- Identify a mechanism to ensure that these critical issues are being addressed going forward.
- Develop a mechanism for reporting on progress that could include:
  - Periodic reports to the Legislature through DWR or other designated entities.
  - Inclusion of progress reports in CUWCC reports to the SWRCB.
  - Inclusion of progress reports in urban water supplier UWMPs.
- Ensure a process to address these issues is in place and is initiated by the end of 2014.

5.0 Water Use Metrics and Data Collection

5.1 Preview

The purpose of this section is to provide a conceptual understanding and approach to establish appropriate metrics for evaluating water use, efficiency, and productivity in the Commercial, Institutional, and Industrial (CII) sectors. The usefulness and feasibility of metrics are tied to the availability and reliability of data. This section addresses the need for consistent and reliable water use data collection, reporting, and monitoring.

The Task Force agreed upon the recommendations summarized in this section for the development and use of metrics to evaluate water use and on an approach to improve data collection and reporting in California.

The objectives identified for water use metrics and data collection include:

Metrics:

- Providing a framework for understanding water use metrics and their applications
- Discussing who uses metrics and why
- Presenting criteria for selecting appropriate metrics
- Providing examples of metrics in use and potential new metrics
- Providing recommendations to improve the use of metrics that will encourage water use efficiency and demonstrate the effectiveness of BMP implementation

Data Collection and Reporting:

- Providing context perspectives to address CII water use data collection and reporting at the water service provider and state level.
- Providing recommendations to evaluate options for data collection and reporting across end use, water service provider, subsector, state, and sector levels.

A section outline is provided in Table 5.1.

Table 5.1 - Outline of Section 5

Section No.	Section Title
5.1	**Preview**
5.2	**Recommendations** *5.2.1 Metrics Recommendations* *5.2.2 Data Collection and Reporting Recommendations*
5.3	**Introduction**
5.4	**Overview**
5.5	**Water Use Metrics** *5.5.1 Definition of Metrics* *5.5.2 Metric Values, Benchmarks, and Targets* *5.5.3 Calculation and Terminology of Metrics* *5.5.4 Metadata* *5.5.5 Definitional Noise and Confounding Factors* *5.5.6 Metrics Contexts* *5.5.7 Criteria for Selecting a Metric* *5.5.8 Selecting Appropriate Metrics*
5.6.	**Data Collection and Reporting** *5.6.1 Introduction* *5.6.2 Existing Water Data Collection by Water Service Providers* *5.6.3 Existing Statewide Water Data Reporting to State and Federal Agencies and Nongovernmental Organizations* *5.6.4 Existing Data Reporting in the States* *5.6.5 Potential for Improvement* *5.6.6 Options for Further Study*
5.7	**References**

5.2 Recommendations

The CII Task Force recommends the following steps toward the development and use of metrics to evaluate CII water use, as well as an approach to improve data collection and reporting in California. These recommendations are based on the deliberations of the CII Task Force and the Metrics Subcommittee and information provided by support staff to the Task Force, as documented in this section and associated appendices.

This section does not currently recommend any single metric for use in all CII sectors. Furthermore the CII Task Force cautions against setting regulatory minimum standards for water use efficiency metrics that would be applicable to specific CII establishments, sectors, or subsectors. Even within subsectors, it would be difficult to set uniform standards across CII establishments (defined as individual CII water user sites) because of the variability in the types of products made or services provided and the many confounding factors in how water is used.

5.2.1 Metrics Recommendations

Recommendation 5-1: CII establishments should use metrics to improve and track their water use efficiency over time. Where norms or ranges are available, establishments should compare their metrics to those norms.

Recommendation 5-2: CII associations, water service providers, and the CUWCC, among others, should provide tools, guidance, and training to their constituents and customers on BMPs and the establishment and use of metrics in benchmarking to demonstrate improved water use efficiency over time.

Recommendation 5-3: Organizations such as the U.S. Environmental Protection Agency (through the WaterSense® program) or CUWCC should develop software for voluntary and anonymous water use reporting and trending using an approach similar to Energy Star's® Portfolio Manager. The data developed from these reports can be used to develop norms for CII water use.

> The CII Task Force found there are limited centralized data concerning how much water is used in the CII sectors. Moreover, the data that exist are tracked inconsistently at the local level.

Recommendation 5-4: Manufacturers of equipment and products, CII associations, CII establishments, water and wastewater service providers, and the State should set efficiency standards for certain water use devices and equipment similar to existing device standards for commercial pre-rinse spray valves and clothes washers.

Recommendation 5-5: The CUWCC, water service providers, energy utilities, and CII associations should collect and compile data on market penetration levels for installation of particular devices or practices for which industry or regulatory water use efficiency standards exist.

Recommendation 5-6: DWR should continue to develop appropriate efficiency or productivity metrics for use at the statewide level for CII sector and subsector water use in order to monitor overall progress toward improving water use efficiency. These metrics would not be appropriate for setting standards, comparing sectors, or determining acceptable levels of efficiency.

5.2.2 Data Collection and Reporting Recommendations

Many issues have been identified in metrics data collection and reporting. Some issues can be resolved at the local and state levels by end users, water service providers, governmental agencies, and CII associations to improve the methods of data collection, recording, and reporting. Several options for resolving these issues have substantial support by the Task Force. Nevertheless these options have not been fully researched and representation of the CII community on the Task Force is limited. Thus, these options are described here with the recommendation to move forward with a forum to address the options and develop an implementation plan. More discussion of the options can be found in Section 5.6.6.

The Task Force found that there are limited centralized data available to characterize water use in the CII sectors. Moreover, the existing data are inconsistently tracked at the local level. The following recommendations are intended to improve data classification, collection, and reporting.

Recommendation 5-7: DWR should work with the Association of California Water Agencies (ACWA), CUWCC, California Urban Water Agencies (CUWA), California Public Utilities Commission (CPUC), California Water Association (CWA), and American Water Works Association (AWWA) to develop a full-spectrum, water-centric water use standardized classification system of customer categories. This classification system should include consistent use of North American Industry Classification System (NAICS) codes and assessor's parcel numbers (APNs).

> "Full-spectrum" is a water use classification term denoting the complete range of water uses and users, such that a classification system will have utility across different water planning or management functions at various levels of government and water service providers.

Recommendation 5-8: DWR, in consultation with a stakeholder advisory committee and through a public process, should develop a system and implementation plan for standardized collection of water production, delivery, and use data; for classification; and for reporting and tracking at the user, water service provider, state, and federal levels. One or more of the following options should be considered:

> **Option 5-8.1:** DWR should develop a water-centric water use and user classification system.
>
> **Option 5-8.2:** Water service providers should classify water users using a common classification system and update their customer databases to incorporate this system.
>
> **Option 5-8.3:** Water service providers should consider recording and maintaining key data fields such as APNs for customers. This would enable the linking of water usage data with information from other sources for purposes of metrics, water demand analysis, and demand projections.
>
> **Option 5-8.4:** Water service providers and self-supplied water users meeting defined criteria should be required to report water use to the state.
>
> **Option 5-8.5:** Water service providers, CUWCC, and water users should focus their attention to large landscape irrigation sites to better categorize and separately meter landscape water use and implement the BMP of metering large landscape irrigation sites.

> "Water-centric" is a water use classification term meaning being designed around and central to water uses and users, in contrast to characterizing economic activity, water billing functions, or other factors.

5.3 Introduction

Proper accounting (inventory, tracking, and measurement) of water is necessary to ensure that California's economy, society, and environment have sufficient water to meet their needs. It also is essential to comply with the laws governing water allocation. An adequate supply of water is required in the CII sectors to support a sustainable economy. Cooperation, coordination, and common goals and perspectives must be shared among stakeholders to effectively plan, manage, and use our water. Agreement on how and why we account for water is a necessary first step to achieve that goal.

The most fundamental metric to plan and evaluate water use is total volume of water used over time. Water service providers and state agencies often track these volumes aggregated into several major sectors. While water use trends over time are important, some measure of the efficiency and productivity of water use can guide us to better utilize this limited resource. A common water-use metric, gallons per capita per day (GPCD), is required by the CWC, Division 6, PART 2.55, for setting urban water use targets and measuring progress (compliance measurements) towards meeting those targets. These targets incorporate water use from all of the municipal and industrial sectors, including all of the CII sectors. The Water Code provides an exemption for process water use to ensure that water reductions do not negatively impact the economy, regardless of whether the process water is being used efficiently or not. The legislature's recommendation to develop BMPs is an important step toward increased water use efficiency or productivity of the CII sector.

There are no generally accepted metrics for water use in the CII sector. However, it is widely acknowledged that GPCD might not be illustrative or informative about trends within the CII sectors. This understanding is likely the basis for the CWC requirement that this CII Task Force report include "appropriate metrics for evaluating commercial, industrial, and institutional water use." (CWC §10608.43.)

5.4 Overview

The intent to identify and develop appropriate water use metrics in this report, at any level, is to provide a means to show whether actions at the customer level or policies or laws at the water service provider or state level are effectively improving water use efficiency or productivity in the CII sectors or their subsectors or components.

Acceptable terminology is needed to improve clarity on issues surrounding metrics and their appropriate application. The lack of common definitions has complicated the ability to compile and use data for research and planning. Shared meaning of terms to accomplish this intent is essential. Many terms pertinent to the understanding of use of data and metrics will be presented in this section. The Water Code gives the following definitions specific to the CII sector.

- “Commercial water user” means a water user that provides or distributes a product or service.” (CWC §10608.12(d).)
- “Industrial water user” means “a water user that is primarily a manufacturer or processor of materials as defined by the North American Industry Classification System code sectors 31 to 33, inclusive, or an entity that is a water user primarily engaged in research and development.” (CWC §10608.12(h).)
- “Institutional water user” means “a water user dedicated to public service. This type of user includes, among other users, higher education institutions, schools, courts, churches, hospitals, government facilities, and nonprofit research institutions.” (CWC §10608.12 (i))

These definitions provide the basic and necessary clarity on user types. However, the specific NAICS code sector range designation for “industrial water user” does not include all of the possible industrial uses of water. For example, the following NAICS code sectors are excluded from this sector range: 1) Sector 21--Mining, Quarrying, and Oil and Gas Extraction, and 2) Sector 22—Utilities. As described later in this section, NAICS codes should be assigned to each water user type in a comprehensive manner that includes all water-use sectors. The Water Code states that the above definitions apply “unless the context otherwise requires,” that is, the law allows flexibility to alter definitions where appropriate.

For the purposes of this report, generic definitions will be used without reference to the NAICS codes designations. For example:

“Industrial water user” means a “water user that is primarily a manufacturer or processor of materials.”

An appropriate metric for evaluating water use at any level must start with consistent and feasible data collection. The lessons and techniques learned at the water service provider level could provide models for what may be utilized at the statewide level.

Many water service providers have robust billing systems based on water meter measurements on a monthly or bimonthly basis. A common metric for such data is volume of water per time as given by gallons per month per account. The number of, type of, or size of accounts could be used to normalize or scale the basic ratio metric of gallons per month (volume/time). While many progressive water service providers have robust billing systems that employ detailed customer classifications, they do not follow a statewide standard for CII definitions in classifying customers. Additional effort is needed to standardize customer classifications across water service providers.

5.5 Water Use Metrics

There is growing interest in developing appropriate water use metrics, as demonstrated by a number of recent reports on the topic. For example, the AWWA recently sponsored a guidance report on water conservation measurements metrics (Dziegielewski and Kiefer, 2010), which provides much of the foundation of this section.

5.5.1 Definition of Metrics

Within the context of water use, this report adopts the AWWA guidance report definition of metric:

> "Metric" means a unit of measure (or a parameter being measured) that can be used to assess the rate of water use during a given period of time and at a given level of data aggregation, such as system-wide, sector-wide, customer, or end-use level. Another term for a metric is "performance indicator." (Dziegielewski and Kiefer, 2010).

A metric includes factors such as volume of water use and time and may include other factors such as employment, quantities of manufactured output, or square foot of land or building space.

Metrics often serve one of two basic functions for evaluating water use:

1. A metric that provides a basic quantity of water usage during a period of time.
2. A metric containing a normalizing factor that may be an indicator of efficiency or productivity of water.

The terms "water conservation," "efficiency," and "water use efficiency" are often used when discussing water use metrics. These terms are defined in this report as:

- "Water conservation" means a reduction in water loss, waste, or use.
- "Efficiency" means the ratio of output to input or vice versa.
- "Water use efficiency" means the relation of water-related tasks accomplished with an amount of water, for example, the ratio of input of water to output of a product.

The term "water use efficiency" does not correspond well to aggregate-level metrics because aggregate metrics often reflect the influence of various other determinants of water use, which are unrelated to efficiency-in-use (Dziegielewski and Kiefer, 2010). Therefore, we also refer to productivity of water in this report. However, trend metrics applied to aggregate sectors can show improvements in water use efficiency over time.

5.5.2 Metric Values, Benchmarks and Targets

During the CII Task Force deliberations, the subject of benchmarks and targets received considerable attention. During those discussions there was a lack of commonly understood definition of terms, especially the distinction between “metrics” and “benchmarks” or “targets.” The following definitions, drawn or adapted from the AWWA guidance report (Dziegielewski and Kiefer 2010), are essential to gaining a shared understanding of the terms:

- “Metric value” means a numerical value, either (1) calculated from the mathematical formula for any given metric or (2) assigned to a given metric.
- “Benchmark” means (1) a particular (numerical) value of a metric that denotes a specific level of performance or (2) a current value or beginning (baseline) value of a metric.
- “Target” means a benchmark that indicates a state of achievement expected at some time in the future.

These terms are often used interchangeably, but this can lead to confusion. It is necessary to clarify the different connotations of the words. Targets and benchmarks are not metrics or definitions of a metric; they are numerical values assigned to or derived from metrics. Benchmarks and targets may be used to set water use efficiency goals and measure progress over time. The CII Task Force encourages the use of benchmarks or targets to track progress in water use efficiency or productivity on both the statewide and local levels.

When “benchmark” or “target” is used, its intended meaning must be defined, i.e., as a baseline value, future expected value, or a performance value. Benchmarks or targets are values of the water use metric to which the calculated metric values are intended to be compared. A standard may take the form of a target value of a metric, as 1.28 gallons for a flush of a new toilet. Metrics, benchmarks, and targets can be defined in either absolute or relative terms (Dziegielewski and Kiefer, 2010). For example, in the CWC, Division 6, Part 2.55, the Legislature set a relative water use target for water conservation goals in the form of a percent, i.e., a statewide 20 percent reduction in average annual per capita water use by the year 2020 referenced to a baseline benchmark. For individual water service providers, the specific defined methodologies for calculation of the baseline benchmarks and the 2020 targets constitute the metadata associated with the metric, GPCD.

Similar examples of benchmarks are found at the federal level in connection with Federal Executive Orders (EO) 13423 and 13514. EOs and federal regulations require managers of Department of Defense facilities to achieve a 16 percent reduction in federal institutional water use intensity by 2015. EO 13514 augments those requirements and stipulates that a 26 percent reduction in potable water use be made by the year 2020 and a 20 percent overall reduction in industrial, landscape irrigation, and agricultural water uses be achieved by the year 2020. The metric used is gallons of potable water per year per square foot of gross building area. The baseline is the numeric value of the metric in 2007 and the target is the numeric value of the metric in 2020 (U.S. DOE, 2008).

5.5.3 Calculation and Terminology of Metrics

We must develop clear models and a lexicon to demonstrate why a metric may be appropriate in one application of its use and not in another. In the following section, we offer basic concepts for a metric for application in water use. This involves not only the mathematical models to use, but the attributes (i.e. metadata) associated with a metric or its components.

Metrics can take many forms, from simple to complex. The components which comprise many water use metrics are shown below. The simplest water use metric, called the basic quotient, is calculated as follows:

Equation 5.1

$$Basic\ quotient = \frac{Volume}{Time}, \qquad \left(e.g. \frac{gallons}{day}\right)$$

The basic quotient may stand alone to show trends in total water use. However, to assess the efficiency or productivity of water use, we must apply a scaling factor to the equation. The scaling factor, also called normalizing factor, can take a variety of forms, e.g., general population (per capita), employees, economic output or square feet of building area.

Equation 5.2

$$Scaling\ factor\ (SF) =\ various\ units$$

The most common use of the scaling factor is to relate (i.e., normalize or scale) the basic quotient such that comparisons can be made relative to the scaling factor chosen. The scaling factor becomes the denominator of a water-use efficiency (WUE) or productivity metric equation as shown below:

Equation 5.3

$$WUE\ Metric\ = \frac{Basic\ quotient}{Scaling\ factor} = \frac{\frac{Volume}{Time}}{SF}, \left(e.g. \frac{\frac{gallons}{day}}{capita}\right)$$

With the use of the scaling factor shown above, the basic water use metric is normalized and may become an even more meaningful water use indicator (i.e., metric). A normalized metric can allow comparisons of entities of different sizes or scales or comparisons of a common entity that is changing in scale over time, e.g., population. The reader is directed to Dziegielewski and Kiefer (2010) for a more complete treatise on water use metrics.

5.5.4 Metadata

In any application of a metric, it is necessary to specify or define all of the attributes to ensure consistent data sources, calculation methods, and identification of any limitations on the intended use or application of the metric. It is useful to have terminology to easily describe the complex inter-relationships of the various attributes or factors that have potential in affecting the use of a metric.

"Metadata" is defined as data about data, and in this case metadata are the essential information that is part of the definition of any metric and must be maintained or stated with the value of the metric or its components (e.g., numerator, denominator, and scaling factor) to ensure the proper use or prevent the misuse of the metric. The units of measure; the frequency of measurement; the systematic coding for billing, management, and planning; and a multitude of other related data may act as factors for or against the use of a metric for a particular purpose (e.g., statewide). This multitude of factors or attributes that could have an effect on whether a metric is appropriate can be termed water metric "metadata." Many discussions in both literature and CII Task Force deliberations revolved around the nuances of water use metadata and how it affects the applicability (appropriateness) of any particular metric.

Examples of metadata include volume and the time-value for the basic quotient water-use metric. An example of metadata is whether the volume is the amount of water taken (purchased, pumped, or diverted) by a water service provider, or delivered to a customer. If the scaling factor is population, how are employees, visitors, or residents counted in the population? The nuances of metric metadata are important and play a key role in discovering the limitations associated with a particular water-use data set.

It may seem that metric measures at the statewide level or other aggregated levels should be relatively easy to observe, measure, and track. However, these measurements rely on properly collected and coded water-use activities at the user and water service provider levels regardless of how the water is supplied (e.g., public-supplied or self-supplied). The quality of data may be insufficient for meaningful evaluations without a properly employed water-centric classification system for each and every water user. The methods of data collection and classification become part of the water-use metadata associated with the metric to ensure adequate quality of a metric.

5.5.5 Definitional Noise and Confounding Factors

Common agents that interfere with meaningful metrics are definitional noise and confounding factors:

> "*Definitional noise*" means the inaccuracies in either the numerator or denominator of a metric as a result of different, specific or general,

definitions used for collecting data (adapted from Dziegielewski and Kiefer, 2010).

"*Confounding factor*" means a factor affecting the numeric value of a metric that is not related to the purpose of the metric (adapted from Dziegielewski and Kiefer, 2010).

Definitional noise and confounding factors are "factors" (metadata) affecting water use metrics and may complicate discussions on the subject.

Definitional Noise

An example of definitional noise is the lack of a standardized classification system used by the water industry and water resources managers. The CII sectors referred to in this report are shown in Figure 5.1 along with other sectors comprising the broader and general classification system in common use. The classification of water users served by urban water service providers is primarily linked to categories related to the rate structure for billing customers. The breakdown of water users commonly includes residential, multifamily, CII, large landscape, and agricultural users. Due to agency-specific billing systems, the water service providers do not share common definitions or coding standards when assigning a customer to one of the sectors. For example, establishments such as laundries may be classified as industrial rather than commercial. Multifamily establishments may be classified as residential or commercial. Depending on ownership or legal identity, large landscape customers may be classified as commercial or institutional (e.g., commercial, such as a privately owned golf course or institutional, such as a city park).

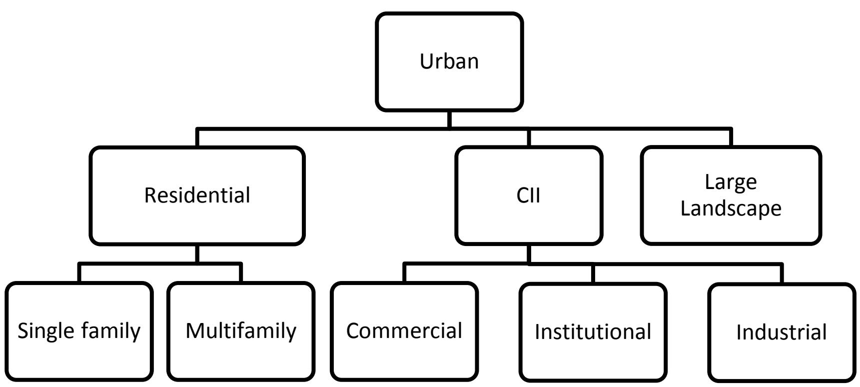


Figure 5.1 - Water Use Sector Classification System Including CII Sectors

Some water service providers maintain more detailed descriptions of customers by including NAICS codes in their data base for their CII customers. A common contributing factor in definitional noise when NAICS codes are used is the failure to distinguish between the primary economic activity of a business and the water-use activities taking place at a particular location operated by that business. It is useful to use the terms "establishment" and "enterprise" for this distinction:

> "Establishment" means a specific water use site (e.g., land parcel or building) at which there may be one or more end-uses of water.
>
> "Enterprise" means a legal entity operating as a business, government, or other organization which may have one or more places of operation or activity.

An enterprise may own or operate businesses at more than one location and each location ("establishment") may have different water use profiles (end-uses of water). For example, an establishment may be a corporate headquarters of an enterprise listed under NAICS as a silicon chip manufacturer, but the water-use profile may be characteristic of an office building that requires a different NAICS code for a water-centric purpose only. Thus, the main function for economic-activity of an enterprise may be manufacturing, and the water-use profiles of the manufacturing establishments may be very different from the corporate headquarters, but the water service provider may be assigning the same NAICS code to both.

Confounding Factors

Variations in climate and weather provide the best example for a confounding factor affecting water use values for an appropriate metric. Variations in climate at the regional level or the statewide level can significantly increase or decrease on a long-term basis the amount of water used for specific end-uses such as landscape irrigation, humidification, and cooling. Knowledge of climatic differences is necessary when comparing and interpreting water data from different regions. Weather differences from year to year confound interpretation of data with regions. Pertinent weather normalization techniques serve to remove weather as a confounding factor. There have been recent advancements in methodologies to normalize weather-related affects on water use data. A recent report titled *GPCD Weather Normalization Methodology* developed through the CUWCC may be useful for testing compliance with the Water Code (Bamezai, 2011).

5.5.6 Metrics Contexts

Whether a metric is appropriate may depend on the context of its use. For example, a metric that may be useful for a single establishment for monitoring its own water use may also be useful for comparing one establishment to another if the processes in both establishments are used to make comparable products. A metric may fail to be useful for comparing one establishment to another due to confounding factors, such as differences in services provided or goods manufactured. Geographic and end-use-profiles are the most common contexts for aggregation and comparison of water uses. An end-use profile is the characterizations of water use by a single water user or group of water users in terms of purpose and methods of water use. It is useful for planning and analysis of water use to group water users having common end-use profiles.

The most common geographic and end-use profiles are described below. After the individual contexts perspectives are defined, they are grouped into five composite contexts that are used for purposes of this report. These contexts become part of the defined cases for each metric to clarify the intended use of the metric.

Geographical Perspectives

1. ***Process/application***, the single end-use of water within a geographically defined area such as a specific parcel of land or a specific portion or “process train” of an establishment.
2. ***Establishment***, the single or aggregated end-use(s) of water within that area defined by the establishment, typically taken as the parcel on which the establishment occupies but could vary.
3. ***Water service provider***, the aggregated end-uses of water which typically occur within a water service provider’s geographic boundaries including, but not limited to, all establishments served by the water service provider, water uses by the water service provider itself (e.g., water for flushing pipelines and filters), water losses, and nonrevenue or other water uses.
4. ***Region***, the aggregated end-uses of water which occur within a defined regional designation, such as regions defined for hydrology, water quality control, and political (e.g., counties) purposes.
5. ***State***, the aggregated end-uses of water occurring within the state as a geographical unit (i.e., boundaries of the state).
6. ***National***, the aggregated end-uses of water which occur within the United States.

End-use Profiling Perspectives

1. ***Process/application***, the end-use of the water within a single process.
2. ***Establishment profile***, the combination of end-uses characteristic of an establishment, including all the processes or applications of water.
3. ***Shared subsector profiles***, common water use profile shared by establishments within one of the commercial, institutional, or industrial sectors.
4. ***Shared cross-sector profiles***, a common water use profile shared by establishments within all CII sectors.
5. ***Subsector***, an aggregation of enterprises that have a common business activity, but may not share water use profiles due to diversity within the subsector, such as oil refining.
6. ***Sector***, an aggregation of enterprises that share activities within the broad definitions of commercial, institutional, or industrial water users.

Composite Perspectives (contexts)

The CII Task Force distilled geographical and end-use profiling perspectives of metric application shown above into the following five composite perspectives. For convenience of reference in this report, these composite perspectives are called “contexts.” The relationships of the perspectives are shown in Figure 5.2.

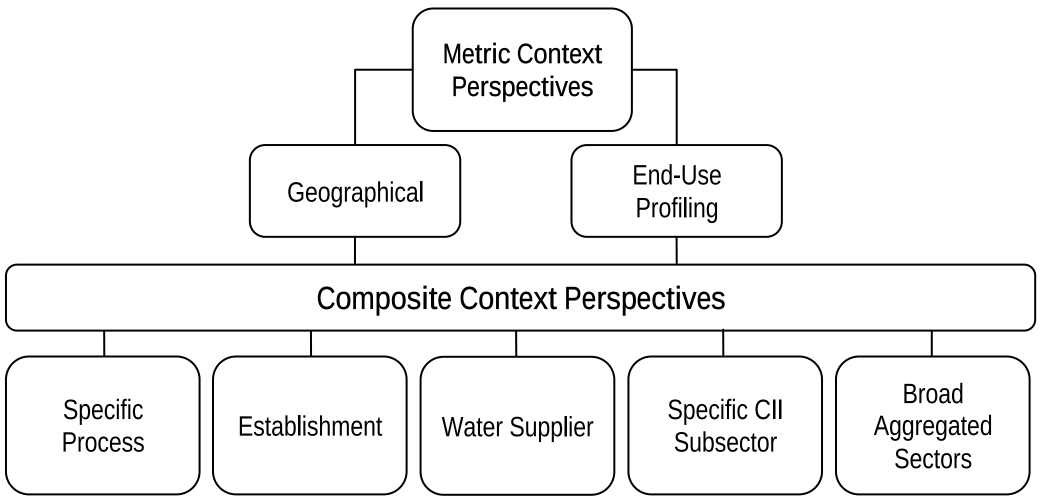


Figure 5.2 - Metric Context Perspectives

1. **Specific process** or application of water use within a CII establishment, such as cooling towers or vegetable washing. A subset of this level would be specific efficiency standards for designated technologies, such as toilets or laundries for which efficiency standards have been established. Note: Standards and codes are addressed in Section 8.
2. **Establishment** water use tracked by water service providers at the meter or service connection, provided that water deliveries are metered or otherwise measured, perhaps tracked by self-supplied water establishments.
3. **Water service provider** deliveries including retail and wholesale water agencies, usually tracked at the sector level, but may be tracked at the subsector level in various degrees of disaggregation.
4. **Specific CII subsector**, such as petroleum refining, commercial laundries, or hospitals, at regional or statewide levels.
5. **Broad aggregated CII sectors** at regional or statewide levels.

These contexts were identified because metrics have been applied or proposed for these contexts or because there is an apparent need for metrics to monitor changes or improvements in water use efficiency or productivity within these contexts.

5.5.7 Criteria for Selecting a Metric

There are many complex factors that affect whether a particular metric is appropriate in a given situation. A metric should not be dismissed because it is ineffective for a familiar situation. A systematic approach is needed to evaluate a metric. The approach developed by the Task Force involves methodically evaluating metrics using consistent defined criteria. Criteria were established to evaluate the advantages and limitations associated with the application of particular water-use metrics. These criteria are described in detail in Appendix D.1. The following steps are used to apply the criteria:

1. Define the metric, its components, intended purpose, intended perspective or context, and intended application.
2. Determine the technical merits and effectiveness of the metric as a water-use efficiency or productivity performance indicator for the specific purpose.
3. Identify the specific data needed to calculate the metric, the necessary parameters associated with the data, and the potential sources of data to implement the metric.
4. Identify the definitional noise and confounding factors associated with the metric and sources of data.
5. Make a judgment based on the available information including, but not limited to, the enumeration of advantages and limitations associated with the application of the metric, and the recommended conditions and caveats to prevent erroneous conclusions or misuse of the metric.

5.5.8 Selecting Appropriate Metrics

Many water-use metrics are in use, as shown in Appendices D.2 and D.3. Most have very narrow intended uses. Elsewhere in this report, metrics are proposed for application to specific BMPs or technologies. Examples of metrics used as standards are described in Section 5.5.2 of this Volume. Water supply planners and policy-makers may use water-use metrics to make broad assessments of how trends in efficiency may affect future water demands, or look at the effectiveness of water use efficiency and management programs. Metrics for this purpose may involve large groupings of water users into sectors or subsectors that may share common business activities or water use characteristics. As noted at the beginning of this section, a goal was to identify metrics that might be more useful than GPCD for CII sectors. This turned out to be a challenging exercise.

For large aggregations of CII water users into sectors or subsectors, commonly suggested metrics to evaluate water use efficiency are:

- GPCD
- Gallons per employee per day or year
- Gallons per square foot of building area per day
- Gallons per day per dollar of economic value added.

There were insufficient resources and time to conduct a thorough analysis of these and other metrics to determine the appropriateness of these metrics in evaluating water use efficiency in the CII sectors and subsectors. However, a limited analysis was conducted for three cases, using the criteria described above and in more detail in Appendix D.4. The case analyses are fully presented in Appendix D.4 and summarized below:

Metrics Case 5.1: Office Buildings without Cooling Towers

Metric: gallons per square feet per day of total building area (gal/ft^2/day).

Gallons per square feet per day (gal/ft^2) may be used as an indicator of water use efficiency or productivity for CII buildings without cooling towers. Data from Sydney Water are given as an example in Table D.2 in Appendix D.4. Specific building area and water use data are required to calculate this metric. Because building area data is not widely available to water service providers or water resource planners and managers in California, this metric is difficult to calculate at this time. Availability of building area data from municipal building departments, county assessor offices, or other sources may make this metric a feasible and useful indicator in the near future.

Metrics Case 5.2: All Commercial and Institutional Establishments, Statewide

Metric: gallons per day per capita (gal/day/capita, GPCD)

The evaluation of this case metric relies on the assumption that commercial activities in the State primarily serve the residents of the State. Therefore, a normalization of water use by general population and trended over time may produce an indicator of water use efficiency or productivity. The lack of consistent and reliable water use data from self-supplied establishments in California, coupled with other confounding factors, prevent using GPCD at the CII sector level. No recommendation is given at this time to use this metric.

Metrics Case 5.3: All Industrial Establishments, Statewide

Metric: Volume (gallons) of water used per unit of value (dollars) added to the California economy per year (gal/$)

The value added to the California economy is the difference between the costs of inputs of production and the market value of the outputs for establishments within the state of California. The evaluation of this case metric was limited to the statewide industrial sector, excluding any commercial and institutional sector establishments. Using value added to the state economy in dollars as a scaling factor may be useful to the water resources planner and manager as an indicator to show increases in technological efficiency or other changes in water use over time. Due to the data and interpretation requirements, this metric would likely be determined by DWR. This metric should be used along with other water use metrics to maintain a portfolio of tools necessary to assess increases in water use efficiency or productivity at the statewide level. No specific recommendations are made in regards to this metric.

Case Example by Others

Water use metrics were analyzed by the United Nations Division for Sustainable Development using a similar approach to the cases above. An example for cubic meters of water volume per value added in dollars is shown in Appendix D.5.

5.6 Data Collection and Reporting

5.6.1 Introduction

Water resources management is reliant upon data regarding how much water is used, the purposes for which it is used, where it is used, and how efficiently it is used. The data are used for:

- Planning and designing water supply facilities
- Developing programs to use water more effectively and reduce waste
- Managing water to reduce environmental impact
- Developing funding sources to manage water supply and quality
- Developing policies, regulations, and laws to govern the wise use of water

> Water supply planners and policy-makers may use these metrics to make broad assessments of how trends in efficiency may affect future water demands or to look at the effectiveness of water use efficiency and management programs.

The data are used by water users to estimate their water needs or reduce unnecessary expenditure on water by water service providers at all levels of government to plan and manage water. Economists use the data to correlate use and availability of water to economic sustainability. Nongovernmental organizations use the data to provide assistance in managing water.

Most studies on water use have cited the problems in available data due to the lack of data on all water use in the state, to the inconsistent definition of water user classification between water service providers, and to the lack of sufficient granularity of water use customer classification by water service providers to be able to analyze the data properly (note, for example DWR (2010)).

The following describes the data currently collected on water in California, including problems in these data, the data collected in other selected states to illustrate what kind of reporting is feasible, potential for improvement and recommendations for further study and action.

5.6.2 Existing Water Data Collection by Water Service Providers

Most water service providers collect data from each customer to provide adequate water service, collect revenue, meet state laws, and comply with local ordinances. Customers may be classified by code to include general sectors as shown in Figure 5.1, major customer types such as wholesale or retail, and more specific codes exist for special billing or customer management purposes. As discussed in Section 5.3 of this Volume, there is a need to not only know how much water is delivered to each water user, but also how the water is used through classification by water use profiles, sectors, and subsectors.

A comprehensive analysis was not conducted to determine prevailing data collection practices by water service providers. However, East Bay Municipal Utility District (EBMUD) provided information to the Task Force to provide valuable insight into its classification of water customers. The table provided in Appendix D.6 shows that EBMUD has 91 business classification codes assigned to customers to characterize water use in its district. The table also shows how the categories are combined into aggregated water sectors similar to those shown in Figure 5.1.

Urban water service providers do not use consistent definitions of water use sectors when aggregating data for reporting to the state, based on a review of water use data that are reported to DWR and CUWCC.

5.6.3 Existing Statewide Water Data Reporting to State, Federal and Nongovernmental Organizations

The principal organizations collecting fresh water use data in the state are:

- Department of Water Resources (DWR)
- Department of Public Health (CDPH)
- State Water Resources Control Board (SWRCB)
- Public Utilities Commission (CPUC)
- California Urban Water Conservation Council (CUWCC)
- At the federal level, water supply and use data are collected and reported by the U.S. Geological Survey (USGS) and the US Bureau of Reclamation (USBR)

While statutory and regulatory requirements for reporting water use or diversions for storage and use exist, these requirements leave significant gaps that either are unreported or are not reported in sufficient granularity for adequate analysis.

Department of Water Resources (DWR)

There are two primary reporting mechanisms for DWR to collect data on water use: the Public Water System Statistics Survey and Urban Water Management Plans. Periodically, DWR conducts specialized surveys for water use in specific sectors.

Public Water System Statistics Survey (PWSS). The DWR has conducted the PWSS, in its present form, since 1987 to gather water production and use data. This is an annual voluntary survey. Data from individual respondents is kept confidential. To illustrate the scope of the survey, in 2010 DWR sent about 1,000 PWSS forms to urban water agencies of all sizes, both public and investor-owned. Approximately 800 water agencies responded. The data collected includes, but is not limited to, the number of connections, the amount of water into the system, and the amount of metered or estimated deliveries by month. Customer classifications are:

- Single family residential
- Multi-family residential
- Commercial/institutional
- Industrial
- Landscape irrigation (large landscape sites)
- Agricultural irrigation
- Other

Some of the issues associated with the PWSS are:

- The survey is voluntary, leaving gaps in data collected.
- Self-supplied water use is not included.
- Some regions are poorly represented.
- There is no category for system losses.
- There are many errors (e.g., wrong or missing units, incorrect data, and misinterpretation of water use categories).
- Multi-family data may be included in the commercial classification.
- Large landscape customers may be included in commercial or institutional categories.
- Nurseries may be classified in landscape or agricultural irrigation.

- Commercial and institutional sectors (categories) are combined.
- Population estimates are unreliable due to lack of standard methodology.
- There is no subdivision of commercial and industrial sectors into any subsectors.
- Population and number of accounts are the only correlating factors, which are not tailored for CII use.

Urban Water Management Plans (UWMPs). Urban water management plans are required for “urban water service providers” (over 3,000 connections or 3,000 AF/year) to be submitted every five years. There are about 450 water service providers. As a result of the Water Code, UWMPs must now include 2020 per capita water use targets using a prescribed methodology for calculating baseline water use, past and future population, and the targets.

Water service providers are required to report past, current, and projected water use. Data is requested to be broken down by the following water use sectors, but they are not required to provide the breakdown or to use the requested standard reporting forms:

- Single-family residential
- Multifamily
- Commercial
- Industrial
- Institutional and governmental
- Landscape
- Sales to other agencies
- Saline water intrusion barriers, groundwater recharge, or conjunctive use, or any combination thereof
- Agricultural

The number of accounts and amount of water used for each sector are requested on the data submittal forms. Population estimation is based on prescribed criteria and should be reliable except for seasonal or tourist populations served.

Some of the issues associated with data reported by the water service providers in the UWMPs are:

- There is no breakdown of Commercial and Industrial use into subsectors.
- Population and number of accounts are the only correlating factors, which are not tailored for CII water use.

- Governmentally-owned large landscape may be included in Governmental rather than Landscape. Other large landscape may be included in Commercial.
- Multi-family data may be included in the Commercial classification.
- The data are available only in five-year intervals.
- There is no category for system losses.
- Self-supplied use is not included.

California Urban Water Conservation Council (CUWCC)

CUWCC is a voluntary membership organization consisting of urban water service providers, consulting firms, and other organizations and individuals. The primary purpose of CUWCC is to promote water conservation BMP implementation. Water service providers signing the memorandum of understanding of the CUWCC agree to implement specified BMPs. Membership includes about 225 wholesale and retail water agencies covering about 75 percent of total urban water supply. At the retail supply level, about 65 percent of total urban water supply is represented.

Urban water agencies commit to report the following information to the CUWCC for each year (submitted biannually):

- Population
- Water deliveries and number of accounts for the following sectors:
    - Single-family
    - Multi-family
    - Commercial
    - Industrial
    - Institutional
    - Dedicated irrigation
    - Recycled water
    - Unaccounted for [system losses or meter discrepancies]
    - Other

The issues and limitations described above for DWR's PWSS are generally applicable to the information submitted by members to CUWCC's reporting system.

- Population estimates can be unreliable.
- Multi-family water use may be included in commercial.

- Large landscape water use may be included in commercial or institutional.
- Unaccounted for water estimates are often suspicious (for example, reported as zero).
- There is no breakdown of commercial and industrial use into subsectors.
- Population and number of accounts are the only correlating factors, which are not tailored for CII water use.
- Self-supplied use is not included.

California Department of Public Health (CDPH)

CDPH regulates "public water systems" that have at least 15 service connections or at least 25 people served at least 60 days per year. As of 2006, there were 7,745 public water systems.

A subset of public water systems is another category defined by CDPH, "community water systems." These are public water systems that serve at least 15 service connections used by year-long residents or regularly serve at least 25 year-long residents. As of 2009, there were 3,116 community water systems, of which 839 had over 500 connections.

CDPH collects data through the Public Water System Annual Report, which is a component of the Drinking Water Program (DWP). The report focuses on the following critical areas of the DWP: emergency contacts, drought and conservation, and water consumption. The information collected is used by CDPH and other state and community organizations to assess and plan water strategies for the future. The data collection is through an Electronic Annual Reporting System by California's public water systems. More information can be obtained from http://drinc.ca.gov/.

Information is collected by the CDPH for its annual reporting and is associated with water use. Public water system service connections are type coded as:

- Agricultural
- Commercial
- Industrial
- Power Production
- Residential
- Combined

No definitions for the above type codes are given by the CDPH. By providing data in the combined category, a water service provider does not need to provide any data for the named sectors.

The number of service connections is collected in accordance with the type of service connection shown above with a meter type designation (e.g., metered, unmetered). Population served is an estimated count of populations served by type (e.g., residential, transient) during the specified annual operating period. The CDPH does not prescribe a methodology for estimating population served.

The data collection of CDPH shares most of the same issues described above for DWR's PWSS.

California Public Utilities Commission (CPUC)

CPUC regulates investor-owned water agencies. The data reported to CPUC has not been investigated.

State Water Resources Control Board (SWRCB)

The SWRCB regulates wastewater discharges and water rights. The primary water supply data that must be reported to SWRCB are connected with surface water rights and diversions from surface water. Thus, the data are collected from water service providers or individual water users with their own water rights.

The SWRCB also has issues and limitations in data collection:

- The data reported are not directly correlated with service areas of water service providers or deliveries of water to water users.
- Data on deliveries by water service providers to water users are not reported.
- For water agencies with multiple water rights and sources of water not requiring water rights, such as groundwater or purchases from other agencies, the data submitted for each water right would not represent a complete accounting of water deliveries.

U.S. Geological Survey

The U.S. Geological Survey (USGS) plays a key role at the national level in water-use data acquisition, management, and dissemination. It deploys high-end information technology products to enhance data storage and access methods against natural resources datasets. Its partners include various local, state, national, and international agencies.

The U.S. Geological Survey's National Water-Use Information Program is responsible for compiling and disseminating the nation's water-use data. The USGS works in cooperation with local, state, and federal environmental agencies to collect water-use information. USGS compiles these data to produce water-use information aggregated at the county, state, and national levels. Every five years, data at the county level are compiled into a national water-use data system and state-level data are published in a national report, the most recent of which is

Estimated Use of Water in the United States in 2005, Circular 1344. This report contains data on water withdrawals, surface, and groundwater use, and deliveries and corresponding populations broken down by state. The sources of data include state agencies and surveys by USGS. The following use categories are reported:

- Public supply
- Domestic freshwater
- Irrigation freshwater
- Livestock freshwater
- Agriculture freshwater
- Industrial fresh and saline water
- Mining fresh and saline water
- Thermoelectric power fresh and saline water

Public supply (urban water) is not disaggregated into sectors.

U.S. Bureau of Reclamation

The U.S. Bureau of Reclamation (USBR) has several area, field, and specialized offices throughout California as part of its Mid-Pacific Region office. In general, the USBR conducts many water related activities and produces data sets and related documents. The USBR operates, maintains, and coordinates many activities related to water supply, flood control, and power generation with other agencies. The classification systems and geospatial and relational data sets available through USBR were not investigated for this report but should be considered if an effort is made to develop a unifying water-use categorization system as recommended in this section. Information about USBR related data sets and other information can be found on the USBR "Programs, Activities and Related Database" at http://www.usbr.gov/mp/programs.html

5.6.4 Existing Data Reporting in Other States

A comprehensive survey was not conducted on water data reporting requirements or practices in other states. However, the reporting requirements for Kansas, Illinois, and Texas are indicative of feasible reporting requirements.

Kansas

Kansas requires water appropriation permits for all use of surface water or ground water. All water right holders must report annually to the state. Water use data are collected and published by the Division of Water Resources' water appropriation program. Each year, about 14,000 water use report forms for 32,500 active water rights are mailed to water right holders for the 14 classified beneficial uses of water. See *Kansas Fact Sheet*--*Water Use Data Collection and*

Use, Kansas Department of Agriculture, www.ksda.gov, for additional information (Kansas DOA 2009).

Illinois

The State of Illinois, through its Illinois Water Inventory Program (IWIP), collects water data throughout the state. The program began in 1978. Annual submission of the Illinois Water Inventory form is mandatory according to Public Act 096-0222. It is designed to collect data in three major categories: water withdrawal, water use, and water returns. For each water-using facility inventoried, the database includes locations and amounts of water withdrawn from surface water and groundwater sources, as well as significant amounts of water purchased from other facilities. Public water supplies, self-supplied CII, irrigation, fish and wildlife, and conservation uses are inventoried. Data can be summarized geographically by county, township, and drainage basin, as well as by various water use and water source categories for inclusion in publications of the USGS National Water Use Program. The amount of water used by commercial and industrial facilities is kept confidential unless the facility grants a specific release of the data. Commercial-industrial data are published only in combination with township or regional totals. For additional information on the Illinois program go to http://www.isws.illinois.edu/gws/iwip/.

Texas

The Texas Water Development Board (TWDB), through the powers vested in it through the Texas state legislature, requires all recipients of the TWDB's Survey of Ground and Surface Water Use (Survey) to submit a complete survey or face possible civil and other penalties (see Texas Water Code (TWC) Section 16.012(m)). Theoretically, the TWDB has the authority, as given in TWC, to send a survey to any individual establishment or organization with a few exceptions for entities using windmills for domestic and livestock water supply. In implementation, the survey covers nearly all community public water systems, non-community systems with use deemed significant in its region, and industrial facilities that either use greater than 10 million gallons per year of water, pump groundwater, or whose water use is deemed significant in its region or industry category. Texas does not survey self-supplied residential establishments using groundwater wells as a rule, but does make a water-use estimate of self-supplied domestic and commercial water users for statewide water resources planning and management. Much of the state is covered by approximately 100 groundwater conservation districts, most being single-county districts, that issue groundwater use permits. To what degree each of these districts actually manages groundwater in their area varies greatly and was not investigated for this report. Even though the state does not issue groundwater permits and groundwater conservation districts may issue groundwater permits, the state does use the Survey to gather groundwater use data from end-users as a method to quantify groundwater withdrawals (pumping) throughout the state of Texas. An example of the statewide reported water-use categories is given in Appendix D.7 and includes the following categories: municipal, manufacturing, mining, steam electric, irrigation, and livestock.

5.6.5 Potential for Improvement

Many limitations have been described in current data collection, categorization, and reporting in California. These limitations hinder the ability to quantify CII and other water use or to have sufficient details for an adequate understanding of how water is used. All water users and managers would benefit from improved data collection and reporting. A discussion of potential improvements is provided below.

Water Use and User Classification

Current technology increasingly allows water service providers to easily store data on each water customer, including characteristics of end-uses of water and classification codes related to the water end-use profile of a water user. Water service providers are already classifying their customers for billing purposes. It appears that many have a very limited number of customer categories, the categories may not be indicative of water use characteristics, and the categories are inconsistently defined. There are water and wastewater service providers, however, that have detailed classification systems. For example, East Bay Municipal Utility District (EBMUD) uses a Business Classification Code system with 88 codes assigned to commercial, institutional, industrial, and agricultural customers (see Appendix D.6) The County Sanitation Districts of Los Angeles County uses the Standard Industrial Classification (SIC) system to code approximately 2,600 commercial, institutional, and commercial wastewater dischargers. Once water users are classified, the maintenance of the customer classifications is minimal. A customer classification should be reevaluated upon site ownership or land use change.

There is need for a full-spectrum water-centric classification system. Stewardship at all levels will be enhanced when such a system is used in conjunction with the primary data sets used to track economic activity, land ownership, land use planning, and water, air and land quality records. The classification system should be water-centric by being indicative of end-uses of water or similar profiles of end-uses of water. For example, certain business categories, such as motels, have several types of end-uses on site but share similar profiles of end-uses.

Classification systems are often limited in the scope of the uses to meet the immediate needs of an entity. An urban water service provider may not have codes for uses it does not serve, such as mining or agriculture. A full-spectrum system incorporating or allowing for all potential water uses consistently defined would better facilitate the aggregation of data for water-use efficiency metrics and other purposes.

In summary, a ‘water-centric” classification system is a coding system specifically designed to characterize water uses and users and may involve the adaptation of other coding systems, such as NAICS, which was designed for tracking economic activity. In this context “full-spectrum” means a comprehensive classification system that encompasses the full array of water uses and users, not just urban or CII uses, such that the system will have utility across different water planning or management functions at various levels of government and water service providers.

NAICS, the successor to SIC, is a very detailed coding system for governmental, institutional, and business entities. The system was designed for tracking economic activity; however, it is possible to apply it in a water-centric way to be indicative of water use. For example, an electronics manufacturing firm may generally be classified as such, including an office headquarters where no manufacturing takes place. A water-centric use of NAICS would be to apply the NAICS code for office buildings to the water meter serving the headquarters.

This report includes the applicable NAICS codes wherever possible for the CII water users under discussion due to the prevalence of NAICS codes in current use. NAICS is a two- through six-digit hierarchical classification system, offering five levels of detail. Each digit in the code is part of a series of progressively narrower categories, and the more digits in the code signify greater classification detail. The first two digits designate the economic sector, the third digit designates the subsector, the fourth digit designates the industry group, the fifth digit designates the NAICS industry, and the sixth digit designates the national industry. The five-digit NAICS code is the level at which there is comparability in code and definitions for most of the NAICS sectors across the three countries participating in NAICS (the United States, Canada, and Mexico). The six-digit level allows for the United States, Canada, and Mexico each to have country-specific detail. A complete and valid NAICS code contains six digits. The use of this system by water service providers would provide better consistency of classifications and ability to aggregate users in a consistent fashion. This would greatly improve the quality of data reported either voluntarily or mandatorily to other regional or state agencies for planning or regulatory purposes or the quality of data gathered by researchers.

Because of the comprehensive inclusion of all business and many governmental functions, NAICS comes closest to being a full-spectrum system. However, as an economic activity tracking system, it was not designed to be water centric. USGS has laid some groundwork in the water centric direction by assigning each four-digit industry code in the 1987 SIC manual to a water-use category. In some cases, a code may be listed under more than one water-use category. The SIC codes can be useful to USGS for assigning water withdrawals to the public-supply, industrial, mining, and thermoelectric-power categories used by USGS for its national water use reporting. A list of SIC codes by water-use category is shown at http://pubs.usgs.gov/tm/2005/tm4A4/.

The Water Research Foundation has research under way with a project titled "Methodology for Determining Baseline Commercial, Institutional and Industrial End Uses of Water - 4375." The objective is to develop and test a methodology to collect standardized data to determine CII end uses of water. This methodology could be used by water service providers of various sizes to collect CII end use data for demand forecasting, rate design studies, benchmarking, and conservation program planning. This project will focus on methodology for determining values, not actual end use values for the CII category. The project has a tentative start date of March 1, 2012 and may likely take two to three years to complete. One California water service provider, East Bay Municipal Utility District, is participating in the project. For more information on this research, go to http://www.waterrf.org and search "4375".

It is possible to apply more than one classification system to water uses or users to serve multiple purposes, such as billing or water use characterization. A comprehensive water-centric classification system need not replace a separate classification that a water service provider may need for purposes of setting water rate structures and billing purposes. Better understanding of water use characteristics by customer class from using a water-centric classification system may make it possible to devise more appropriate water rate structures. A water-centric use of NAICS to classify customers by water use would not prevent a water service provider from also tracking customers with a separate business purpose classification using NAICS.

The potential burden on water service providers to identify and store a detailed water use classification system has raised concerns. These concerns should be studied further and include a survey of current water service provider practices by customer classification and overall adaptability of the water service provider databases to store this information. Consideration can also be given to exempt small water service providers from a detailed classification system. Nevertheless, there is still the need for water service providers of all sizes to use consistent definitions of sectors.

Disaggregated Data Recordkeeping

The most common sector categories in use are:

- Single-family residential
- Multi-family residential
- Commercial
- Institutional
- Industrial
- Large landscape
- Agricultural
- Unmetered or unaccounted-for water

Some major uses may be incorporated into the above, or classified separately, such as with mining or thermoelectric power generation. As described earlier, state agencies or other organizations often collect data classified by these sectors with poor or no definitions of them. Further disaggregated breakdown of water use would be beneficial to develop metrics for subsectors with common uses or to allow targeted funding or assistance programs where they could be of greatest benefit for improving water use efficiency and demand management. As described above, EBMUD has 91 categories to classify its customers, 88 primarily for the CII sector and 3 to capture residential and other customers. Creating a comprehensive water use classification system and applying it to each customer would yield benefits at the local and state levels.

Integration with Other Data Sources

We have the ability to fully integrate large datasets for land, air, and water use at the individual parcel level through primary record sets such as the public domain real-property parcel records collected and maintained by counties. Facilitating access to these other datasets could make certain metrics more feasible.

As discussed in Section 5.5 Water Use Metrics, some useful metrics use square feet of land area or building area, number of employees, or residents. Some of these data are maintained by county assessors or planning departments, wastewater agencies, the US Bureau of the Census, or others. The data may be accessed or shared more easily if water supply customers are identified by APNs. With modern database systems, it is often easy to store data associated with customer data. Once APNs are entered into a database, it is seldom necessary to change them. There are commercial services that track changes in APNs and ownership, as with parcel splits, and provide ongoing alerts to clients. Some service providers already track APNs, such as the County Sanitation Districts of Los Angeles County.

The use of remote sensing of land use is improving the potential ability to identify irrigated land area. When combined with APNs, such data could improve the ability to segregate irrigation water use (as estimated from land area) from other sectors (residential and CII). It could allow correlation of actual metered water use at sites using dedicated landscape meters with land area to provide better estimation of total irrigation water use under different climatic and weather conditions.

Florida provides an example of non-water datasets that can be useful for water use metrics. Florida's Department of Revenue (FDOR) maintains a database of legal, physical, and economic property-based information for each of the 8.8 million parcels of land in the State of Florida. Of this total number, 326,000 are CII parcels (215,000 commercial, 69,000 industrial, and 42,000 institutional). This database is audited and updated annually and is publicly available free of charge from the FDOR file transfer protocol website (ftp://sdrftp03.dor.state.fl.us/). FDOR partitions parcels, on the basis of their land use, into 100 subsectors using two-digit FDOR codes. These codes are standardized across the state, providing consistent definitions of terms. The parcel information in this database is provided annually to FDOR for a statewide land use database.

Self-Supplied Reporting

Estimation of self-supplied water use in California, based on infrequent surveys which only sample portions of the CII sector, is proving insufficient to determine current and future groundwater use and demand. Developing a more robust reporting program would help determine self-supplied water use in California and assist with future planning and policy-making at the state level.

Much data about CII water use by individual establishments is already in the public domain. The long-term trend has been toward greater mandatory reporting of water extraction and use. While water diverted from surface waters, based on appropriative water rights, has been reported to the State Water Resources Control Board for many years, reporting of riparian diversions has only recently been mandated. Groundwater extraction reporting is currently required in basins that are adjudicated or under authority of a local groundwater agency authorized to require reporting, but is not required in other basins. The law recently established a mandate to report groundwater levels but not groundwater extractions.

It is instructive to look at what other states do. The states of Kansas and Illinois require reporting to the state of all water use, either by self-supplied water users or by water service providers. In Illinois, for example, the locations and amounts of water withdrawn from surface water and groundwater sources, as well as significant amounts of water purchased from other facilities, are inventoried every year for a variety of water-using facilities, including commercial and industrial facilities. The amount of water used by commercial and industrial facilities is kept confidential unless the facility grants a specific release of the data. Commercial-industrial data are published only in combination with township or regional totals.

Landscape Irrigation Tracking

Irrigation water use constitutes about half of the urban water use in California. A very useful and relevant metric for landscape irrigation water use is gallons per day per square foot of irrigated area. If the water applied to irrigated landscape were separately measured and reported, the efficiency of water use in this major water end-use could be monitored. As was discussed earlier, water deliveries to irrigated residential landscape are commonly combined with indoor residential use. CII landscape irrigation is usually combined with other end-uses unless water service providers have installed separate meters for landscape water use. Certain users with large landscape use are inconsistently assigned to sectors, such as golf courses variously assigned to commercial, institutional, or large landscape sectors. While the Water Code requires installation of separate landscape water meters for certain sized landscapes, the requirement is not applied retroactively to all large landscapes that existed before the law was in effect. The Memorandum of Understanding for the CUWCC requires signatories to work with customers with large landscapes to reduce their water use; it does not establish any targets for installing separate meters for existing customers.

Segregating out large landscape water use from CII sectors into a separate large landscape sector would allow better quantification of landscape water use and better use of water rate structures to enforce efficient water use, and would clarify and make more consistent the meaning of CII water use data. Following this option would still leave residential landscape water use combined with indoor water use.

5.6.6 Options for Further Study

The following are options identified for further study or action to improve data collection and reporting. These options can be studied separately or in combination to improve current methods.

Option 1: DWR should develop a water use and user classification system. The system should comprehensively address all sectors of water use, not just CII water users. The system should be designed for all water use establishments to be classified using a full-spectrum water-centric coding system integrated with national, state, regional, and local goals and objectives for water resources planning and management. The classification system should include common definitions for water use sectors for consistent aggregation of data. Consideration should be given to using a commonly accepted coding system, such as NAICS, as a basis for definitions.

Option 2: Water service providers should classify water users using a common water-centric classification system and transition their customer databases to incorporate this classification system. Water service providers should classify their customers with sufficient disaggregation to allow consistent and accurate characterization of water use or water use profiles of establishments and to allow compilation of water use by various subsectors to prioritize and focus programs to assist CII businesses to improve their water use.

Option 3: Water service providers should consider recording and maintaining key data fields for customers/establishments in such a manner that water use data can be correlated with data from other sources for purposes of metrics and water demand analysis and demand projections, e.g., assessor's parcel numbers.

Option 4: Water service providers and self-supplied water users meeting certain criteria should be required to report water use to a state repository (e.g., DWR) using standardized reporting forms, definitions, and sector breakdowns.

Option 5: Water service providers should separately meter large landscape irrigation sites, even where this is not currently required by law. The CUWCC should be encouraged to make this a foundational best management practice for its signatories. CII water users should be encouraged to install submeters at any location with significant on-site irrigation when significant other end-uses of water are also occurring at establishment sites. Large landscape irrigation uses should be subclassified according to the use context, namely residential, commercial, institutional, or industrial, for improved ability to analyze water use data.

5.7 References and Additional Resources

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6.0 Technical, Financial Feasibility and Potential Water Use Efficiency Improvements for Best Management Practices and Audits

Technical and financial feasibility are two key criteria used in making investment decisions, whether by CII entities or water service providers. The Legislature recognized this and called upon the CII Task Force Report to include "[i]dentification of technical feasibility and cost of the best management practices to achieve more efficient water use statewide in the commercial, industrial, and institutional sectors that is consistent with the public interest and reflects past investments in water use efficiency" (CWC Section 10608.43(e)). The general framework for these two criteria is presented in this section. Analytical procedures for conducting cost analyses are provided for use when making a decision to implement any particular BMP.

The Legislature also called upon the CII Task Force to develop "an assessment of the potential statewide water use efficiency improvement in the commercial, industrial, and institutional sectors that would result from implementation of these best management practices" (CWC Section 10608.43). A statewide assessment was challenging, as described in this section, but examples of water savings accomplished in specific applications are presented in this section along with an estimation approach based on penetration rate for a BMP.

Finally, water audits have been found to be effective in assisting managers of CII entities to identify areas of inefficient water use within facilities and appropriate BMPs to reduce water use. A discussion of audits concludes this section.

This section begins with CII Task Force recommendations related to this section.

6.1 Recommendations

The CII Task Force has the following recommendations based on the background information provided in this section.

Recommendation 6-1: CII entities should perform water audits to identify opportunities for implementation of BMPs.

Recommendation 6-2: Following audits CII entities should evaluate the technical and financial feasibility of BMPs to determine whether to implement BMPs.

Recommendation 6-3: Water and energy service providers should incorporate water audits into their efficiency programs, consider financial incentives for BMP implementation, and provide other technical assistance as appropriate.

Recommendation 6-4: Organizations representing business and industry, water service providers, the CUWCC and DWR should educate CII water users or entities on the BMPs and approaches to doing audits and performing a cost-effectiveness analysis.

Recommendation 6-5: All new water users should consider implementing the recommended BMPs at the time of installation or construction.

Recommendation 6-6: When replacing equipment CII business should evaluate the equipment and the maintenance and operational practices needed to achieve an industry standard of water use efficiency for the new equipment being purchased.

Change to a waterless process

There are many examples of replacing water using equipment with equipment that does not use water.

6.2 Technical Feasibility of Implementing the BMPs

All BMPs described in this document are technically feasible and have been used in the past. However, this does not mean that each BMP is applicable in all cases. In developing the BMPs in this document three guiding principles were deemed to be important:

1. **One size does not fit all** – For any given CII sector, subsector, or entity, there may be a dozen potential BMPs. Not all will be applicable. In many cases establishing one BMP could mean that another will not be applicable because they will "be saving the same water."
2. **Every facility is unique -** Analysis of potential payback is unique to each facility and situation. Facilities, even in the same CII sector, vary in their process, equipment selection, and design. This means that what may work at one vegetable processing plant may not be applicable at another; what works in one research laboratory or hotel may not be applicable in another.
3. **The BMPs in this document should be used only as a guide -** The intent of this report is to provide a compendium of BMPs that are possible measures that a CII entity can adopt for their specific situation.

The legislation stated that the final report should contain "identification of technical feasibility and cost-effectiveness of the best management practices to achieve more efficient water use statewide in the commercial, industrial and institutional section…" Because each use site is unique, cost-effectiveness and the feasibility of using BMPs must be determined on a case by case basis for each site.

6.3 Cost Analyses

SB X7-7 calls for the CII Task Force to address "cost of the best management practices to achieve more efficient water use statewide in the commercial, industrial, and institutional sectors that is consistent with the public interest and reflects past investments in water use efficiency." This can be addressed in three dimensions. The first is the stand-alone costs of implementing the BMPs. To the extent that data are available, these costs are presented in the discussion of the BMPs in Section 7.0. The second is the cost-effectiveness analysis of implementing BMPs from the perspective of the water user or water service provider. The third is the economic analysis of implementing BMPs from the perspective of regional or state public policy makers to address the public interest. The latter two dimensions involve computational methodologies that provide the basis for deciding whether to implement BMPs. The computational methodologies will be presented and followed by discussion of analysis approaches depending on perspective.

Because each use site is unique, the costs of the BMPs and the cost-effectiveness and the feasibility of using BMPs must be determined on a case by case basis. While all of the BMPs in this document are technically feasible and are cost-effective in certain situations, the appropriateness of using any one BMP must be assessed for each site. The CII water user will need to conduct a site audit to determine which BMP(s) would be technically feasible for them. This would be followed by a cost/benefit analysis to determine if implementing the BMP(s) would be cost-effective. Organizations representing business and industry, water service providers, the CUWCC and DWR should educate CII businesses on the BMPs and approaches to doing audits and performing a cost-effectiveness analysis.

6.3.1 Computational Methodologies

Conducting cost analyses for determining whether or not to implement BMPs involves some basic methodologies. In general, the methodologies allow comparison of benefits to the short- and long-term costs of implementing a BMP.

Benefits can take various forms:

1. Avoided costs from purchasing less water or from delaying development of alternative water supplies.

2. Added productivity from a more reliable water supply or environmental benefits from reduced water withdrawals.

The common computational methodologies are described below.

6.3.1.1 Calculating the Unit Cost of Water

For many types of cost analyses, it is helpful to compare costs based on unit costs, that is, the dollars per unit volume of water. When evaluating the benefits of water savings, the cost of heating water for certain purposes and the cost of wastewater disposal may also be important. Calculations can become complicated because water, wastewater, and energy are measured in various units, so conversion factors must be on hand. A few useful conversion factors are given in Table 6.1. These conversions will be helpful to follow the example calculations that follow.

Table 6.1 - Water and Energy Conversion Factors

Unit of Measure	**Equivalent Measure**
Water	
1 CCF	100 cubic feet
1 cubic foot	7.48 gallons
1 million gallons (MG)	3.07 acre-feet
1 gallon (gal)	8.34 lb
Energy	
1 British thermal unit (BTU)	The energy required to raise the temperature of 1 pound of water by 1°F
1 therm	100,000 BTU
1 CCF natural gas or propane	100 cubic feet
1 MCF natural gas or propane	1,000 cubic feet
1 cubic foot natural gas	Approximately 1,000 BTU
1 cubic foot gaseous propane	2,516 BTU
1 gallon liquid propane	91,500 BTU
1 kWh	3412 BTU

EXAMPLE 1

Question – If a business used 52 CCF of water in a month on average and the amount paid for water for a year was $4,682, what is the unit cost of water per gallon?

Answer -

Step 1: Calculate the annual water use in gallons:

(52 CCF/month) × (100 ft^3/CCF) × (7.48 gal/ft^3) × (12 months/year)

= 466,752 gal

Step 2: Calculate the unit cost:

($4,682/year)/(466,752 gal/year) = $0.010/gal

If water is heated before use and is discharged as a wastewater after use, the costs of heating and wastewater disposal should be considered when evaluating the benefits of water savings using BMPs. The cost of water softening or other treatment should also be included in calculations. For heated water, determine the type of energy used to heat the water (gas, electric, solar, or other) and its cost per unit (cents per kilowatt hour, dollars per therm, dollars per MCF of natural gas, etc.). For typical domestic water use, assume water is heated from 55^{o}F to 120^{o}F. High temperature use in a commercial dishwasher in Southern California typically requires a temperature rise from 125^{o}F to 180^{o}F. There are energy inefficiencies in devices using electricity or fuel, which need to be accounted for when calculating costs. For simplification, and because of the variability of device efficiencies, the example calculations below are based on the theoretical energy needed assuming 100 percent efficiency. For your specific calculations, you would use the actual stated efficiency of your device instead of the assumed efficiency.

A propane cost of $2.00 per gallon is equivalent to natural gas costing $22.00 per MCF.

EXAMPLE 2

Question – If natural gas costs $0.80 per therm, what is the unit cost per gallon of raising the water's temperature by 55^{o}F?

Answer – ($0.80/therm) × (1 therm/100,000 BTU) ×(1 BTU/lb-°F) × (55°F) × (8.34 lb/gal) x 1.0 (assumed efficiency)

= $0.00367/gal

EXAMPLE 3

Question – If water costs $3.50 per CCF, wastewater treatment and discharge costs $4.00 per CCF, and the water is heated with electricity that costs ten cents per kilowatt hour, what is the unit cost per gallon of heating the water by 55^{o}F?

Answer –

Step 1: Calculate the unit cost of water supply:

($3.50/CCF) × (1 CCF/100 ft3) × (1 ft3/7.48 gal)

= $0.00468/gal

Step 2: Calculate the unit cost of wastewater management:

($4.00/CCF) × (1 CCF/100 ft3) × (1 ft3/7.48 gal)

= $0.00535/gal

Step 3: Calculate the unit cost for heating water:

(1 BTU/lb water-°F) × (55°F) X (8.34 lb/gal) ×(1 kWh/3412 BTU) × ($0.10/kWh) x 1.0 (assumed efficiency)

= $0.01344/gal

Step 4: Calculate total unit cost:

$0.00468/gal + $0.00535/gal + $0.01344/gal = $0.0235/gal

6.3.1.2 Payback Period

The payback period is the time required for an investment to pay for itself in terms of accumulated benefits, such as profits or reduced costs. If the annual benefits are uniform from year to year, the 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, as shown in Equation 6.1.

Equation 6.1

Payback Period in years = (Initial investment)/(Annual benefits)

If benefits are not uniform, then cumulative annual benefits from the time of the investment are calculated for each year until the accumulated total benefits equal the initial investment.

While the payback method is relatively easy to calculate, it does not account for the life of the device or the time value of money. For example, Device A may have an incremental capital cost of $100, annual water and energy savings of $50, and a lifetime of three years. Device B, in comparison, may have the same incremental capital cost and annual water and energy savings, but have a lifetime of 20 years. Thus, while both devices have a simple payback of two years, Device B will provide benefits for 17 years beyond that of Device A. Additionally, the payback does not account for the rate of interest that an investor must pay (or forgo) when making the initial investment.

6.3.1.3 Return on Investment (ROI)

The return on investment (ROI) has various definitions in use. For this report it is defined as the percent of payback the BMP produces per year. For a uniform annual investment, this is equivalent to the inverse of the payback period. ROI is usually expressed in percent per year. In the case of a one-year payback, the ROI is 100 percent. If the payback is in 1.6 years as shown in the example below, the ROI equal to (100%/1.6) or 62.5 percent a year.

If energy, chemicals, labor, and other savings or costs are involved, they must be included in the annual benefit.

EXAMPLE 4

In a school gymnasium shower facility heated with natural gas, showerheads are being replaced from a 2.5 gallon per minute device to a 2.0 gallon per minute device. Using the assumptions in Table 6.2, what are the total expenditure savings, payback period, and ROI?

Table 6.2 - Assumptions for Example 4

Parameter	**Assumed Value**
Number of showerheads	5
Gym usage	180 days/year
Average shower frequency	4 times/day
Average shower time	8 minutes
Cold water temperature	60°F
Shower water temperature	100°F
Showerhead replacement cost including labour	$25
Water cost	$3.50/CCF
Wastewater charge	$4.00/CCF
Natural gas cost	$8.50/MCF
Water heater energy efficiency	0.75

Step 1: Calculate annual water use with old showerheads:

(5 showerheads) × (180 days/year) ×
(4 showers/day/showerhead) × (8 min/shower) × (2.5 gal/min)

= 72,000 gal/year

Step 2: Calculate annual water use with new showerheads:

(5 showerheads) × (180 days/year) ×
(4 showers/day/showerhead) × (8 min/shower) × (2.0 gal/min)

= 57,600 gal/year

Step 3: Calculate annual water saved by showerhead replacement:

72,000 gal/year – 57,600 gal/year = 14,400 gal/year

Step 4: Calculate avoided energy use due to showerhead replacement:

(14,400 gal/year) × (8.34 lb/gal) × (100°F - 60°F) ×
(1 BTU/lb-°F)

= 4,804,000 BTU/year

Step 5: Calculate reduced natural gas use due to showerhead replacement:

(4,800,000 BTU/year) × (1 ft^3/1,000 BTU) ×
(1 MCF/1000 ft^3)/0.75

= 6.405 MCF/year

Step 6: Calculate saved energy costs:

(6.405 MCF/year) × ($8.50/MCF) = $54.45/year

Step 7: Convert water and wastewater unit costs to cost per gallon:

($3.50/CCF + $4.00/CCF) × (1 CCF/100 ft^3) ×
(1 ft^3/7.48 gal)

= $0.01003/gal

Step 8: Calculate saved water and wastewater costs:

(14,400 gal/year) × ($0.01003/gal) = $144.43/year

Step 9: Calculate total annual expenditure savings due to showerhead replacement:

$54.45/year + $144.43/year = $198.88/year

Step 10: Calculate initial BMP (showerhead replacement) investment:

($25/showerhead) × (5 showerheads) = $125.00

Step 11: Calculate payback period:

($125)/($198.88/year) = 0.63 year

Step 12: Calculate ROI:

1/(0.63 year) = 1.59 or 159%

6.3.1.4 Internal Rate of Return (IRR)

The internal rate of return, or IRR, provides an indication of the efficiency or profitability of an investment. It is defined as the effective annual interest rate at which an investment accrues income. Based on an assumed investment and expected cash flow, the internal rate of return is the equivalent interest rate at which an investment would yield identical net profits. The IRR can be compared to the interest rate on borrowed funds or the rate of return possible from other investments. If IRR is higher than the company's or agency's cost of capital, expected rate of return, or discount rate, then the investment is deemed to be worthwhile.[3].

The IRR is the rate at which the net present value of the initial investment and subsequent cash flows is zero. Solving for this rate may be a trial and error computational process. While the IRR is useful for determining whether a single project is worth investing in, it cannot be used to compare mutually exclusive projects. The IRR can only be used under certain conditions. With a complex series of cash flows that change signs more than once, there is more than one mathematically feasible solution. In other words, the information from an IRR is not always meaningful.

6.3.1.5 Net Present Value Analysis

A business may also want to analyze the costs and benefits over the economic life of the device, 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 BMP 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 increasing costs of water, energy, or sewage disposal over the life of the equipment. This analysis may also include labor, tax, and insurance savings.

The net present value (NPV) is among the most common financial metric used in capital budgeting. It is based on the concept of present value, which is the conversion of future cash transactions into equivalent values in the present taking into consideration the time value of money. NPV is the sum of the present values of all costs and benefits over a time period and reports their value at the beginning of the project. For devices or facilities having a useful life, the time

[3] Note that the model calculates the IRR based on the undiscounted net cash flows. Therefore the resulting rate of return should be compared to the agency's undiscounted rate of return.

period should be the lifetime of the facilities, that is, the life cycle of the facilities. The NPV analysis has advantages over payback period and ROI methods in that is takes into consideration the time value of money, the useful life of the item being purchased or built, the sometimes complex variations in annual costs and benefits over time, and residual effects at the end of the useful life, such as disposal costs for a device. NPV is more useful for long-term investments.

The general formula for calculating present value is:

Equation 6.2

$$PV = C_t/(1 + i)^t$$

where PV = present value

C_t = cash flow in period t (income has positive value, outgoing has negative value)

t = number of time period following the present, e.g., years

i = interest rate per time period expressed as a decimal fraction, e.g., 0.07 for 7 percent per annum

The NPV is the summation of the present values of each cash flow during the period of analysis. The usual time reference point for present value analyses is the point of initial investment or start of a program, designated as time zero.

For a water conservation action, the costs include initial start-up or investment costs plus those needed to operate the conservation program, such as the cost of the rebate and program administration. While the costs typically accrue only during the duration of the conservation program, the benefits accrue over the life of the device. 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 business as the ROI or payback approach, but may become more applicable in the future.

6.3.2 Financial and Economic Analyses

Aside from technical feasibility, financial feasibility is probably the most prominent test of whether implementing a BMP makes business sense. Financial analyses are often viewed from different perspectives, including those of the utility and the customer. The focus of a financial analysis is on cash flow with the goal of remaining at least financially whole if not achieving greater monetary benefits than costs from implementing a BMP. In water resources economics, financial analyses are distinguished from economic analyses, which are viewed from the perspective of the community or society as a whole. An economic analysis looks beyond the perspective of any particular entity and incorporates benefits and costs that may not be realized when doing an analysis from the perspective of a single customer or water service provider. In simplified terms, a financial analysis addresses the question, *can* a project (such as a BMP) be implemented? An economic analysis addresses the broader question, *should* a project be implemented? (Mills and Asano, 1986/87)(Full citation for references: Mills, R. A., and T. Asano (1986/87), "The Economic Benefits of Using Reclaimed Water," *J. Freshwater*, 10: 14-15.)

The perspective and type of analysis determine which costs and benefits to include in the analysis. The water service provider and customer/business perform analyses based on costs and benefits to themselves. The societal perspective is based on costs and benefits to the water service provider and its customers and may also include external costs and benefits, such as recreational benefits to downstream communities created by leaving more water in streams and rivers or the avoided costs of alternative water supplies. This section focuses on the customer/business perspective. However, if a BMP is found to be economically justified from the societal perspective looking at all benefits and costs, regardless of who pays or receives the benefits, the goal of decision-makers is to develop the financial incentives, such as rebates, that will make a BMP financially attractive to the customer. The complexities of an economic analysis from the perspective of the community or society, including identifying who are the beneficiaries and who have the burden of paying the costs, is an important topic of water conservation but beyond the focus of this report.

The varying degrees of complexity, size, type of water use, technical needs, and inherent barriers to analyzing BMP costs for industrial equipment, processes, and plants, make a one-size-fits-all statewide assessment of costs to implement BMPs impossible. Therefore, this report outlines an approach that businesses may use to evaluate the costs and benefits of a particular BMP.

6.3.2.1 Overall Cost-Effectiveness Approach

To determine whether a BMP is cost-effective, the customer will need to assess the financial costs and benefits of implementing the BMP. This section describes an analysis looking at the true cost of water to a business or industry, examining the costs of implementing the BMP, and focusing on the balance of costs to benefits to reduce associated water costs. The true cost of water considers all costs to the customer associated with its use and disposal as it flows through the system.

A sample of applicable costs, benefits, and factors typically included in a financial analysis includes:

- Capital costs of installing the BMP (if it includes equipment)
- Changes in operation and maintenance costs including changes in water, wastewater, energy, waste disposal, pre-treatment, chemical, and labor costs

- Expected usable life of the measure
- Reduced risk factors

In addition, all rebates, tax liabilities (or benefits), and other related incentives and costs must be taken into account.

A variety of financial metrics can be used to determine whether a particular BMP makes economic sense. No single metric is perfect; rather each has strengths and weaknesses, and some combination of these indicators can be useful for financial planning. The basic goal is to determine if benefits to a specific industry or business outweigh the costs. Several methodologies are described in Section 6.3.1. The payback period, ROI, and IRR methods provide guidance on a short time scale, helping to determine if a proposed modification is worth the investment. Longer-term analyses look not only at the costs and benefit, but also at lifecycle factors such inflation and useful life, and the net present value approach is more useful.

Many firms set a simple payback criterion of two years to four years or less unless the life of the device is shorter. If a firm's business plan defines three to four year paybacks as cost effective, the return on investment is 25-33 percent on investment. If a business using a more efficient device does not own the building or the equipment, some issues with the economics of payback become more challenging.

As another example of calculating the cost-effectiveness using the near-term methodologies, replacing a 3.5-gallon per flush toilet with a 1.28-gallon per flush toilet saves 2.22 gallons per flush. Assume the combined water and sewer cost for that toilet is $6.50 per CCF, or $8.69 per thousand gallons, or 0.869 cents per gallon. Therefore, this saves 1.93 cents per flush. If the toilet is flushed an average of 35 times per day and the building is open 255 days a year, installing the 1.28 gallons per flush toilet will save $172.18 in water and sewer costs each year. If the total installed cost of the toilet (toilet and labor) is $275.00, the payback is 1.6 years ($275 / $172.18). The return on investment is the percent of payback the BMP produces per year. In this example, the ROI is 62.5 percent per year (100 / 1.6).

6.3.2.2 Factors Affecting Cost Considerations

There are long-term trends that should be considered when evaluating a BMP. Some can be quantified on a cost basis to incorporate into the cost analysis directly and others are nonmonetary benefits or factors that must be weighed along with the cost analysis.

Increased Water Rates

Water shortages and development of costly water supplies will result in increased water rates. Implementing water use efficiency measures will reduce the demand on the local water supply and the need to develop costly future water supplies, which may reduce the long-term costs of water to the business. Large water users are likely to feel the greatest impacts of increased water rates. Predicting water rates is not an exact science since water agencies have many factors influencing rates, such as supply, conservation pricing, operational costs, capital costs, bonds, and employee salaries and benefits. In addition, water is priced differently throughout the state because water sources, infrastructure, and reliability vary. However, water and garbage rates are increasing on a percentage basis faster than all other utilities, and therefore, decreasing water demand will have a greater effect over time. The National Utility Service, Inc. (NUS Consulting Group) annual survey shows that between 2004 and 2008 water and wastewater costs

nationwide increased by an average of 6.5 percent a year, far more than consumer price index inflation.

Figure 6.1 shows that national water and wastewater rates are increasing faster than the consumer price index and other utility rates. Water and wastewater rates have risen faster than fuel prices over the same period, according to information from the U.S. Department of Commerce. A number of factors are driving this trend, including limitations on the availability of conventional fresh water resources, needed investment in aging water and wastewater infrastructure, increases in water quality and compliance costs, and climate impacts. Water users may want to occasionally reassess the cost effectiveness of implementing BMPs as water and sewer rates and other cost increases.

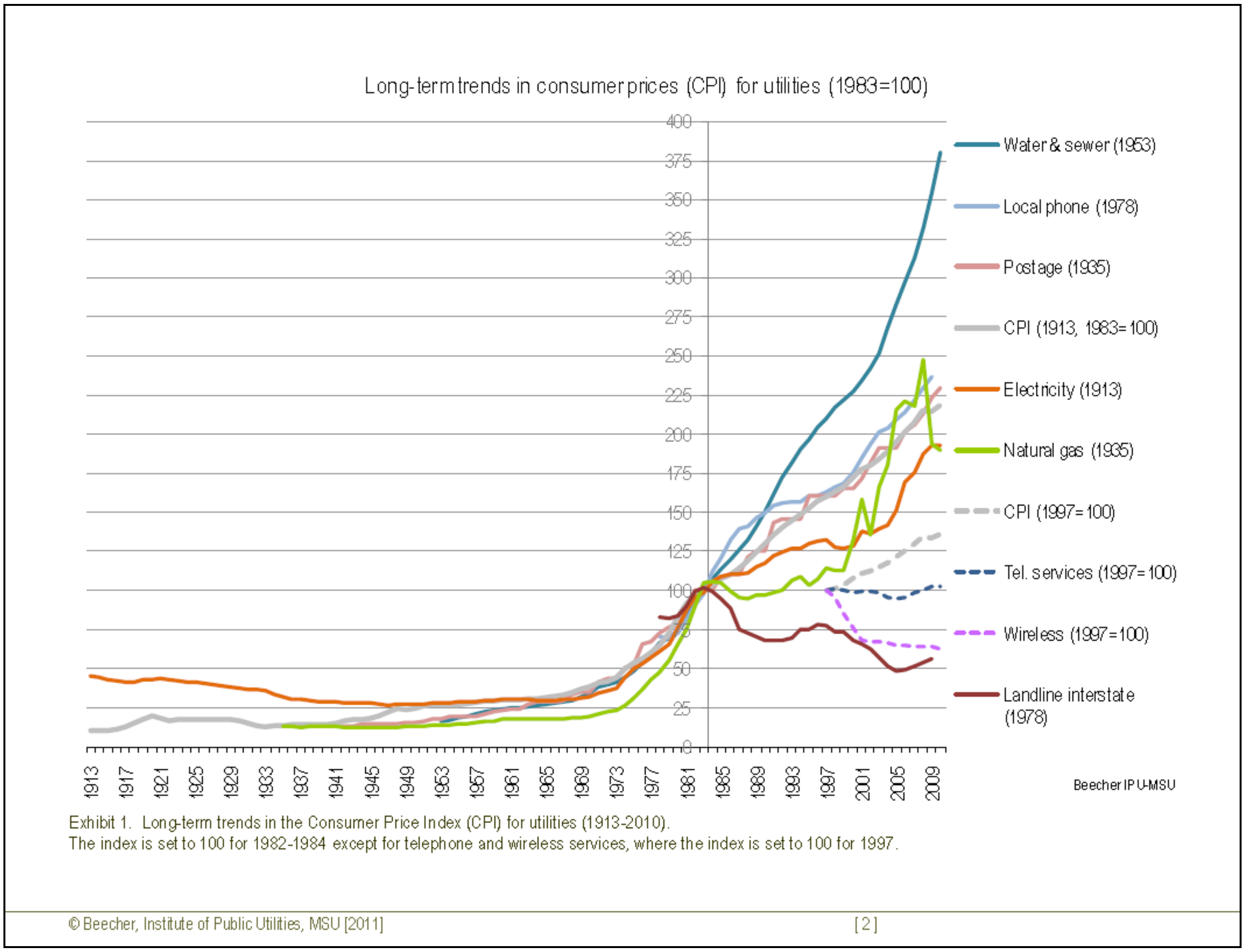


Figure 6.1 - Consumer Price Index for Utilities

These increases should be factored into the lifetime cost analyses. To take these increased water costs into account, the net present value method is the best approach. In this situation, the cost of the retrofit will remain the same, but the actual savings will include expected increases in water and wastewater costs over the anticipated useful life of the BMP. Where energy, chemical, labor, tax, insurance, and other savings are costs are involved, they would also have to be included. With many measures, the costs are incurred in year one while the benefits accrue in subsequent years. For this reason, the discount rate is used. Rising water and wastewater rates would be taken into account as escalation factors.

Replacement of Outdated Equipment

As improved technology becomes available, CII entities may decide to upgrade their water-using equipment, fixtures, and machines as a cost-effective measure when they reach the end of their useful life. Older equipment by design will typically use more water, energy, chemical, and wastewater than newly designed equipment. As a good business practice, the CII business should evaluate the equipment and the maintenance and operational practices needed to achieve an industry standard of water use efficiency for the new equipment being purchased.

Geographical Variability

Water, wastewater, and energy costs are continually increasing, have significant variations across the State (Figure 6.2), and are increasingly becoming a larger component of a business' bottom line. How water is used at a specific location, variations in plant design for similar types of facilities, and past conservation efforts all further affect the cost-effectiveness calculations for any given BMP. As shown in Figure 6.2, rates also vary significantly from one utility to another in California, meaning that a BMP that may be cost-effective in one area may not be in another.

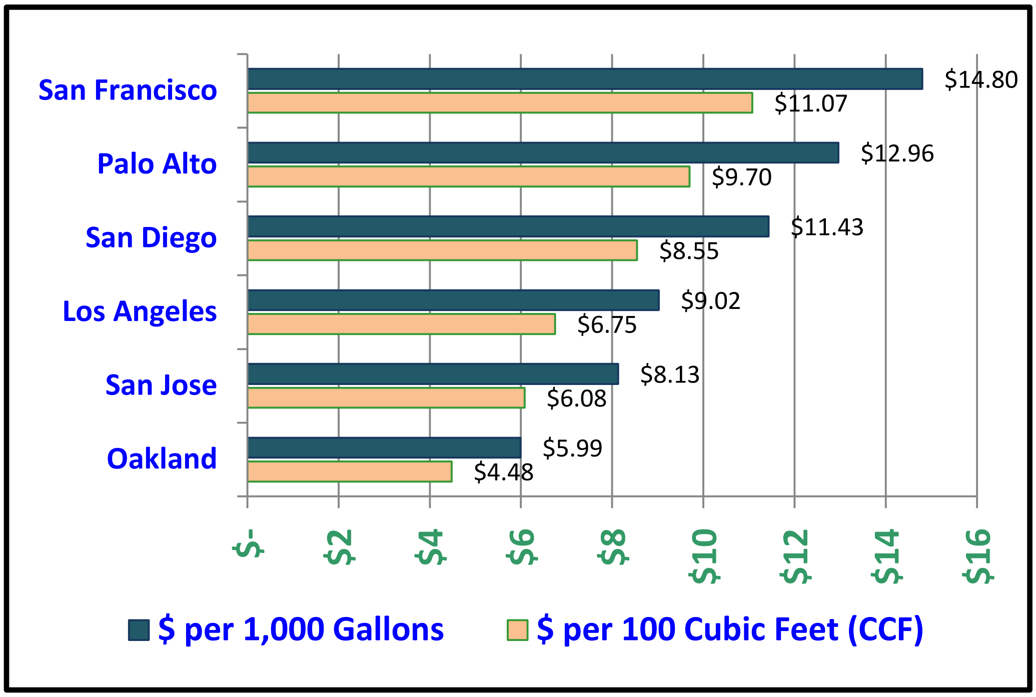


Figure 6.2 - 2011 Combined Commercial Water and Sewer Rates

Consideration of Risk Factors by Businesses

When making a business decision, an economic analysis forms the primary basis for making decisions. However, when considering whether to make an investment in water use efficiency, a business may also want to look at other factors that are not as simple to quantify. Businesses may consider the external risks on the business that would be associated with taking no action. These risks may include reduced reliability, potential for future mandates, costs, and reputational risks or benefits. Assessment of these risks will require close communication and cooperation between the business community and its local water service provider. While it is possible to quantify the risk, doing so would require complex analysis and modeling which may require excessive effort to complete.

- **Reliability of Water Supply -** A business may want to consider the reliability of the local water supply in the region or community, the possible impacts of disruptions in the water supply, or a lack of adequate supply would have on the operations and the long term profitability of the company. This assessment would be based on the conditions of the local utility supplying water.
- **Reputational Risks and Benefits -** A business with a large presence in a community generally strives to maintain a positive reputation and good relations with the rest of the community. In communities experiencing water shortages, particularly where users are subject to restrictions, the ability for businesses to demonstrate efficient water use will help maintain a positive reputation in the community In addition, many businesses have been proactive in being good environmental stewards to better market their company. Companies that have taken this approach can include water use efficiency as a priority in demonstrating their environmental stewardship.

6.4 Potential Water Savings by Implementation of the BMPs

Many CII entities in California are already practicing up-to-date water efficiency techniques. Others have a real opportunity to further reduce water use economically. The selection and implementation of these BMPs is determined by the economics and design of individual facilities. The issue of statewide assessment of potential water use efficiency is addressed first, then examples of water use savings from BMP implementation are presented.

6.4.1 Potential Statewide Water Use Efficiency Improvement

A number of factors are involved in assessing the potential statewide water use efficiency improvement in the CII sectors that would result from BMP implementation:

- Savings potential from application of an individual BMP.
- Existing penetration levels of a BMP, that is, the degree of current use of a BMP.
- The penetration potential of a BMP, the maximum potential applications of a BMP where it would be cost-effective.
- The total water use in particular CII sectors or subsectors or in particular common CII processes where a BMP would be used, to assess water use efficiency improvement.

As has been emphasized in Section 5.0, Water Use Metrics and Data Collection, the State does not currently have the data necessary to establish baseline water use in each CII sector or subsector. Because of the variability of process designs and the number of potential applications of particular BMPs (penetration potential), the CII Task Force could not estimate the potential water savings statewide for most BMPs. One of the major objectives of section 5.0 is to suggest the use of metrics and better data collection to begin making statewide assessments of CII water use efficiency improvements over time and to provide comparative data that CII entities can use to assess their efficiencies relative to other similar entities. In most cases, the information needed to estimate statewide savings must await the development of the baselines and metrics recommended in this report.

6.4.2 Examples of Potential Water Savings from BMPs

Demonstrating water savings that have actually occurred from implementing BMPs has been an easier task where data have been collected or maintained by water service providers or individual CII entities. Two examples of statewide achievement illustrate what such analysis has to offer. The first statewide example is the California Department of Corrections and Rehabilitation (CDCR), which is described in Section 7.1.6, Prisons and Correctional Facilities of this report. CDCR has already realized a 21 percent reduction totaling over 2.4 billion gallons of water annually (7,365 acre-feet annually). The second example is found in the Section 9.0, Public Infrastructure Needs for Recycled Water. Based on a statewide survey of 2009 recycled water use, almost 670,000 acre feet (af) (218 billion gallons) of water are being recycled annually, of which 224,700 AF of recycled water were used directly in CII applications.

Numerous examples to illustrate potential water savings are described in Section 7.0 on BMPs and in case studies in Appendix C. The reader is urged to read these examples and case studies to assess how BMPs might benefit a particular CII entity.

The BMPs may involve a range of implementation approaches from maintenance adjustments and equipment replacement to alternative water supply use. Five such approaches are illustrated below.

1. **<u>Adjustment of equipment and repair of leaks</u>**
   Adjustments and repairs can be made to existing equipment and processes so that they operate more efficiently. For example, in Section 7.3.6 General Building Sanitation, an example is given of the Park 55 Wyndham Hotel in downtown San Francisco. Its toilet retrofit resulted in a more water savings than expected based on "engineering" estimates because leaks and faulty equipment were also fixed. In another example, Eagle Food in Sun Valley, California audited its facility and implemented the following measures:

   - Restrict water flow at hose stands – Eagle Foods installed flow control valves to reduce water flow from 7.5 gallons per minute (gpm) to 3.5 gpm.
   - Use water brooms instead of hoses to wash down for sanitary purposes.
   - Install hose bib connectors to reduce leakage at water tanks.
   - Replace cracked hoses as needed to reduce leakage.

   The first two measures are examples of modifying or installing more efficient equipment, and the last two measures reduced leaks. The combination of measures resulted in savings of nearly 7,264 gallons per day (see Eagle Foods case study in Appendix C).

2. **<u>Modification of equipment or installation of water saving devices and controls</u>**
   Devices, automated systems, or equipment can be added to existing water using equipment and processes. For example, the Los Angeles County, Department of Parks and Recreation installed weather based controllers, rain sensors, and a monitoring system at its El Cariso Park & Golf Course and Veterans Park. This resulted in a 27 percent reduction in water use equivalent to 198 AF (64.5 million gallons) a year.

   Artistic Plating and Metal Finishing, Inc. of Anaheim, California installed electrode-less conductivity controllers on nine tanks on the plating line. This reduced water use by 49 percent and also reduced chemical costs by 20 percent. The total cost for these improvements was

$14,500, however, because it saves $13,800 per year, the payback is only 13 months.

3. **Replacement with more efficient equipment**
Replacing older inefficient water-using equipment and fixtures with water saving types of equipment is one of the most recognized ways to reduce water use. For example, in the General Building Sanitation section of this report, an estimate of total potential statewide water savings that could result from the replacement of existing CII toilets with high-efficiency toilets was made in 2005. That analysis estimated the water savings potential as being between 26,000 and 38,000 acre-feet per year (AFY). Another 3,000 to 5,000 AFY could be saved through legislation, codes, and standards applied to new construction. In a similar manner, installing a clean in place (CIP) system in a food processing plant can cut the water use by half for washing pipes and vessels.

4. **Alternative water supplies and internal recycling**
There are many examples of using treated municipal wastewater in California showing the potential for using this non-potable water source, as described in Section 9.0. Examples of other alternative supplies range from the low impact stormwater management options being used in San Diego County, California to rainwater harvesting and air conditioning condensate recovery throughout the United States. The food processing industry also has many examples of reusing effluent for crop irrigation. Recycling of water in cooling towers is also common reuse of water.

5. **Change to waterless process**
There are many examples of BMPs where water using equipment is replaced with equipment that does not use water. From section 7.3.3 Thermodynamic Processes in this report, using air cooling and ground effect (geothermal) air conditioning systems eliminates cooling tower water use entirely. In conventional cooling towers, approximately 2.5 gallons of water are used per ton-hour of cooling. A large office building with a cooling tower can require 20,000 to 30,000 gallons of water per day during the hottest part of the summer.

   The use of dry vacuum pumps in laboratories and medical facilities offers another waterless process example. In recent years, most major radiology departments in hospitals have converted to digital imaging because of its superior medical diagnostic capabilities, eliminating water used by large plate X-ray film development. This can save as much as 500,000 gallons of water per year per film developer.

6.4.3 Calculation of Water Saving Potentials

There are some BMPs that have easily quantifiable water savings at the end use. If it is also possible to quantify the number of actual and potential applications of a BMP either within a particular water use sector or statewide, that is, the penetration rates, then it may be possible to estimate the potential water savings resulting from implementing a BMP within a water use sector or statewide. The Pacific Institute (2003) provided the following method to estimate the Percentage Water Conservation Potential (S):

Equation 6.3

$$S = 100[(1-p)c]/(1-pc)$$

Where p is the current Penetration Rate of the BMP; and c is the ratio of conservation potential or Technical Ssavings that can be achieved with each application of the BMP.

Using the water saving for toilets as an example to illustrate the above formula, suppose a small community has 50 toilets total with ten toilets at 1.6 gallons per flush and 40 toilets at 3.5 gallons per flush. Also suppose that the lower flush rate (1.6 gallons) meets the best management practice. The Technical Savings, c, is calculated as (3.5-1.6)/3.5 = 0.543, and the Penetration Rate, p, is calculated as 10/50 = 0.20. We can thus calculate the Percentage Water Conservation Potential:

Equation 6.4

$$S = 100[(1 – 0.20) \times 0.543]/(1 – 0.20 \times 0.543) = 48.7\%$$

After obtaining S, we can calculate the Annual Water Saving of the community by multiplying S by the Current Annual Water Use. Assuming the Current Annual Water Use is 0.5 million gallons (MG), the Annual Water Saving Potential = 0.5 MG x 48.7% = 0.2435 MG or 243,500 gallons per year.

Applying Equation 6.3 to a BMP, in order to calculate the Percent Water Conservation Potential, S, and the Annual Water Saving Potential in 2010 statewide in CII sectors, we need the current Penetration Rate, p, and Technical Potential, c, as well as the current water use in each NAICS sector. For most BMPs there are insufficient data to make statewide estimates of savings.

6.5 Conducting the Audit

To determine which BMPs will be effective for a given business or industry, a CII facility should either conduct a water audit itself or obtain the services of a professional consultant trained in this area. This report provides CII water users with potential BMPs they can consider to reduce water and wastewater bills and to help reduce water use, but it is up to the entity to evaluate specific circumstances.

Many facilities managers have found that they can begin the audit by reviewing water and wastewater bills and comparing their use to similar facilities that their company may operate. To truly understand a facility's water use and the value of increased water efficiency, a more thorough analysis is required. A suggested audit process is illustrated in Figure 6.3. The audit should include the current overall water use by the facility, including water use by location and types of water-using equipment. The the following seven important questions are addressed in the audit:

- How much water is the facility using?
- Where in the facility is the water being used?
- When is the water being used?
- How and for what is it being used?
- Who controls its use?
- Why is water needed here?
- Are there other ways to do the same work that do not use water?

Once these seven questions have been answered, the facility manager can evaluate methods of reducing water use. The financial feasibility methodologies provided above in this section can assist in the evaluation. The first step is to repair malfunctions and leaks. Following loss reduction, the best ways to reduce use entails a comparative assessment of available options. The BMPs in this report are one source of these options. Generally, these options fall into one of five measures, starting with the lowest in cost:

- Adjust existing equipment to use less water
- Modify existing equipment or install a water saving device
- Replace existing equipment with more efficient models or types
- Reuse and recycle water or use alternate water supplies where possible
- Choose equipment or methods that eliminate water use

One potential method of reducing potable and freshwater use, for example, is to use recycled water if it is available from a public utility. The use of recycled water may require dual plumbing. Economic incentives and reduced rates for the use of recycled water are available from some water suppliers.

Another way to reduce potable and freshwater use is to examine how water may be reused within a facility. This reuse can span from industry process water to the capture of rainwater or using air conditioning condensate for irrigation or in a cooling tower. The following decision table can help the facility manager or engineer identify all water uses, the water quality needed for that operation, and the water streams from their operation to see if they may be candidates for reuse.

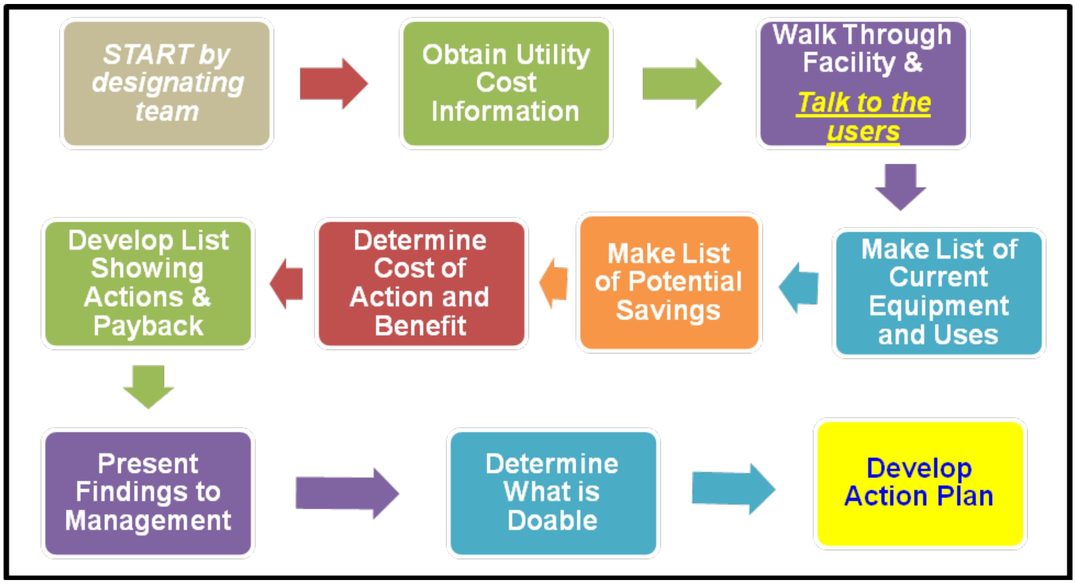


Figure 6.3 - The Audit Process

7.0 Commercial, Industrial, and Institutional Sectors and Best Management Practices

This report is generally intended to help businesses be more water efficient by providing information on water-saving technologies and best management practices (BMPs) applicable in the commercial, industrial, and institutional (CII) sectors. The information in this section is intended for use as a resource for:

Note, the BMPs discussed in this report are not the same BMPs that are reported to the CUWCC.

- Existing and new businesses
- Developers, consultants, and designers
- Water service providers
- Planning agencies

Since technology and practices change over time, the information in this section is intended and recommended to be updated periodically.

This section provides the CII sector with valuable BMP information to capture the multiple benefits of reduced costs for water, energy, wastewater, and onsite water and wastewater treatment facilities. Also provided is information on landscape water use efficiency practices, since outdoor water use is an important issue and may represent a significant percentage of use for any given CII entity. Recommendations include the use of alternate water sources for certain applications, and many of the BMPs can be applied to other CII entity types not specifically addressed herein.

The BMPs included in this report have been implemented and demonstrated to be technically feasible.

This section of the report, Volume II, contains an in-depth description of the hardware and processes associated with water-use efficiency improvements for various types of CII entities, along with a series of proven example case studies. The information provided includes references on where to find additional technical data and recommendations.

The Best Management Practices are divided into three distinct sections:

1. Section 7.1 contains BMPs related to common CII sectors.
2. Section 7.2 contains BMPs related to specific industrial sectors, which the CII Task Force determined were responsible for a significant amount of water use in California.
3. Section 7.3 contains BMPs related to common water uses found among many CII sites.

The sources for the information about CII BMPs found in Volume II include: the US EPA WaterSense® program, the CUWCC's potential BMP research projects, the Federal Energy Management Program (FEMP), and the Consortium on Energy Efficiency (CEE). Also included is research performed by academia, CII

Associations, and other industrial sources using statistically and scientifically defensible methods and professional expertise. A wide number of sources were considered and are cited in association with the BMPs to which they relate. When available, general information about the size of the CII sector and its associated water uses is included with the BMPs. Many CII factors affect water use and the water use efficiency potential. Some applicable business factors include the size, type, and location of the CII entity, the relative market impacts of the general economy, and for some uses, weather. There are also differences in the price of water and relative ease of use or reuse of treated effluent or alternative water resources (rainfall, stormwater, and onsite reuse of water), which are covered in greater detail in this volume.

The BMPs included are technically feasible because they are in use.

7.1 Commercial and Institutional Sectors

This section summarizes BMPs for specific water uses within the typical CII sectors. These range from commercial food service and laundries to carwashes and offices. Information is organized to be useful both for those who are intending to implement or to assist in BMP implementation and for those concerned with the overall potential for water use efficiency and conservation.

The level of detail varies for each CII sector discussion and BMPs, depending upon the availability of reliable information and system complexity. Each discussion presents water use efficiency BMPs for both equipment and processes. Where information is available and applicable, equipment retrofit and replacement BMPs are addressed separately; improvements in maintenance or management practices and design options are identified; and, water use efficiency standards (e.g., regulatory requirements, Energy Star®) that can be applied to the equipment being used are addressed. Additional detail can be found in Volume II Section 7 and Appendix A.

7.1.1 Commercial Food Service

Overview

According to information from the National Restaurant Association and the 2003 Census, California has more restaurants than any other state. Table 7.1 shows the ranking and restaurants per capita for each state based on that study. California, New York, Texas, and Florida account for one third of all restaurants in the United States.

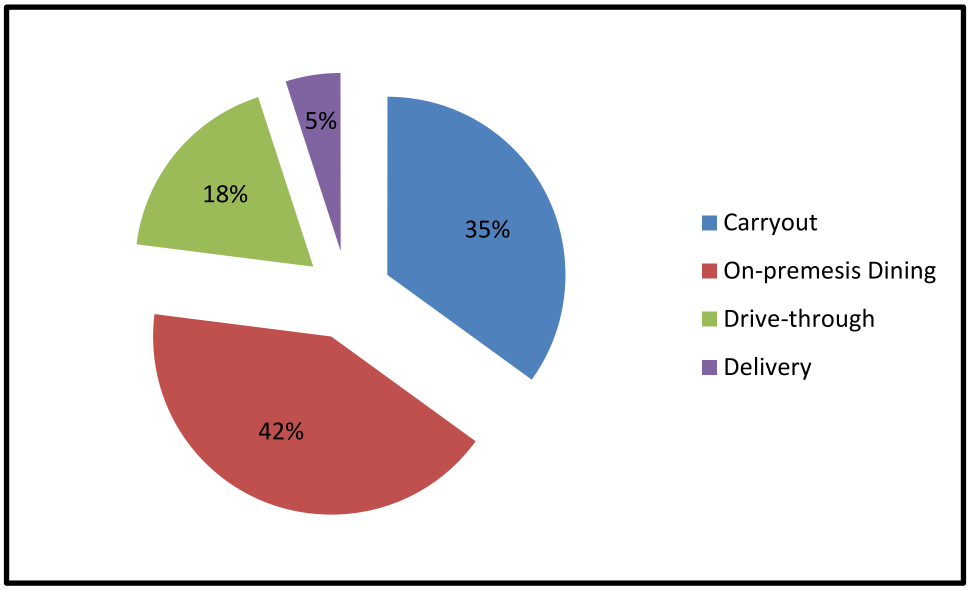
Table 7.1 - Top Five States by Number of Restaurants in 2003

State	Number of Establishments	Restaurants per 1,000 Population
California	87,225	2.41
New York	58,027	3.01
Texas	53,631	2.35
Florida	41,901	2.36
Pennsylvania	31,466	2.53
National Totals	**714,232**	**2.41**

Source: National Restaurant Association and 2003 U.S. Census information (http://en.wikipedia.org/wiki/List_of_US_states_by_number_of_restaurants_per_capita)

As Table 7.1 shows, California had approximately 12 percent of the restaurants in the United States in 2003. Based upon the above table, the seven-year increase in population, and other information, there may have been as many as 87,000 to 92,000 restaurants in the state in 2010.[4]

The national distribution of restaurants by type, as shown in Figure 7.1, is considered to apply to California.



Source: University of Georgia, Business Outreach Services, 2002 as reported in Koeller and Company, 2010.

Figure 7.1 - U.S. Distribution of Restaurant Customer Traffic (2001)

In addition to the restaurant types shown in Figure 7.1, there are numerous institutional food service establishments such as schools, prisons, municipal buildings, and military mess halls. According to State of California data, the state is also home to 9,972 public schools, 3,782 private schools, over 200 universities and colleges, and several hundred jails and prisons.[5] Military facilities include 21 Army, Navy, Marine, and Air Force installations, along with several dozen Coast

[4] Does not account for closures due to 2010-2011 economic conditions
[5] Koeller and Company. 2010. *A Report on Potential Best Management Practices —Commercial Dishwashers, for the California Urban Water Conservation Council.*

Guard facilities.[6] Many of the food service operations in these facilities are operated by "managed services companies," but a large percent is self-operated. With the addition of bars, the number of California’s food service facilities easily exceeds 100,000, A large percentage of these facilities have commercial dishwashers.[7]

Kitchens in commercial and institutional facilities use a variety of practices, technologies, and equipment to prepare food, manage food waste, and maintain sanitary and safe conditions. The amount of water used in these activities depends largely upon the type of technology applied and the volume of food produced, although user practices play a large role as well.

Water use characteristics and BMPs of ware washing (scullery) and food preparation, within the context of overall food service operations, are covered in the following subsections:

- Garbage grinders
- Pre-rinse spray valves
- Dishwashers (ware washers)
- Washing and sanitation
- Ice machines
- Combination ovens
- Dipper wells
- Steam cookers
- Steam kettles
- Wok stove

Scullery Operations

Within the food service sector, it is important to understand how the ware washing process begins and how it may affect total water use for a food service establishment. First, some smaller food service establishments and many fast food restaurants that serve on disposable ware do not use an automatic dishwasher. Instead, they depend upon the “three-compartment sink” to wash pots, pans and other cooking utensils. However, almost all other restaurants and food service establishments, of any size, use commercial dishwashers.

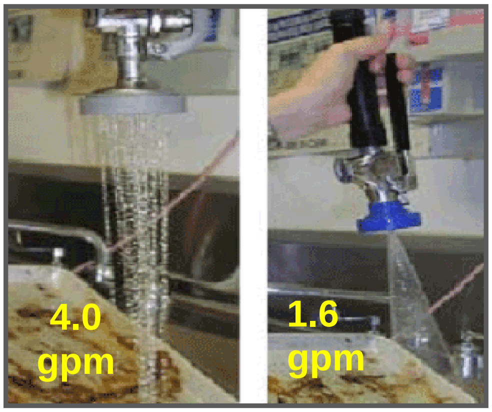
Water use in the scullery operations can include:

[6] Koeller and Company. 2010.
[7] Koeller and Company. 2010.

- Waste transport in sluice troughs
- Garbage disposal with grinders, pulpers, and similar equipment[8]
- Pre-rinsing of dishes prior to washing
- Soaking of pots and pans in special equipment
- Washing pots and pans either by hand or in a dishwasher
- Cleaning and sanitation of the scullery work area

One water-using area found in almost every restaurant is the three-compartment sink. Many use these sinks for washing pots and pans or "pre-cleaning" them prior to placing them in a dishwasher.

The first scullery step in most restaurants and food service establishments is to scrape the dish, pot, pan, or tray into a garbage can. However, some facilities only remove the silverware and paper and cloth items, and then use sluice troughs, which feed into a garbage disposer. Flow rates in these troughs can range from 2.0 gallons per minute (gpm) to over 15 gpm, depending on how many nozzles flow into the trough to wash the food waste towards the disposal.



Pre-rinse spray valves (PRSVs) are used to rinse dishes prior to their being placed in the dishwasher. Since 2005, the Federal energy policy act (EPAct) has required that spray valves use no more than 1.6 gpm. New models have even lower flow rates.[9] The photos on the left show an old type spray valve using four gallons per minute while the picture on the right shows one using only 1.6 gallons per minute.

Another water-using device found in some larger facilities is a powered pot-soaking tank. Pots and pans are placed in the tank containing hot water with a special detergent. Pumps circulate the water around the tank softening cooked-on food deposits. These tanks are normally filled at the beginning of the day and dumped down the drain at the end of the day. In especially busy restaurants, the tank may need dumping and filling more often.

[8] It should be noted that garbage grinders (disposers) are prohibited in some jurisdictions.

[9] Anecdotal information from the field indicates that, in some cases, PRSV flow rates below 1.3 gpm may result in longer cleaning times and user dissatisfaction. The U.S. EPA's WaterSense program will be releasing a draft specification for PRSVs that will likely set the maximum flow rate near 1.3 gpm. Before purchase of a PRSV designed to operate at less than 1.3 gpm, the food service operator should field trial the unit to ensure that it will operate satisfactorily, particularly if the facility experiences low water pressure.

Food Service and Preparation Operations

Commercial and institutional food service practices can also affect water use. These include practices such as ice making and service line rinsing operations. Food preparation (cooking) can affect water use, depending on the type of cooking devices used; some commercial cooking equipment use water to directly cook food, generate steam to cook food, or to cool equipment or steam condensate.

Technical Feasibility

All of the practices, products, and technologies described within this section have been in existence for an extended period of time and found to be technically feasible. In each case, however, economic feasibility must be evaluated within the context of the physical condition and demands of the specific property or building food service operations.

7.1.1.1 Garbage Disposal

Overview – *Garbage Disposals*

Garbage disposal is the first step in the scullery process. As mentioned above, this can include scraping waste from service ware into a garbage can or use of a sluice trough to wash scraps into a garbage disposal unit.

Types of Equipment – *Garbage Disposals*

Four major types of garbage disposal systems are typically used in commercial and institutional food service. These consist of devices to either grind up waste to wash into the sanitary sewer system, trap waste for off-site disposal, or a combination.

Garbage Grinders

Garbage grinders are found in many restaurants. The purpose of a grinder is to break the food waste into small particles that are then mixed with water. This mixture is then discharged to the sanitary sewer. The use of grinders increases the loading on wastewater treatment plants and, as such, wastewater utilities vary in their support for using these scullery appliances. Also, solids will build up more rapidly in a grease trap if the waste passes through the grease trap. Because of this build up, some cities have either banned grinders or placed excess sewer charges on operations using grinders. Grinders, however, *do* remove food waste from the solid waste disposal stream, an advantage in some cities; Some jurisdictions are concerned that food waste placed in dumpsters may attract rodents and flies and increase solid waste disposal volume. They, therefore, encourage use of grinders. Others encourage composting of food scraps.

Food Waste Pulpers

Food waste pulpers are used by some entities to collect food scraps and extract water from the disposal process. They are located where a grinder would otherwise be located and can recover the extracted water for reuse in pre-rinsing dishes and act as a sluice trough where food wastes are dumped. When a recirculation system is used, pulpers recirculate between 5.0 to 15 gallons per minute (gpm) of water through the system; fresh makeup water rates are typically below 2.0 gpm.

Food Strainer

An alternative to the mechanical systems discussed above is the simple scrap basket or strainer basket system. Strainer baskets can either be an under-the-sink type, as the one pictured here, or simply a basket with holes or slots in it placed in a sink. Food scraps are emptied into a garbage can for solid waste disposal or composting.

Salvajors

Another system, called a Salvajor, works similarly to a pulper and can recirculate water for sluicing of food scraps, but it uses a strainer basket system to collect food waste for disposal as solid waste.

The choice of waste disposal methods affects energy and water use in the scullery operations. Table 7.2 summarizes the water, energy, and solid waste considerations for each disposal method.

Table 7.2 - Summary of Four Waste Disposal Methods

Parameter	Grinder	Salvajor	Pulper	Strainer Basket
Solids to Sewer	Yes	No	No	No
Recirculate	No	Yes	Yes	No
Strain Solids	No	Yes	Yes	Yes
Compost Produced?	No	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

Operation, Maintenance, and User Education BMPs – *Garbage Disposals*

For optimum garbage grinder efficiency, consider the following:

- Turn off the water during idle periods when the unit is not in use and when the facility is closed.
- Scrape larger food scraps into a trash receptacle prior to rinsing food waste into the disposal unit. Consider composting food waste if appropriate.

- Never pour grease into the garbage grinder unit, as this will lead to clogged drain lines.
- Do not place any hard objects into the unit. This can dull the blades, reducing the unit's efficiency.
- Always run cold water through the garbage grinder unit during its use. Hot water may damage the unit. Cold water helps to keep the unit cool.
- Regularly inspect and clean the unit to make sure the blades are sharp and the unit is not clogged with debris.

Retrofit BMP Options – *Garbage Disposals*

To reduce the water use associated with a traditional garbage grinder disposal unit, consider installing a device that can sense the grinder motor's load and regulate the amount of water necessary to complete the disposal task. These devices can reduce the idle flow rate when the garbage disposal is not in use, from between 2.0 to 15 gpm under non-regulated conditions, to as low as 1.0 gpm with a load regulator, saving a substantial amount of water. Also, consider installing a timer to stop the flow of water to the grinder after 15 minutes, requiring the user to periodically reactivate the system.[10]

Replacement BMP Options – *Garbage Disposals*

When purchasing a new garbage grinder unit or looking to replace an existing unit, consider these options:

- Purchase a garbage grinder with a load sensor that regulates the amount of water conveyed through the unit based upon its use.
- Install a food pulper or food pulper/strainer combination system (Salvajor), which can recirculate 75 percent of the water used for the food disposal process.
- Replace mechanical food disposal systems with food strainers, which use little to no water.

Savings Potential – *Garbage Disposals*

A conventional garbage grinder connected to a sluice trough can use more than 650,000 gallons per year and cost a facility more than $4,500[11] in water and sewer bills. This water use can be significantly reduced either through a retrofit with a load sensor to regulate and reduce the amount of water used by the existing garbage grinder during idle mode *or* by replacing the unit with a food

[10] East Bay Municipal Utility District. 2008. *Watersmart Guidebook — A Water-Use Efficiency Plan Review Guide for New Businesses*. Pages FOOD 9-11.
[11] Assumes a water and sewer rate of $7.16 per 1,000 gallons. From: Raftelis. 2009. *Water and Wastewater Rate Survey*.

pulper or food strainer. To estimate facility-specific water savings and payback from retrofits and replacements, use the following information:

Conventional Garbage Grinder Retrofit – Load Regulator

Conventional grinders can be retrofitted with a load regulator to reduce the idle water flow rate. Depending upon the original flow rate and load regulator, idle water use can be reduced by 50 to 90 percent.

Current Water Use

To estimate the current water use of an existing garbage disposal during idle periods, identify the following information and use Equation 7.1 below:

- Flow rate of water through the garbage disposal. This flow rate typically ranges from 2.0 to 15.0 gpm.
- Average daily idle period of the garbage grinder. The idle period is the time when the unit is turned on but not in use. While this time will vary by facility, some estimates indicate that garbage grinders are typically in a fully operating mode about three hours per day. For a commercial food service facility operating 12 hours a day, this would mean an idle period of nine hours if the garbage disposal is kept on throughout the day.[12]
- Days of facility operation per year.

Equation 7.1

Water Use of a Garbage Disposal During Idle Use (gallons/year) =
Flow Rate (gallons/minute) X Daily Idle Period (minutes/day)
X Days of Facility Operation (days/year)

Water Use After Retrofit

To estimate the water use from an existing garbage grinder that is retrofitted with a load sensor during idle period, use Equation 7.1, substituting the reduced idle flow rate. A load sensor can reduce the idle flow rate when the unit is not in use to as little as 1.0 gpm.

Water Savings

The expected water savings is determined by subtracting the water use after retrofit from the current water use.

Payback

[12] East Bay Municipal Utility District. 2008. *Watersmart Guidebook—A Water-Use Efficiency Plan Review Guide for New Businesses*. Pages FOOD 9-11.

To calculate the simple payback for retrofitting an existing conventional garbage grinder, identify the following information and use Equation 7.2 below:

- Equipment and installation cost of the retrofit load sensor.
- Water savings as calculated above.
- Facility-specific cost of water and wastewater.

Equation 7.2

Payback (years) = Equipment and Installation Cost ($) /
[Water Savings (gallons/year) X Cost of Water and Wastewater ($/gallon)]

Conventional Garbage Grinder Replacement – Food Pulper

Conventional garbage grinders can be replaced with a food pulper. A food pulper can recirculate and reuse up to 75 percent of the water used for the food disposal process, thus reducing the potable water required to operate the garbage disposal unit.

Current Water Use

To estimate the current water use of an existing garbage disposal, identify the following information and use Equation 7.3 below:

- Flow rate of water through the garbage disposal unit. This flow rate typically ranges from 2.0 to 15.0 gpm.
- Average daily use time of the garbage disposal unit. While this time of use will vary by facility, some estimates indicate that garbage disposals are typically in full operation a total of three hours per day.
- Days of facility operation per year.

Equation 7.3

Water Use of a Garbage Disposal In Use (gallons/year) =
Flow Rate (gallons/minute) X Daily Use Time (minutes/day)
X Days of Facility Operation (days/year)

Water Use After Replacement

To estimate the water use of a replacement food pulper, use Equation 7.3, substituting the flow rate of fresh water through the food pulper. The fresh water flow rate through a food pulper is typically 2.0 gpm.[13]

[13] East Bay Municipal Utility District. 2008. Watersmart Guidebook—*A Water-Use Efficiency Plan Review Guide for New Businesses*. Pages FOOD 9-11.

Water Savings

The expected water savings is determined by subtracting the water use after replacement from the current water use.

Payback

To calculate the simple payback from replacing a conventional garbage grinder, identify the following information and use Equation 7.2:

- Equipment and installation cost of the replacement food pulper.
- Water savings as calculated above.
- Facility-specific cost of water and wastewater.

Conventional Garbage Grinder Replacement – Food Strainer

Conventional garbage disposals can be replaced with a food strainer. Since a food strainer does not use water, installing a food strainer to replace an existing garbage grinder unit can completely eliminate water use.

Current Water Use

To estimate the current water use of an existing garbage grinder, use Equation 7.3.

Water Use After Replacement

A food strainer can completely eliminate the use of water for the food disposal process.

Water Savings

In the event of complete replacement, water savings would be equal to the current water use.

Payback

To calculate the simple payback from replacing an existing conventional garbage disposal with a food strainer, identify the following information and use Equation 7.2.

- Equipment and installation cost of the replacement food pulper
- Water savings as calculated above.
- Facility-specific cost of water and wastewater.

7.1.1.2 Pre-Rinse Spray Valves

Overview – *Pre-Rinse Spray Valves*

Dishwashing operations in a typical restaurant can consume over two-thirds of all of the water used by that establishment. In some cases, nearly 50 percent of the water used in dishwashing is consumed by a pre-rinse spray valve (PRSV),[14] which is used to remove food residue from dishware, utensils, and pots and pans prior to placing them in the dishwasher for sanitation. Commercial PRSVs consist of spray nozzles that use water under pressure and are different from typical spray valves that are used for filling pots, kettles, or washing down countertops, floors, and other kitchen areas, all of which operate with higher flow rates than a commercial PRSV.[15] Pot and kettle fillers, spray valves used on produce in grocery stores, and spray valves used in pet grooming facilities are not covered under this BMP.

PRSVs designed for commercial dishwashing are connected to a hose, which, in turn, is connected to the pressurized building water supply. These handheld devices consist of a spray nozzle, a squeeze lever that controls the water flow, and a dish guard bumper. They often include a spray handle clip, allowing the user to lock the lever at full spray for continual use, which can reduce hand irritation from repeated use. They can be installed at the end of a flexible stainless steel hose and may include a foot-operated, on-off lever. PRSVs are usually located at the input side of a dishwasher or over a sink, and are used in conjunction with a faucet fixture fitting.

The Energy Policy Act (EPAct) of 2005 established the maximum allowable flow rate for all commercial PRSVs sold in the United States at 1.6 gallons per minute (gpm). However, older models still in use can use between 3.0 and 4.5 gpm. Since the EPAct maximum was established, more efficient products have been developed with flow rates as low as 0.65 gpm, although the performance of PRSVs at flow rates below 1.0 gpm may be significantly affected by low pressure situations [<30 pounds per square inch (psi)]. Similarly, in very high-pressure installations (>80 psi), severe splatter may occur, leading to user dissatisfaction. A pressure-reduction device should be installed on the feed line in those cases.

On average, PRSVs are reported to experience a physical life of about five (5) years.

Operation, Maintenance, and User Education BMPs – *PRSVs*

Water and energy benefits result from proper installation and use of PRSVs because most operational uses of PRSVs involve pre-rinsing with heated water. Therefore, any reduction in flow rate and water usage has the potential to reduce energy consumption as well.

[14] Delegah, Amin, 2011. Food Service Technology Center. Personal Communication, December 2, reports that recent field monitoring studies have shown a significantly higher percentage of water use at the dishwasher (75 percent of total hot water usage) as older dishwashers operate outside of their original design specification at the same time as older PRSVs are replaced with new efficient models, thereby altering the ratio of water use between dishwasher and PRSV.

[15] Pot and kettle fillers are primarily volume-dependent, and lowering the flow rate could unnecessarily impact user satisfaction by significantly increasing wait times.

For optimum PRSV operation, system pressure should be tested to ensure that it is between 30 and 80 psi. This pressure range will help to ensure that the PRSV will deliver the expected flow and performance. **In addition, consider the following practices to maximize efficiency and performance:**

- Ensure that the pre-rinse spray valve unit's hose height is appropriate for the user (neither too high nor too low). In the absence of an optimal installation height, users would more likely choose to use other kitchen sprayers (e.g., pot and kettle fillers, washdown sprayers, any other non- PRSV sprayers), which may have higher flow rates and waste more water.
- To decrease water use, train users to manually scrape as much food waste from dishes as possible before using the PRSV (see the discussion of Scullery Operations under the Overview in this section).
- If possible, pre-soak heavily soiled dishes in a basin of water to loosen food residue.
- Train users how to properly use the spray handle clip ('always-on' clamp) if available on the PRSV. Improper use of the clip could lead to unnecessary water waste. If a constant stream of water is not necessary, train users to manually depress the PRSV handle only when water is needed.
- Periodically inspect PRSVs for scale buildup on the faceplate orifices to ensure flow is not being restricted. Use cleaning products designed to dissolve scale. Do not attempt to bore or otherwise enlarge holes in the PRSV faceplate, as this may lead to increased water and energy use or cause cleaning performance problems. If scale cannot be removed, consider replacing the PRSV with a new model.[16]
- Periodically inspect PRSVs for leaks and broken or loose parts. If necessary and possible, tighten screws and fittings to stop leakage. If the product cannot be manually adjusted to perform properly, consider replacing the entire unit.
- Conduct routine inspections for leaks and train appropriate custodial and cleaning personnel and users to identify and report leaks.

Retrofit BMP Options – *PRSVs*

PRSVs are relatively inexpensive; therefore, consider replacement rather than an extensive repair. In general, avoid retrofitting existing, inefficient PRSVs with flow control inserts (which restrict water flow) to reduce the flow rate. These

[16] Unless the unit is of substandard manufacture, is improperly installed, is abused, or is installed in a facility with very poor water quality, there is no reason to believe that a typical pre-rinse spray valve would last less than the expected five years.

devices will generally fail to provide adequate rinse performance in some facilities, thereby increasing use time and total water used.

Replacement BMP Options – *PRSVs*

Choose models with flow rates of 1.3 gpm or less when installing new PRSVs or replacing older, inefficient units. However, give consideration to building water pressure when selecting a PRSV. In some cases, it may be advisable to actually install and test a PRSV in your facility before making a purchase commitment.

Savings Potential – *PRSVs*

Sizable water savings can be achieved by replacing existing inefficient PRSVs. Because water use of PRSVs depends on facility operations, such as average throughput, water savings will vary by facility. To estimate facility-specific water savings and payback, use the following information:

PRSV Replacement

Current Water Use

To estimate the current water use of a pre-rinse spray valve, identify the following information and use Equation 7.4 below:

- Flow rate of the existing pre-rinse spray valve. PRSVs installed after 2005 may operate at 1.6 gpm or less, although older higher flow rate valves may still be in place. PRSVs installed before 2005 can have flow rates of up to 4.5 gpm. In both cases, it is prudent to determine the flow rate by collecting the valve output in a containment vessel for a defined period of time and measuring the volume of the collected water.
- Average daily use time. This will vary by facility, but PRSVs are generally operating in the “on” position for no more than 90 minutes per day.[17]
- Days of facility operation per year.

Equation 7.4

Water Use of a Pre-Rinse Spray Valve (gallons/year) =
Flow Rate (gallons/minute) X Daily Use Time (minutes/day)
X Days of Facility Operation (days/year)

Water Use After Replacement

[17] Pre-rinse spray valve use time data was collected from facilities that participated in EPA’s Pre-Rinse Spray Valves Field Study in 2010. Refer to: EPA WaterSense. 2011. *Pre-Rinse Valves Field Study Report.* http://www.epa.ca.gov/WaterSense/partners/prsvs.html

To estimate the water use of a more efficient replacement PSRV, substitute the flow rate of the replacement PSRV into the above equation. Efficient PSRVs use 1.28 gpm (recently recommended by the USEPA).

Water Savings

Determine the expected water savings by subtracting the water use after replacement from the current water use.

Payback

To calculate the simple Payback from replacing an existing PRSV, identify the following information and use the equation below:

- Equipment and installation cost of the replacement pre-rinse spray valve. Pre-rinse spray valves typically cost less than $100. Installation cost is negligible.
- Water savings as calculated above.
- Facility-specific cost of water and wastewater.

Equation 7.5

Payback (years) = Equipment and Installation Cost ($) /
[Water Savings (gallons/year) X Cost of Water and Wastewater ($/gallon)]

Facilities may also save a significant amount of energy due to the reduction in hot water use with replacement of a PRSV with a lower flow model. This energy savings will further reduce the payback time and increase replacement cost-effectiveness.

Savings Potential - California – *PRSVs*

As of 2009, the California State Board of Equalization had issued sales tax permits to 91,000 restaurants and similar food establishments in the state.[18] This figure does not include food service operations within a larger commercial or industrial entity (such as company cafeterias or food service operations within hospitals or schools), firms whose business is to manufacture and/or prepare food for sale by others,[19] and other similar entities. On the other hand, this figure does include very small restaurants that do not use PRSVs.

With very limited information on the current number of installed PRSVs in California, the above inventory information was coupled with the experience gained through the California Urban Water Conservation Council's (CUWCC) Rinse 'n Save Program (for statewide PRSV replacement) to arrive at an estimate

[18] California State Board of Equalization, no date. Taxable Sales in California (Sales & Use Tax). Fourth Quarter, 2009.
[19] Food product processors and manufacturers, catering firms, etc.

of approximately 120,000 installed hot water valves, with a range of between 100,000 and 130,000.

Through implementation of the CUWCC's Program and subsequent natural PRSV replacement, the estimated statewide saturation rate (as of 2007) of water efficient valves is about 70 percent. We estimate the potential water-savings benefit of replacing the remaining 30 percent of the 120,000 hot water PRSVs in California to be approximated 6,000 acre-feet per year (af/yr) using Equation 7.6:

Equation 7.6

30% X 120,000 valves X 0.874 af average savings per average valve =
31,000 af total or approximately 6,000 af/yr
(assuming a physical life of five years for a PRSV)

7.1.1.3 Commercial Dishwashers (Warewashers)

Overview – *Dishwashers*

Dishwashing (warewashing) is one of the largest water users in commercial food service operations. These installed systems (dishwashers and pre-rinse spray valves) clean and sanitize plates, glasses, bowls, utensils, and other food service ware.[20]

NSF International, a certifying body that provides a directory of commercial dishwashers, currently lists approximately 900 individual machine models in today's marketplace. Dishwashers (warewashers) are found in diverse settings ranging from conventional restaurants to health care and other institutional food service facilities, as well as catering and similar food preparation operations. Equipment has been designed for specific purposes such as general dish, pot and pan, and glass washing.

Dishwashers in many commercial food service operations are owned by a leasing company and provided to the food service operator. Although ownership of the machine is held by the lessor, the water and energy costs associated with operating the equipment are borne by the operator. As such, the lessor's incentive for purchasing and installing the most water- and energy-efficient equipment does not always exist. In the case of single-rack door machines, for example, it is estimated that 75 percent of these machines are leased, usually for a five-year period.[21] Similarly, the larger dishwashers in the largest establishments are leased equipment with the same diminished incentives for efficiency. [20].

[20]Alliance for Water Efficiency. 2010b "Commercial Dishwashing Introduction". www.allianceforwaterefficiency.org/commercial_dishwash_intro.aspx?terms=commercial+dishwasher

[21] Cardwell R.. Conservation Specialist, Contra Costa Water District,Concord (CA)., December 19, 2011. – personal communication.

Types of Equipment – *Dishwashers*

Commercial dishwasher design can vary greatly by application, depending on the how many employees, visitors, and/or customers are served by the commercial kitchen (i.e., the amount of facility throughput). Commercial dishwasher technologies are typically differentiated in three ways:

- Sanitizing method
- Basic design
- Water reuse potential

The equipment described here includes both standard dishwashing machines and those designed for washing trays, glassware only, and pots and pans. To understand the technologies available, three equipment variants are described.

Sanitizing Method Variant

The first variant relates to how dishes are sanitized.

The most commonly found sanitizer in small restaurants is the chemical type machine, also known as the low-temperature machine. This type typically uses a chlorine-based disinfectant to sanitize the dishes. While these chemicals can often damage plastic and flat ware, the lower temperatures are desired for items that have low heat tolerance.

The other type of sanitizer is the high-temperature machine. The high-temperature machine uses water at 180^{o} F (82^{o} C) or higher for sanitation and may employ a booster heater to achieve these high water temperatures. These machines do not require the addition of chlorine-containing chemicals and do not damage flatware or plastic dishes.

Basic Design Variant

The second variant has to do with the basic design of the washer. Four fairly distinct types of equipment exist:

Under-counter type. Under-counter type equipment is commonly found in bars where only glassware is washed or in small restaurants serving fewer than 60 persons per day. They generally use heat to sanitize and are the closest to residential dishwashers in design and cost.

Door or hood type. Door or hood type equipment is primarily found in restaurants that serve fewer than 150 customers a day. Racks holding dishes[22] are either hand loaded into the machine or loaded with an automatic system. The cost for these types of machines generally ranges between $10,000 and $20,000, plus installation.[23]

Conveyor-type. The C-Line or conveyor-type machine pulls the rack of dishes through the washer and pushes the clean rack out the other side. Larger restaurants serving between 150 and 300 people a day commonly use this type. Machine cost is approximately $60,000, plus installation.[24]

Flight-type. Flight-type machines are designed for service to many hundreds or even thousands of people per day. They are typically found in large institutional facilities, hospitals, and large hotels with banquet facilities. These machines have a continuously moving belt with pegs or fingers onto which the dishes are placed. Machine cost is generally $90,000 or more, depending upon design and size with additional cost for installation.[25]

Water Reuse Potential Variant

The third variant is based on whether or not the machine uses holding tanks.

All commercial dishwashers hold water in a reservoir called a wash tank. These tanks allow recirculating pumps to operate and can be used to store water between washes. The volume of these wash tanks can range from under two gallons for an under-counter machine up to 65 gallons for large flight-type systems.

Fill-and-dump machines dump water after each wash, whereas the other type of machines house holding tanks and supply makeup water through the rinse cycle. For machines that use holding tanks, the number of tanks can vary from one to three. These holding tanks allow dishwashers to recirculate water from one load to the next and reduce energy use by reducing the need for heating water.

According to manufacturer specifications, door-type machines are supposed to be dumped after every two hours of operation while other types are dumped to drain after each meal. When the dishwasher is started again at the beginning of the next workday, the tanks must be refilled and reheated. If the average volume of these tanks is 15 to 20 gallons, dumped from one to six times per day, and there are an

[22] Generally of 20-in. by 20-in. size, roughly the size of those commonly found in most residential dishwashers.
[23] Delegah A. Project Engineer, Food Service Technology Center. December 2, 2011 – personal communication.
[24] Delegah A. 2011.
[25] Delegah A. 2011.

estimated 65,900 machines in California[26], this amounts to estimated water waste in the range of 1,100 to 8,900 af/yr, but most likely between 2,000 and 5,000 af/yr.[27]

The most efficient commercial dishwashers reuse water from one wash load to the next, using one or more holding tanks. This design not only reduces water use, but also reduces the amount of energy required to heat additional water. Alternatively, fill-and-dump commercial dishwashers discard water after each load, making this type of commercial dishwasher inherently less efficient.

Water Use Information – *Dishwashers*

There are no federal standards limiting the water or energy consumption of commercial dishwashers. However, the Energy Star® program qualifies dishwashers for its voluntary labeling program,[28] and includes under-counter, door, and conveyor (multi-and single-stage tank) basic design-type machines. Flight-type machines are not currently rated. Energy Star®-qualified commercial dishwashers can reduce both energy and water use by up to 25 percent, according to the U.S. EPA.

In some cases, however, potable water must be used for drain water tempering where code requirements set a maximum temperature of 140°F (60°C) for drain water (refer to text box for a discussion on drain water tempering).

Drain Water Tempering

Drain water tempering kits work by opening a potable water valve whenever the water being discharged from a dishwashing machine exceeds the code maximum. For example, the Uniform Plumbing Code, 2009, paragraph 810.1 reads as follows:

> *"No steam pipe shall be directly connected to any part of a plumbing or drainage system, nor shall any water having a temperature above 140°F (60°C) be discharged under pressure directly into any part of a drainage system."*

The following information is from the Hobart web page* describing their information on water tempering.

> ***Requirement:*** *If water at or above 140ºF will be drained in cooking equipment with steamers and warewashers, a drain-water-tempering kit must be installed in the equipment to ensure the water does not soften the plastic piping.*
>
> ***Avoid the violation:*** *Prior to ordering cooking equipment, find out if draining water temperatures will be at or will exceed 140ºF. It is easier and more cost efficient to install the drain-water-tempering kit during the installation process rather than to add the kit after the equipment has been installed. If the water temperature is unknown, it is recommended that a measurement be taken. Though the final rinse water temperature on a conveyor dishwasher is 180ºF, it cools rapidly when sprayed through the final rinse nozzle and therefore might not exceed 140ºF by the time it enters the drain.*

Drain water tempering devices should not be installed unless absolutely necessary, since they usually lead to excessive water waste. Check with code officials and the dishwasher manufacturer before installing such devices.

*Available at: http://www.hobartcorp.com/. Accessed: n.d. Last Updated: [2013].

The USEPA Energy Star® criterion represents the lower end of water use and, in fact, may have already approached what is currently technologically feasible for the commercial dishwasher. For example, consider the multi-tank conveyor maximum water use threshold level of 0.54 gallons per rack; a rack holds 14 plates, which comes to about a half-cup of water per plate to thoroughly wash, rinse, and heat the plate to the sanitation temperature.

Under-Counter, Door-, and Conveyor- Type Machines

The amount of water used to wash a rack of dishes for under-counter, door-, and conveyor-type machines varies with the model of machine and the type of sanitizing process used. Similar factors affect flight-type dishwashers, but since racks are not used in these machines, the parameter for comparison is gallons per dish washed. NSF International publishes dishwasher data for all available models.[29]

NSF International information was used to establish the USEPA Energy Star® criteria. The NSF International database is updated regularly as manufacturers develop new products. This information can be used to calculate water use per rack for all except flight-type machines. Table 7.3 displays the USEPA Energy Star® commercial dishwasher criteria for those dishwasher types that it currently qualifies.

Table 7.3 - Energy Star® Efficiency Requirements for Commercial Dishwashers

Dishwasher Type	High Temperature Machine Requirements		Low Temperature Machine Requirements	
	Idle Energy Rate*	Water Use**	Idle Energy Rate*	Water Use**
Under-Counter	≤ 0.9kW	= 1.00 gal/rack	≤ 0.50kW	= 1.70 gal/rack
Stationary Single Tank**	≤ 1.0 kW	≤0.90 gal/rack	≤ 0.6 kW	≤1.18 gal/rack
Single Tank Conveyor	≤ 2.0 kW	≤ 0.70 gal/rack	≤ 1.6 kW	≤ 0.79 gal/rack
Multi Tank Conveyor	≤ 2.6 kW	≤ 0.54 gal/rack	≤ 2.0 kW	≤ 0.54 gal/rack

*Measured with door closed and representative of the energy used by the tank heater only.
**Includes pot, pan, and utensil machines.

Energy Star® qualified dishwashers are reported to use at least 41 percent less energy than the Federal minimum standard for energy consumption and much less water than conventional models. Other data has been developed for this report for conveyor and flight type dishwashers using the NSF International December 2009 data.

Flight-Type Dishwashers

[29] That data can be found at: NSF International. 2004. "NSF/ANSI STANDARD 3 Commercial Warewashing Equipment." Available at: http://www.nsf.org/Certified/food/Listings.asp?Standard=003

Energy Star® criteria have not yet been developed for flight-type machines, although it is reported that plans exist to do so. Tables 7.4 and 7.5 summarize water use characteristics for both single-tank and multi-tank flight-type commercial dishwashers. Three parameters to rank efficiency were developed based on the NSF International data. These were the:

- Gallons used per square foot of the flight conveyor belt surface moving through the machine.
- Gallons used per dish using the NSF International equations to estimate.
- Gallons used per rack equivalent based on the standard 20” x 20” rack.

Gallons-per-dish is the most common parameter used by the industry to compare flight-type machines; as such, all data was sorted on that parameter. Tables 7.4 and 7.5 the show **lower quartile level**, which roughly corresponds to where Energy Star® initially sets most of their qualification thresholds.[30] It is important to note that very efficient flight-type models do exist.

Table 7.4 - Single-Tank Hot Water Flight-Type Water Use

Characteristics for 17 models			
	Gal. / sq ft	**Gal. / Dish**	**Gal. / Rack Equivalent**
Maximum	0.61	0.031	1.70
Average	0.30	0.0185	0.83
Median	0.14	0.013	0.40
Lower Quartile	0.11	0.009	0.30
Lowest	0.07	0.007	0.21

Table 7.5 - Multi-Tank Hot Water Flight-Type Water Use

Characteristics for 83 models			
	Gal. / sq ft	**Gal. / Dish**	**Gal. / Rack Equivalent**
Maximum	0.45	0.041	1.26
Average	0.21	0.020	0.58
Median	0.19	0.017	0.52
Lower Quartile	0.07	0.010	0.20
Lowest	0.05	0.005	0.13

Summary of Water Use – All Machine Types

[30] The lower quartile level corresponds to the 25th percentile; the value below which 25 percent of the numbers all. In other words, 25 percent of dishwasher models use more water than this value.

Table 7.6 summarizes water use information from the various sources. The upper quartile (75th percentile)[31] value for water use was chosen as the efficiency threshold. Table 7.6 identifies what represents the current state of the market and provides insight as to the efficiency of the approximately 65,900 commercial dishwashers currently in use in California.

[31] The upper quartile level corresponds to the 75th percentile; the value below which 75 percent of the numbers fall. This is a larger value than the 25th percentile.

Table 7.6 - Examples of Commercial Dishwasher Use

75th percentile - 75% of machines are lower Median - half of machines are lower							
Hot Water Type Dishwashing Machines							
	Units	**75th percentile 2006**	**75th percentile 2009**	**Median for 2009 Machines**	**Median for 2006 Machines**	**Energy Star® Threshold**	**Energy Star® 2010 Median**
Under Counter	Gal/rack	1.75			1.20	1.00	0.79
Door Type	Gal/rack	1.33			1.18	0.95	0.79
Single Tank Conveyor	Gal/rack	1.12	0.95	0.70	0.94	0.70	0.51
Multi-Tank Conveyor	Gal/rack		1.10	0.77		0.54	0.39
Single Tank Flight	Gal/plate		0.031	0.015			
Multi Tank Flight	Gal/ plate		0.032	0.017			
Chemical Type Dishwashing Machines							
	Units	**75th percentile 2006**	**75th percentile 2009**	**Median for 2009 Machines**	**Median for 2006 Machines**	**Energy Star® Threshold**	**Energy Star® 2010 Median**
Under Counter	Gal/rack	1.87			1.75	1.70	1.18
Door Type	Gal/rack	1.98			1.22	1.18	1.09
Single Tank Conveyor	Gal/rack	1.22	1.08	0.79	0.95	0.79	0.49
Multi Tank Conveyor	Gal/rack		0.58	0.53		0.54	0.49
Multi Tank Flight	Gal/plate		0.012	0.12			

Note: Shaded areas indicate that data was not available.
Sources: NSF International for dishwashers for 2006 and 2009, Energy Star®, and CEE Commercial Kitchens Study.

Operation, Maintenance, and User Education BMPs – *Dishwashers*

For optimum commercial dishwasher efficiency, follow these operating tips:

- Only run dishwashers when they are full. Each dishwasher rack should be filled to maximum capacity.

- Educate staff to scrape dishes prior to loading the dishwasher (see discussion on Scullery Operations under the Overview in this section).
- Replace any damaged dishwasher racks.
- Ensure that the final rinse pressure and water temperature are within the manufacturer's recommendations.
- Operate the dishwasher close to or at the minimum flow rate recommended by the manufacturer. Set the rinse cycle time to the manufacturer's minimum recommended setting and periodically verify that the machine continues to operate with that rinse cycle time.
- Turn off machines at night when not in use.
- Install steam doors to reduce evaporation.
- Ensure that manual fill valves close completely after the wash tank is filled.
- Fix and repair any leaks. Inspect valves and rinse nozzles for proper operation and repair worn nozzles.

For conveyor-type machines, further steps can be taken to ensure optimum efficiency:

- Install and/or maintain wash curtains. Wash curtains are able to retain heat within the machine.
- Ensure the rinse bypass drain is properly adjusted so that the wash tank is adequately replenished during operation.
- Operate conveyor-type machines in auto-mode to save energy by running the conveyor motor only when needed.

Retrofit BMP Options – *Dishwashers*

Retrofit options are available for conveyor-type dishwasher units. When retrofitting an existing conveyor-type dishwasher, consider installing rack sensors that allow water flow only when racks or dishes are present, thus saving water and energy by initiating the cleaning cycle less frequently.

Replacement BMP Options – *Dishwashers*

When purchasing or leasing a new commercial dishwasher or replacing an existing commercial dishwasher, look for Energy Star® qualified models,[32] which save water, energy, and reduce overall operating costs. For flight-type dishwashers, which are not subject to Energy Star® product criteria, choose equipment with a flow rate of less than 170 gallons per hour.[33] Avoid fill-and-dump machines, which use the most water.

It is important to consider the typical kitchen throughput and select an appropriately sized commercial dishwasher. A commercial dishwasher that is larger than necessary may waste water if the machine is not loaded to capacity.

Savings Potential – *Dishwashers*

Energy Star® qualified commercial dishwashers use at least 25 percent less water than conventional models.

Depending upon the type of machine, a wide range of water and energy savings may be achieved. For example, potential savings achieved by replacing a conventional multi-tank, conveyor-type, high-temperature dishwasher with an Energy Star® qualified model is shown in Table 7.7.

Table 7.7 - Example of Potential Savings from Energy Star® Qualified Dishwashers

	Conventional Unit Use	Energy Star® Qualified Unit Use	Savings
Electricity (kWh/year)	238,000	117,000	121,060
Water (gallons/year)	38,000	26,000	12,000

Use Energy Star's® Life Cycle Cost Estimate tool[34] to estimate facility-specific water, energy, and cost savings achieved when replacing an existing commercial dishwasher with a model with the Energy Star® label.

[32] USEPA. n.d.b. "U.S. Environmental Protection Agency, Energy Star® Program: Commercial Dishwashers Key Product." www.energystar.gov/index.cfm?c=comm_dishwashers.pr_crit_comm_dishwashers
[33] Koeller and Company, 2010. *A Report on Potential Best Management Practices—Commercial Dishwashers*.
[34] USEPA. n.d.c. "U.S. Environmental Protection Agency, Energy Star Program: Energy Star® Life Cycle Cost Estimate for Qualified Commercial Dishwasher(s)." www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorCommercialDishwasher.xls

Savings Potential for California – *Dishwashers*

For the purposes of this analysis, the median[35] data for 2006 (or 2009 if the 2006 data was not available) was used to represent the water use for the base case (market median) estimates of total water used by commercial dishwashers in California (refer to Table 7.6 for water use data). The 2010 Energy Star® median water use of qualified equipment was used to calculate the water saving case.

Table 7.8 shows the median values for all machines currently in the marketplace, the median value for those that are listed by Energy Star®, and the potential savings.

Table 7.8 - Estimated Water Savings per Rack or Plate (gallons)

Hot Water Type Dishwashing Machines				
Type	**Market Median**	**Energy Star® Median**	**Savings**	**Measurement**
Under- Counter	1.20	0.79	0.410	Gallons per rack
Door	1.18	0.79	0.390	Gallons per rack
Single Tank Conveyor	0.94	0.51	0.430	Gallons per rack
Multi-Tank Conveyor	0.77	0.39	0.380	Gallons per rack
Single Tank Flight	0.015	.010	0.005	Gallons per plate
Multi-Tank Flight	0.017	.009	0.008	Gallons per plate
Chemical Type Dishwashing Machines				
Type	**Market Median**	**Energy Star® Median**	**Savings**	**Measurement**
Under- Counter	1.75	1.18	0.570	Gallons per rack
Door	1.22	1.09	0.130	Gallons per rack
Single Tank Conveyor	0.95	0.49	0.460	Gallons per rack
Multi-Tank Conveyor	0.53	0.49	0.040	Gallons per rack
Multi Tank Flight	0.012	0.009 equivalent	0.003	Gallons per plate

Estimating the average number of racks or plates washed per hour or per day is a guess at best. An analysis was performed using assumed volumes of washer throughput to estimate water savings. The Restaurant Report website[36] provides the maximum racks per hour for various types of dishwashing equipment. Assuming that the actual number of racks washed is only 50 percent of the maximum, and that the machines are in operation for 5.0 hours per day, Table 7.9 summarizes the estimated throughput used in the water savings analysis.

[35] The median value is the middle value in a data set; it is typically not the same as the mean, which is an average of all values. Roughly 50 percent of the values in a data set will be above the median value and 50 percent will be below the median value.
[36] McQuire C. 2012. "Buying the Right Commercial Dishwasher." www.restaurantreport.com/departments/restaurant-dishwasher-buying-guide.html

Table 7.9 - Estimated Dishwasher Use*

Meals/hour	Dishwasher type	Max racks per hour	Assumed Actual racks per hour	Racks per day based on 5.5 hours of operation
Up to 100	Under-counter	35	17.5	88
100-500	Door	125	62.5	313
500-2000	Conveyor	425	225	1,125
2000+	Flight**	11,450 plates per hour	5,000*** Plates per hour	25,000 Plates per day

* Based on http://www.restaurantreport.com/departments/restaurant-dishwasher-buying-guide.html
** Flight systems measured in plates per hour.
*** The average flight machine can process up to 11,450 plates per hour, but 5,000 is used as a more reasonable estimate of through-put for this analysis.

Using the estimated numbers of machines in California shown in Table 7.10, the estimated number or racks or plates washed per day, and the water savings per rack or plate, the total annual savings was calculated. The estimated savings were collapsed into four dishwasher types: under-counter, door, conveyor and flight. Table 7.10 summarizes these savings.

Table 7.10 - Estimated Total Annual Potential Water Savings in California

Dishwasher Type	Estimated Number in California	Saving per Operation* *(gallons)*	Operations* per day	Market Medial *(acre-feet per year)*	Energy Star® Median *(acre-feet per year)*	Annual Savings *(acre-feet per year)*
Under-counter	7,900	0.49	88	1,149	767	382
Door-Type	42,800	0.26	313	18,007	14,106	3,901
Conveyor-Type	11,900	0.328	1,125	11,959	7,048	4,911
Flight-Type*	3,300	0.005	25,000	1,355	863	462
TOTAL				**32,470**	**22,783**	**9,656**

* For flight machines one operation is one dish washed. For all others, it is one rack washed.

Table 7.10 shows that current machines use a little over 32,000 af/yr of water for washing dishes. Another 1,110 to 8,860 af/yr are used when the machines are dumped to exchange water (refer to the Water Reuse Variant under Washing Machine Types discussion in this section). Therefore, total water use is approximately 33,000 to 41,000 af/yr. These results show that by operating *only* with the median Energy Star® qualified machines, California can save about 10,000 af/yr, or about 25 to 30 percent of water used by dishwashing machines.

7.1.1.4 Washing and Sanitation

Overview – *Washing and Sanitation*

Wash-down sprayers perform cleaning in food service operations. These sprayers consist of hoses and nozzles used for a variety of cleaning purposes, including washing countertops, floors, mats, and other kitchen areas. Wash-down sprayers use a high-pressure stream with large volumes of water to clean dirt and residue from surfaces. Wash-down sprayers typically deliver flow rates of seven gpm,[37] while heavy-duty hoses used without nozzles can deliver higher flow rates from nine to 20 gpm.[38]

Washing floors in food-service establishments can use large quantities of water. The common practice has been to mop the kitchen floor with soapy water, then use a high-pressure hose with hot water to rinse the soapy water into the floor drain. This process uses large amounts of water, as well as energy to heat the water, and has a tendency to splash dirty water onto clean equipment. Some literature reports that water use for floor cleaning in a large commercial kitchen can be in the range of 1,000 to 1,500 gallons a day. [37]

Using an alternative cleaning method could improve the efficiency of cleaning tasks, reduce water use, and save on water costs. These cleaning methods (e.g., mopping or sweeping) perform the same tasks as using a spray-washer yet require significantly less water or no water at all. If implementing new cleaning methods is not feasible, replacement options that use lower flow rates than wash-down sprayers include pressure washers and water brooms.

Operation, Maintenance, and User Education BMPs – *Washing and Sanitation*

Consider the following for optimum wash-down sprayer efficiency:

- Only use wash-down sprayers to clean floors, countertops, and other surfaces. Do not use wash-down sprayers to clean dishware, which should be cleaned with PRSVs.
- Any conventional floor cleaning system with a hot-water hose should, at a minimum, have a self-closing valve. If the wash-down sprayer does not have such a valve, shut off the water supply when the sprayer is not in use.
- For floor washing applications, consider using a broom and dust pan to clean up solid waste and/or using a mop and squeegee instead of a wash-down sprayer.
- Use floor-cleaning machines equipped with a water tank.

[37] Fisher-Nickel, Inc. 2010. "Water Conservation Measures for Commercial Food Service." www.fishnick.com/savewater/bestpractices/Water_Conservation_in_CFS.pdf

[38] USEPA. n.d.f. "U.S. Environmental Protection Agency's Energy Star program: Best Practices—How To Achieve the Most Efficient Use of Water in Commercial Food Service Facilities." www.energystar.gov/index.cfm?c=healthcare.fisher_nickel_feb_2005

Retrofit BMP Options – *Washing and Sanitation*

Consider installing a self-closing nozzle if a high-flowing wash-down sprayer hose is used without a nozzle. This nozzle can reduce a 10-20 gpm flow to seven gpm or less, and prevent water waste when the wash-down sprayer is not in use.

Replacement BMP Options – *Washing and Sanitation*

For certain applications, wash down sprayers may be replaced with mopping or sweeping, which require little to no water.

Pressure washers can serve as a viable replacement option for facilities that rely on the washing capability of wash-down sprayers. Pressure washers typically operate at high pressure flow rates of three gpm or less and often outperform wash-down sprayers.

Water brooms can replace existing wash-down sprayers for surface cleaning applications. Water brooms have wide spray patterns with multiple jets that are more efficient at cleaning large surfaces than a wash-down sprayer and use significantly less water.[39]

Savings Potential – *Washing and Sanitation*

Water savings can be achieved through retrofit or replacement. Existing high flowing wash-down sprayers can be retrofitted with a self-closing nozzle. Wash-down sprayers can also be replaced with a pressure washer or water broom. To estimate facility-specific savings and payback, use the following information:

Wash-Down Sprayer Retrofit

Installing a self-closing nozzle on a high-flowing wash-down sprayer to reduce water flow can result in sprayer water savings between 40,000 to 280,000 gallons per year.[41] Nozzle retrofits cost approximately $100; therefore, a facility saving 40,000 gallons per year could recoup the initial cost of the retrofit equipment in less than one year.[40]

Current Water Use

Use Equation 7.7 below to estimate the current water use of an existing wash-down sprayer without a nozzle, identify the following information:

- Flow rate of the existing, high-flowing wash-down sprayer without a nozzle. Most high-flowing wash-down sprayers have flow rates between nine and 20 gpm.[41]
- Average daily use time in the food service operation.

[39] Fisher-Nickel, Inc. 2010.
[40] Assumes a water and sewer rate of $7.16 per 1,000 gallons. From: Raftelis. 2009. "Water and Wastewater Rate Survey."
[41] East Bay Municipal Utility District. 2008. *Watersmart Guidebook—A Water-Use Efficiency Plan Review Guide for New Businesses*. Pages FOOD8-FOOD9.

- Days of food service operation per year.

Equation 7.7

Water Use of a Wash Down Sprayer or Water Broom (gallons/year) = Flow Rate (gallons/minute) X Daily Use Time (minutes/day) X Days of Facility Operation (days/year)

Water Use After Retrofit

Use Equation 7.7 to estimate the water use after installing a nozzle on an existing wash-down sprayer without a nozzle, and substitute the flow rate of the new nozzle. Self-closing nozzles often flow at a rate of seven gpm. [42]

Water Savings

Determine the expected water savings by subtracting the water use after nozzle retrofit or replacement from the current wash-down water use.

Payback

Use Equation 7.8 below to calculate the simple payback for the wash-down sprayer retrofit, identify the following information:

- Equipment and installation cost of the self-closing nozzle. Self-closing nozzles typically cost $100.
- Water savings as calculated using Equation 7.7.
- Facility-specific cost of water and wastewater.

Equation 7.8

Payback (years) = Equipment and Installation Cost ($) / [Water Savings (gallons/year) X Cost of Water and Wastewater ($/gallons)]

[42] Fisher-Nickel, Inc. 2010.

Wash-Down Sprayer Replacement

Replacing a wash-down sprayer with a pressure washer or water broom can result in water savings between 100,000 and 400,000 gallons per year. Pressure washers and water brooms typically cost between $100 and $200; therefore, a facility saving 100,000 gallons per year could recoup the initial cost of the retrofit equipment in less than one year.[43] To estimate facility-specific savings and payback use the following information:

Current Water Use

Use Equation 7.7 to estimate the current water use of an existing wash-down sprayer.

Water Use After Replacement

Use Equation 7.7 to estimate the water use of a replacement pressure washer or water broom, and substitute the flow rate of the new device. Water brooms can use as little as two gpm.[44] Pressure washers have similar flow rates yet use higher water pressure.

Water Savings

Determine the expected water savings by subtracting the water use after replacement from the current wash-down water use.

Payback

Use Equation 7.8 to calculate the simple payback for the wash-down sprayer replacement, and substitute the cost of the pressure washer or water broom for the cost of the retrofit self-closing nozzle.

7.1.1.5 Commercial Ice Machines

Overview – *Ice Machines*

The use of ice for drinks, preserving and cooling food, and various other commercial purposes is common today, but it was not always so. Before the development of the commercial ice machine industry, ice was produced at large central ice plants and delivered to the commercial user in the form of either blocks or crushed ice. The crushed and block ice market is still a viable industry, but commercial ice machines have replaced delivered ice in routine commercial activities. This section summarizes the operational characteristics of commercial ice machines and examines a California-based perspective on the potential for both water and energy savings. To do this, it examines five items:

- Types of ice-making technologies and equipment
- Ice machine market dynamics

[43] Assumes a water and sewer rate of $7.16 per 1,000 gallons. From: 2009. “Water and Wastewater Rate Survey.”
[44] Fisher-Nickel, Inc. 2010.

- Regulations and incentives
- Energy and water use chrematistics[45]
- Potential future water savings

The market for ice-making machines tends to increase in proportion to population. The hospital, food service, and hotel industries purchase approximately 75 percent of all ice machines nationally, but ice machines are also found in other businesses and institutions (Figure 7.2).[46]

According to information from the Pacific Gas & Electric Company (PG&E) Food Service Technology Center (FSTC) (Zabrowski, 2007), about 20 percent of the installed inventory of ice machines in California are water-cooled and the balance are air-cooled. According to the Air Conditioning and Refrigeration Institute (ARI), once-through, water-cooling ice machines use from 75 to 200 gallons of cooling water for every 100 pounds of ice made.

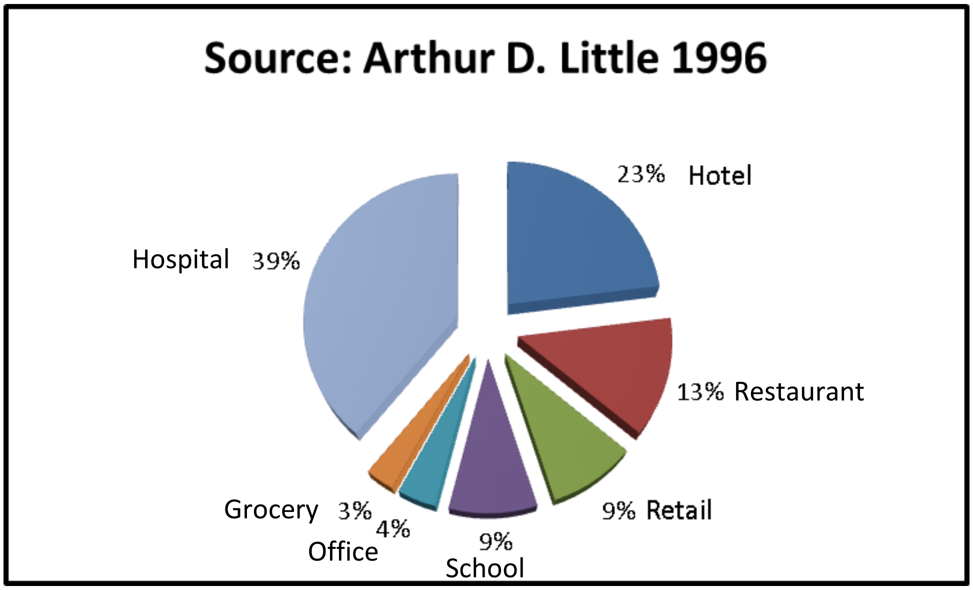


Figure 7.2 - Commercial Ice Machine Distribution by Business Sector

Ice machines can produce several kinds of ice:

- *Cube ice* (clear, regularly shaped ice weighing up to 1.5 ounces per piece and containing minimal amounts of liquid water)
- *Flake ice* (chips or flakes of ice containing up to 20 percent liquid water by weight)

[45] Chrematistics is the study of wealth or a particular theory of wealth as measured in money as defined at: http://www.merriam-webster.com/dictionary/chrematistics. Accessed May 23, 2013.
[46] This figure was based on older studies performed in 1996 by Arthur D. Little. In Westphalen D, Zogg RA, Varone AF, and Foran MA. 1996. Energy Savings for Commercial Refrigeration Equipment Final Report. Available at: http://infohouse/p2ric.org/ref/36/35923.pdf.

- *Crushed ice* (small, irregular pieces made by crushing bigger pieces of ice)
- *Nugget ice* (small portions of ice created by extruding and freezing the slushy flake ice into a nugget)[47]

In 2003, total nationwide ice machine sales were approximately 360,000 units, of which about 78 percent were cube machines; the others were flake and nugget machines or combination machines such as soda machines (Figure 7.3). According to a 2004 PG&E study, there are about 1.2 million ice machines in the United States, with about 174,000 in California (about 14.5 percent of the total).[48] Allowing for population growth, staff estimate that California currently has an installed base of about 180,000 machines.

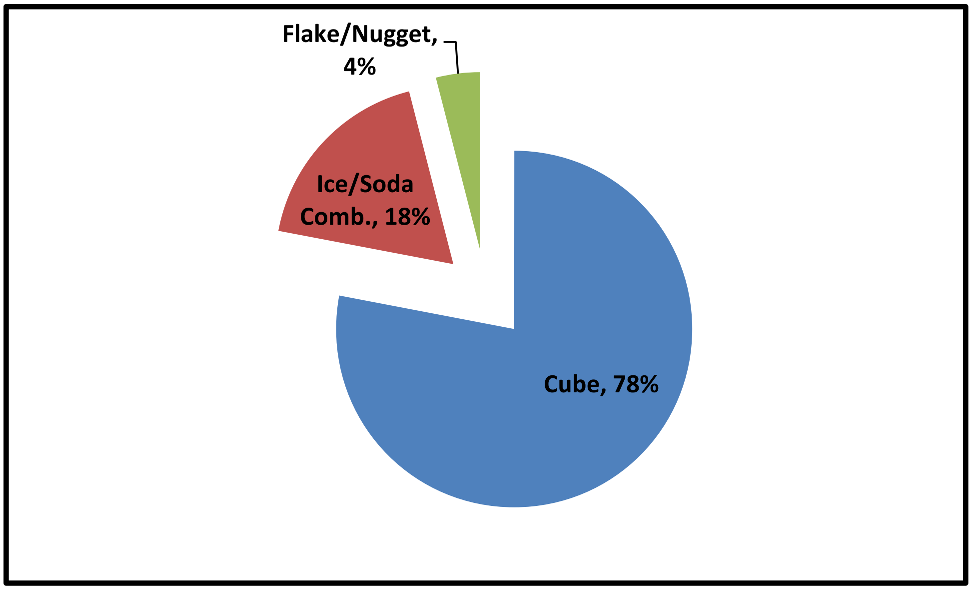


Figure 7.3 - National Sales by Type of Ice Machine

In recent years, there has been an increase in sales of nugget-type ice machines for soft drink use since this ice absorbs some of the drink flavor and is chewable. However, according to information from PG&E FSTC (Zabrowski, May 2008), the percent increase is small. The importance of this trend is that nugget ice machines tend to be both more energy and water efficient.

The amount of ice consumed by various individual operations varies greatly, but ice machine manufacturers have developed estimates for each of those applications. Table 7.11 summarizes this information.

[47] Pacific Gas and Electric Company. (PG&E). 2013."Information Brief, Commercial Ice Machines." www.pge.com/includes/docs/pdfs/mybusiness/energysavingsrebates/incentivesbyindustry/hospitality/icemachinetech.pdf.

[48] This value was based on older studies performed in 1996 by Arthur D. Little. In: Westphalen D, et al. 1996.

Table 7.11 - Approximate Ice Use by Activity or Product

Type of Use	Unit	Ice Use per Activity
Restaurant	Per Meal	1.5 lb. per person served
(Either stand alone or at a hotel)	Cocktail Bar	3 lb. per person served
	Salad Bar	40 lb. per day per cubic ft.
Cafeteria	Per Person	1 lb per person served
Hospital	Per Patient	10 lb per patient per day
Hotel	Per Guest	5 lb per guest per day
Catering	Per Person	1 lb per person served
Cold Soft Drinks & Tea	10-12 oz.	6-8 oz. per drink
	20 oz.	8-10 oz. per drink
	32 oz.	16 oz. per drink

Source: Information based on Ice-O-Matic[49] and Cornelius[50] Web sites.

Types of Equipment – *Ice Machines*

There are three primary types of ice machines: *ice-making head units* (water- or air-cooled), *self-contained units* (water- or air-cooled), and *remote condensing units* (air-cooled). Ice-making head units have the ice-making mechanism and the condenser unit in a single package, and the storage bins are sold separately. Self-contained units have the ice-making mechanism, condenser unit, and a built-in storage bin in an integral cabinet. These units are typically small, under-counter units that produce a smaller volume of ice. Remote condensing units are models with the ice-making mechanism and the condenser unit in a separate section. They transfer the heat generated by the ice-making process outside of the building.

An ice machine's capacity is measured by the pounds of ice produced per day. Water-cooled ice machines with single-pass cooling consume between 100 and 300 gallons of water per 100 pounds of ice produced, while air-cooled ice machines consume less than 50 gallons of water per 100 pounds of ice produced.[51] Although air-cooled machines are usually more water-efficient, water-cooled machines are usually more energy-efficient. Some air-cooled units, however, are able to match or exceed the energy efficiency of water-cooled units while also providing substantial water efficiency.[52]

[49] Ice-O-Matic. www.iceomatic.com. Accessed: n.d.
[50] Cornelius. www.cornelius-usa.com. Accessed: n.d.
[51] Bohlig, Charles M. East Bay Municipal Utility District. February 2006. "Presentation on Water Efficiency in Commercial Food Service."
[52] Alliance for Water Efficiency. 2010d. "Ice Machines Introduction." www.allianceforwaterefficiency.org/Ice_Machines.aspx.

Water Use Information – *Ice Machines*

Commercial ice machines use refrigeration units to freeze water into ice. They have become a mainstay in all types of settings including restaurants, commercial kitchens, fast food establishments, convenience stores, grocery stores, schools, hotels/motels, hospitals, and laboratories. Ice machines typically use water for two purposes: cooling the refrigeration unit and making ice. There are mechanisms to address the efficiency of both aspects.

Water Use For Cooling

Water or air is used to remove waste heat from the ice machine's refrigeration unit because the ice-making process generates a significant amount of heat. In the most basic configuration, water-cooled ice machines pass water through the machine once to cool it, and then dispose of the single-pass water down the drain. Water-cooled systems can use less water by recirculating the cooling water through either a heat exchanger connected to a chilled water loop or a cooling tower in order to lower the temperature, and then returning the water to the machine for reuse. To eliminate using water to cool the refrigeration unit altogether, air can be used to cool the unit instead. Air-cooled ice machines use motor-driven fans or centrifugal blowers to move air through the refrigeration unit to remove heat.[53]

Water Use For Making Ice

Regardless of how the machine is cooled, all of the machines use water to produce ice. If a machine were perfectly water-efficient and wasted no water when producing ice, the machine would use approximately 12 gallons of water to produce 100 pounds of ice.[54] However, in order to create ice of acceptable quality, some water is sent down the drain during the process.

As ice is formed in the freezing trays, minerals in the water collect on the equipment and must be occasionally rinsed off, depending on the water quality. Some machines require more frequent rinse cycles than needed, thus wasting water. Reducing the frequency of rinse cycles can provide an opportunity for savings.

Some ice machines are designed to produce clearer and smoother ice using a repeated freezing and partial thawing process. Ice produced using this method has fewer air bubbles and is more crystalline, however producing ice to this quality uses more water.[55]

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[53] USEPA. n.d.e. "U.S. Environmental Protection Agency's Energy Star® Program. Commercial Ice Machines." www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=CIM.

[54] Alliance for Water Efficiency. 2013.

[55] Alliance for Water Efficiency. 2013

Water used directly for the ice-making process ranges from 15 gallons to more than 50 gallons per 100 pounds of ice,[56] depending on the amount of water used to rinse the machine. For flake machines, this range includes the unfrozen water.

Most cubed ice machines use more water than flake ice machines because they run more water over the freezing ice to remove sediment and minerals that form as the water freezes. In general, the higher the quality of ice, the more water is needed for the ice-making process.

The Department of Energy sets standards for ice machines.[57] In order to recognize energy- and water-efficient ice machines, the USEPA's Energy Star® program issued a specification[58] for commercial air-cooled cube ice machines that are more energy and potable water efficient. On average, commercial ice machines that have earned the Energy Star® label are 15 percent more energy efficient and 10 percent more water efficient than standard air-cooled models. Currently, only cube ice machines qualify to earn that label, although Energy Star® plans to include flake machines in future specifications.

Operation, Maintenance, and User Education BMPs – *Ice Machines*

Consider the following tips to ensure energy- and water-efficient ice machine use:

- Periodically clean the ice machine to remove lime and scale and sanitize it to kill bacteria and fungi. For self-cleaning/sanitizing machines, run the self-cleaning option. For machines without a self-cleaning mode, shut down the machine, empty the bin of ice, add cleaning/sanitizing solution to the machine, switch it to cleaning mode, and then switch it to ice production mode. Although water is wasted in the process, it is very important to create and discard several batches of ice to remove residual cleaning solution for health and safety considerations.
- Keep the ice machine's coils clean to ensure that the heat exchange process is running as efficiently as possible.
- Keep the lid closed to trap cool air inside the ice machine so that it does not have to work harder to maintain the appropriate temperature inside.
- Install a timer to shift ice production to nighttime or off-peak hours mode, cutting down on the facility's peak energy demand.

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[56] Koeller and Company, 2008. *A Report on Potential Best Management Practices – Commercial Ice Machines. Prepared for the California Urban Water Conservation Council*. Page 6. June.
[57] Energy Efficiency and Renewable Energy (EERE). n.d. "Appliance & Equipment Standards, Standards and Test Procedures." http://www1.eere.energy.gov/buildings/appliance_standards/commercial/automatic_ice_making_equipment.html
[58] USEPA. n.d.e.

- Considering local water quality and site requirements, work with the machine's manufacturer to ensure that the machine's rinse cycle is set to the lowest possible frequency that still provides sufficient ice quality. If available, use the ice machine's ability to initiate rinse cycles based on sensor readings of minerals.
- Follow the manufacturer-provided use and care instructions for the specific model ice machine used at the facility.
- Train users to report leaking or otherwise improperly operating ice machines to the appropriate personnel for repair.

Retrofit BMPs Options – *Ice Machines*

If the machine is cooled using single-pass water, modify the machine to operate on a closed-loop that recirculates the cooling water through a cooling tower or heat exchanger, if possible. If eliminating single-pass cooling is not feasible, consider reusing the cooling water for another application within the facility. See Section 7.3.1 Alternate Onsite Sources of Non-Potable Water for more information.

Replacement BMP Options – *Ice Machines*

Ensure that the new model is sized appropriately to fit the facility's need when replacing the ice machine or installing a new one. If the machine produces too large of a yield, water will be wasted by producing unneeded ice. Also choose an ice machine that is appropriate for the quality of ice needed. Producing ice of higher quality than required will use water unnecessarily. Consider selecting flake or nugget ice machines, which use less water and energy than cube ice machines.[59] Choose only Energy Star® qualified models when available.[60] Also consider only air -cooled ice machines that meet the efficiency specifications outlined by the Consortium for Energy Efficiency (CEE).[61]

Savings Potential – *Ice Machines*

A facility will see varying levels of water savings, depending on whether it is replacing an existing air-cooled ice machine or an existing water-cooled model. To estimate facility-specific water savings and Payback, use the following information:

Air-Cooled Ice Machine Replacement

On average, Energy Star® qualified air-cooled cube ice machines are 15 percent more energy-efficient and 10 percent more water-efficient than standard air-cooled models. Total savings depend on the type of machine selected. Switching

[59] East Bay Municipal Utility District. 2008. *Watersmart Guidebook—A Water-Use Efficiency Plan Review Guide for New Businesses.*
[60] USEPA. n.d.e.
[61] Consortium for Energy Efficiency. 2011. *High-Efficiency Specifications for Commercial Ice Machines*. http://library.ceel.org/content/cee-high-efficiency-specifications-commercial-ice-machines/

to a 137-pound capacity Energy Star® qualified air-cooled ice-making head unit from an equivalent conventional unit, for example, can result in water savings of 1,000 gallons per year. Energy savings of 1,600 kilowatt hours (kWh) per year can also be expected, resulting in net cost savings of about $170 per year.[62]

Use Energy Star's® Commercial Kitchen Equipment Savings Calculator[63] to estimate facility-specific water, energy, and cost savings for replacing an existing ice machine with an Energy Star® qualified model. The Calculator estimates savings for the Energy Star® suite of commercial kitchen products, but it can also be used to calculate individual savings from replacing an existing ice machine.

Water-Cooled Ice Machine Replacement

A facility will see the most water savings from replacing a water-cooled ice machine with an Energy Star® qualified air-cooled model. Only cube ice machines currently qualify to earn the Energy Star® label.

Current Water Use

To estimate the current water use from a water-cooled ice machine, identify the following information and use Equation 7.9 below:

- Ice machine's harvest rate, or how many pounds of ice it produces per day
- The ice machine's maximum water use: this figure can be derived from EPAct 2005 requirements.
- Days of facility operation per year

Equation 7.9

Water Use of a Water-Cooled Ice Machine (gallons/year) = Harvest Rate (100 lbs ice/day) X Water Use (gallons/100 lbs of ice) X Days of Facility Operation (days/year)

Water Use After Replacement

To estimate the water use of a replacement Energy Star® qualified air-cooled model, use Equation 7.9, substituting the harvest rate (if it will change) and the new water use per hundred pounds of ice.

Water Savings

Determine the expected water savings by subtracting the water use after replacement from the current water use.

[62] USEPA. n.d.c. "Commercial Equipment Savings Calculator." http://www.energystar.gov/index.cfm?fuseaction=find_a_product.ShowProductGroup&pgw_code=CKP
[63] USEPA. n.d.c.

Payback

To calculate the simple Payback from replacing a water-cooled ice machine, identify the following information and use Equation 7.10 below:

- Equipment and installation cost of the replacement Energy Star® qualified air-cooled model. New ice machines may range in cost between $2,000 and $4,000.
- Water savings as calculated using Equation 7.9.
- Facility-specific cost of water and wastewater.

Equation 7.10

Payback (years) = Equipment and Installation Cost ($) /
[Water Savings (gallons/year) X Cost of Water and Wastewater ($/gallon)]

Savings Potential – California – *Ice Machines*

Water savings (direct and indirect) can be derived from three sources:

- Elimination of once-through cooling, which yields substantial direct savings.
- Moving to Consortium for Energy Efficiency (CEE) Tier 3[64] water use levels for future ice-making machines, including the promotion of the more efficient flake and nugget machines, all of which yield direct savings of water.
- Indirect water savings realized through reduced energy generation.

The following analysis is based on an estimated 180,000 ice machines currently installed in California, of which 36,000 are estimated to be water-cooled.[65] For the purpose of this analysis, these water-cooled machines are assumed (1) to use 150 gallons of cooling water for every 100 pounds of ice made and (2) to have an average daily production, from all units of 600 pounds of ice per day per unit. Two water use rates for ice making are assumed: 25 gallons per 100 pounds of ice and 20 gallons per 100 pounds of ice, with a net savings of five gallons per 100 pounds of ice. This assumption reflects CEE Tier 2 (the Energy Star® Standard) and Tier 3 standards, respectively, which, together, cover the majority of the market available today. The CEE has created voluntary standards for commercial ice maker energy and water efficiency. Tiers are compared to a base model that has a typical low efficiency as defined by the Food Service Technology Center. The other ice makers have efficiencies that meet the thresholds for each of the CEE tiers, with Tier 3 being the most efficient.

[64] CEE.(2013). "CEE Tiers and Energy Star." http://www.ceel.org/content/cee-tiers-and-energy-star. Access: n.d.

[65] If 20 percent of the ice machines are water-cooled, as noted in the Overview portion of this subsection, 20 percent of 180,000 total ice machines results in an estimated 36,000 water-cooled ice machines in California.

The potential statewide savings in water and energy use by the equipment itself (direct savings) and through the reduction in embedded energy use (indirect savings) are both shown in Table 7.12. For assumptions related to the estimated savings, refer to CUWCC Potential BMPs report on ice machines.[66]

Table 7.12 - Summary of Total Potential Annual Water and Energy Savings in California

Savings at Ice Machine (Direct Savings)				
Type	Number of installed machines	Water (acre-feet/year)	Energy (millions of kWh/year)	Notes
Water-cooled machine savings	36,000	36,300	-47	
Air-cooled machine savings	144,000		252	
All machines	180,000	6,000		
Total at machine		**42,300**	**205**	
Embedded Savings (Indirect Savings)				
Type	Number of installed machines	Water (acre-feet/year)	Energy (millions of kWh/year)	Notes
Water-cooled machine savings	36,000		82*	*Savings of embedded energy in reduced cooling water
All machines	180,000		14	
Total embedded		**230****	**96**	**Water savings resulting from reduced energy production
Net Savings – Direct & Indirect		**42,530**	**301**	Includes Embedded Savings

In summary, Table 7.12 shows that by eliminating once-through water cooling machines about 36,000 af of water can be saved each year and the net energy savings would be about 300 million kWh per year when embedded energy is taken into account. Adding the savings realized by moving to Tier 3 or to flake and nugget machines will increase the projected statewide water savings to a total of about 42,300 af/yr.[67]

[66] Koeller and Company. 2008. *A Report on Potential Best Management Practices – Commercial Ice Machines*. Page 6.

[67] This does not take into account the net savings in other *operating costs* (borne by the end user) by eliminating once-through cooling. Typically, over the lifetime of the machine, operating costs to the end user for air-cooled equipment are about half that of the equivalent water-cooled equipment.

7.1.1.6 Dipper Wells

Overview – *Dipper Wells*

Dipper wells are used for applications such as rinsing ice cream scoops, spoons, and other utensils on the serving line between uses. Most dipper wells have a single spigot and a valve that controls the flow of either hot or cold water into a receiving well. Most serving lines have dipper wells running constantly during service hours to provide a continuous exchange of the water in the well in order to reduce the potential for bacterial growth.

Dipper wells usually have flow rates between 0.5 and 1.0 gallon per minute (gpm).[68] Larger wells, however, have higher flow rates.

Food service locations should ensure that the requirements of the U.S. Department of Health and Human Services Food Code are met, specifically Sections 3-304.11 and 3-304.12, when considering changes to facility operations that may involve installing, retrofitting, or replacing a dipper well.

Operation, Maintenance, and User Education BMPs – *Dipper Wells*

Consider the following for optimum dipper well efficiency:

- Turn off water when service periods are slow and the dipper well is not in use. Turn off the water to the well at the end of each day as well. Clean the dipper well prior to restarting the water in order to remove any bacterial build up.
- Keep the flow rate of the dipper well valve at its minimum level. Some municipalities recommend no more than 0.3 gpm.[69]
- Consider rinsing utensils with an existing faucet only as needed rather than using a dipper well.
- Use cold or warm water instead of hot water in dipper wells where appropriate for rinsing utensils.

Retrofit BMP Options – *Dipper Wells*

Consider installing an in-line flow restrictor to reduce the flow rate from 0.5 or 1.0 gpm to 0.3 gpm to reduce the water use associated with a dipper well.

[68] East Bay Municipal Utility District. 2008. *Watersmart Guidebook—A Water-Use Efficiency Plan Review Guide for New Businesses.* Pages FOOD8-FOOD9.
[69] Arizona Department of Water Resources. n.d. *Conservation Tools: Implementing a Water Management Plan Checklist for Facility Managers*. Page 8.

Replacement BMP Options – *Dipper Wells*

Consider these options when looking to replace dipper wells:

- Install a metering faucet for utensil rinsing.
- Consider installing an Energy Star®-qualified commercial under-counter dishwasher70instead of using a dipper well if the facility has a large volume of utensils, sufficient to run full dishwasher loads.

Savings Potential – *Dipper Wells*

During the course of a 12-hour operating day at a typical ice cream shop, dipper wells can consume 300 to 700 gallons of water, or a maximum of 110,000 to 260,000 gallons per year. Water savings can be achieved by retrofitting the dipper well faucet to reduce the flow rate *or* by replacing a dipper well faucet with a metered faucet or an Energy Star® qualified commercial under-counter dishwasher. Installing a flow-restricting device to reduce the water flow of a dipper well can result in water savings between 50,000 and 180,000 gallons per dipper well per year.

To estimate facility-specific water savings and Payback, use the following information:

Dipper Well Retrofit with In-Line Flow Restrictor

Current Water Use

Identify the following information and use Equation 7.11 below to estimate the water use of an existing dipper well:

- Flow rate of the existing dipper well. Most dipper wells have flow rates between 0.5 and 1.0 gpm.[71] Measuring the actual flow rate is a fairly simple task that can be accomplished in a very short time.
- Average specific dipper well operating hours per day.
- Days of facility operation per year.

Equation 7.11

Water Use of a Dipper Well (gallons/year) = Flow Rate (gpm) X Daily Use Time (minutes/day) X Days of Operation per Year (days/year)

Water Use After Retrofit

Use Equation 7.11 and substitute the flow rate of the retrofit for the flow rate of the existing dipper well to estimate the water use after retrofitting an existing

[70] USEPA. n.d.a.
[71] East Bay Municipal Utility District. 2008. *Watersmart Guidebook—A Water-Use Efficiency Plan Review Guide for New Businesses*. Pages FOOD8-FOOD9.

dipper well with an in-line flow restrictor. An efficient retrofit in-line flow restrictor should provide a maximum flow rate of 0.3 gpm.

Water Savings

Determine the expected water savings by subtracting the water use after retrofit from the current water use.

Payback

Identify the following information and use Equation 7.12 below to calculate the simple Payback from retrofitting an existing dipper well:

- Equipment and installation cost of the retrofit in-line flow restrictor.
- Water use as calculated above.
- Facility-specific cost of water and wastewater.

Equation 7.12

Payback (years) = Equipment and Installation Cost ($) /
[Water Savings (gallons/year) X Cost of Water and Wastewater ($/gallon)]

Dipper Well Replacement with Metering Faucet

Though retrofitting an existing dipper well with a flow restrictor is likely the most cost-effective choice for a facility, significant water savings may also be achieved by replacing a dipper well faucet with a metering faucet.

Current Water Use

Use Equation 7.11 to estimate the current water use of an existing dipper well.

Water Use After Replacement with Metered Faucet

Use of metered faucets identify the following information and use Equation 7.13 below to estimate the water use after replacing an existing dipper well with a push-button:

- Flow rate of the metering faucet [in gallons per cycle (gpc)]
- Average cycles used per hour
- Average operating hours per day of the facility
- Days of facility operation per year

Equation 7.13

$$\text{Water Use of a Metering Faucet (gallons/year)} = \text{Flow Rate per Cycle (gallons/cycle)} \times \text{Use per Hour (cycles/hour)} \times \text{Daily Use Time (hours/day)} \times \text{Days of Operation per Year (days/year)}$$

Water Savings

Determine the expected water savings by subtracting the water use after faucet replacement from the current water use.

Payback

Use a similar equation as 7.12 to calculate the simple Payback from replacing an existing dipper well with a push-button, metered faucet, and substitute the cost of replacing the existing faucet with a new metering faucet for the cost of the in-line flow restrictor.

Dipper Well Replacement with Energy Star® Qualified Commercial Dishwasher

Though retrofitting an existing dipper well with a flow restrictor is likely the most cost-effective choice for a facility, significant water savings may also be achieved by replacing a dipper well with an Energy Star® qualified commercial under-counter dishwasher *and* altering the practices of those individuals responsible for utensils.

Current Water Use

Use a similar equation as 7.11 to estimate the current water use of an existing dipper well.

Water Use After Replacement with Energy Star® Dishwasher

Identify the following information and use Equation 7.15 below to estimate the water use after replacing an existing dipper well with an Energy Star® qualified commercial under counter dishwasher:

- Water use per rack washed. A high-temperature, Energy Star® qualified commercial under-counter dishwasher uses 1.0 gallons per rack or less. A low-temperature model uses 1.7 gallons per rack or less.[72]
- Average estimate of racks washed per day.
- Days of facility operation per year.

Equation 7.14

$$\text{Water Use of an Energy Star® Qualified Commercial Under-Counter Dishwasher (gallons/year)} = \text{Water Use per Rack (gallons/rack)} \times \text{Racks Washed per Day (racks/day)}$$

[72] USEPA. n.d.b.

X Days of Operation per Year (days/year)

Water Savings

Determine the expected water savings by subtracting the water use after dishwasher installation from the current water use.

Payback

Use Equation 7.12 to calculate the simple Payback from replacing an existing dipper well with an Energy Star® qualified commercial under counter dishwasher, and substitute the cost of installing an Energy Star® qualified dishwasher for the cost of the in-line flow restrictor. Purchasing and installing a new Energy Star® qualified commercial under-counter dishwasher can cost approximately $6,000.[73]

7.1.1.7 Combination Ovens

Overview – *Combination Ovens*

Combination ovens help keep food from drying out while baking or roasting. They combine three modes of cooking into one oven: steam mode, circulated hot air (dry heat) mode, or a combination of both (combi-mode). The steam mode is used for rapid cooking of food items such as vegetables and shellfish. The circulated hot air mode operates in the same manner as a typical convection oven and is traditionally used for roasting meats or baking. The combi-mode is used to reheat, roast, bake, or oven-fry foods. Steam and combi-modes require generation of steam, an energy and water-intensive process.

Types of Equipment – *Combination Ovens*

Both gas and electric models are available in several configurations: one mode uses a boiler that produces steam, which is injected into the oven chamber; others achieve high humidity with sprays; and, some models have closed systems that recondense steam to achieve higher energy and water savings. The cooking capacity of a typical oven is substantial: one six-pan model can cook as many as 32 chickens at a time.[74] The amount of water used by a combination oven is primarily dictated by whether it is boiler-based or connectionless (without a central boiler connection).

<u>Boiler-Based</u>

Typical boiler-based combination ovens are connected to a boiler system that supplies the steam. These systems waste large amounts of water because they require a continuous stream of tempering water to cool the condensed steam before disposal down the drain. They may also supply steam regardless of whether the oven is in operation.

[73] USEPA. n.d.c.

[74] Sorensen G. 2006. *Rational Model SCC 62G Combination Oven Performance Test*. Food Service Technology Center. Report 5011.06.10.

Connectionless

A connectionless combination oven has a self-contained water and heat source to create the steam required for the cooking process. This eliminates the use of a separate, central boiler system. Connectionless combination ovens are typically drained and refilled each day and do not require a drain for condensate or the frequent addition of cooling water for tempering.

Water Use Information – *Combination Ovens*

A ten-pan boiler combination oven under heavy use can consume 30 to 40 gallons of water per hour. Boilerless misting ovens use only 10 to 15 gallons per hour, resulting in an annual savings greater than 110,000 gallons.[75] Inefficient combination ovens can consume 360 to 480 gallons of water per day, while efficient models can reduce that usage to only 120 to 180 gallons per day.

Operation, Maintenance, and User Education BMPs – *Combination Ovens*

For optimum combination oven efficiency, consider the following:

- Use the oven's programming capabilities to control the use of the different cooking modes in order to minimize water and energy use. Where feasible, use the steam and combi-modes sparingly because these modes consume more water and significantly increase energy use. Maximize the use of the circulated hot air mode.
- Turn the oven off or down during non-peak periods or when not in use.
- Keep the oven doors completely closed.
- Maximize the amount of food cooked per use by ensuring that the oven is loaded to its full capacity.
- Replace door gaskets when necessary and keep door hinges tight in order to provide a firm seal for heat or steam retention.

[75] Reed C. 2005. "U.S. Environmental Protection Agency Energy Star® Program: Saving Water Counts in Energy Efficiency. http://www.energystar.gov/index.cfm?c=healthcare.ashe_sept_oct_2005

Retrofit BMP Options – *Combination Ovens*

For boiler-based combination ovens, a condensate return system can be installed to direct the condensate back into the central boiler system for reuse on a combi-oven. This process will improve both water and energy efficiency because the condensate can be used as boiler makeup water. Packaged condensate return systems can be purchased from most steam equipment suppliers and be plumbed directly into an existing system. Condensate return lines can also be insulated to further improve efficiency.

There are currently no retrofit options available on the market to increase the efficiency of connectionless combination ovens.

Replacement BMP Options – *Combination Ovens*

Look for models that are connectionless and that use no more than 15 gallons of water per hour[76] or 3.5 gallons per pan per hour[77] when purchasing a new combination oven or replacing an existing one. Combination ovens come in varying sizes, depending upon the amount and types of food to be cooked. Consult the manufacturer to choose a combination oven that is appropriately sized for the cooking needs of the food service operation. A larger-than-necessary combination oven can waste water and energy to heat unused compartment space.

Finally, all purchased combination ovens should be among the qualified products on the Fisher Nickel list for energy rebates in California[78]

Savings Potential – *Combination Ovens*

Boiler-based combination ovens can use as much as 30 to 40 gallons of water per hour.[79] Switching to a boilerless unit can reduce that water use to 15 gallons of water per hour or less.[80] According to the East Bay Municipal Utility District, replacing a boiler-based combination oven with a connectionless model can save nearly $3,000 in water and energy bills each year, which could provide Payback for the cost of the new equipment in approximately five years.[81]

To estimate facility-specific water savings and Payback, use the following information:

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[76] East Bay Municipal Utility District. 2008. *Watersmart Guidebook—A Water-Use Efficiency Plan Review Guide for New Businesses*. Page 43.

[77] Food Service Technology Center.2013d. “Combination Ovens.” www.fishnick.com/savewater/appliances/combinationovens/.

[78] Food Service Technology Center. 2013e. “Qualified Combination Ovens.” www.fishnick.com/saveenergy/rebates/combis.pdf

[79] USEPA. n.d.f. “U.S. Environmental Protection Agency, Energy Star Program: Best Practices—How to Achieve the Most Efficient Use of Water in Commercial Food Service Facilities.” www.energystar.gov/index.cfm?c=healthcare.fisher_nickel_feb_2005.

[80] USEPA. n.d.f.

[81] Assumes that heat is electric. Payback may be longer for gas supplied heat. From: Harris R. 2008. *Turning up the Heat on Commercial Kitchen Water Savings*.

Boiler-Based Combination Oven Replacement

A facility will see the most water savings from replacing a boiler-based combination over with a connectionless oven of the appropriate size. As mentioned above, only boiler-based combination ovens have a retrofit option.

Current Water Use

To estimate the current water use of an existing combination oven, identify the following information and use Equation 7.15 below:

- Hourly water use in gallons per hour. A typical boiler-based combination oven may use as much as 30 to 40 gallons per hour.
- Average daily usage time varies by facility.
- Days of facility operation per year.

Equation 7.15

Water Use of a Combination Oven (gallons/year) =
Hourly Water Use (gallons/hour) X Daily Usage Time (hours/day)
X Days of Facility Operation (days/year)

Water Use After Retrofit or Replacement

Use Equation 7.15 to estimate the water use of a system retrofit or replacement combination oven. Substitute the hourly water use for the retrofitted system or replacement combination oven. Boilerless combination ovens can use 15 gallons per hour or less.

Water Savings

Determine the expected water savings by subtracting the water use after retrofit or replacement from the current water use.

Payback

Identify the following information and use Equation 7.16, below, to calculate the simple Payback from retrofitting or replacing an existing combination oven:

- Equipment and installation cost of the retrofit or replacement combination oven. A combination oven may cost approximately $15,000.[82]
- Water savings as calculated using Equation 7.15.
- Facility-specific cost of water and wastewater.

[82] Harris R. 2008.

Equation 7.16

Payback (years) = Equipment and Installation Cost ($) /
[Water Savings (gallons/year) X Cost of Water and Wastewater ($/gallon)]

Facilities may also save a significant amount of energy by reducing the water use and steam generation associated with the use of the combination oven by switching to a boilerless combination oven. These energy savings will further reduce the Payback time and increase replacement cost-effectiveness.

7.1.1.8 Steam Cookers

Overview – *Steam Cookers*

Steam cookers, also known as food steamers, are commercial kitchen appliances used to prepare foods in a sealed vessel that limits the escape of air or liquids below a pre-set pressure. There are two types of steam cookers: boiler-based and boilerless (without a central boiler connection). Boilerless steam cookers can be either completely unconnected to any water supply or can be connected to a water supply just to keep the water reservoir full.

Types of Equipment – *Steam Cookers*

Boiler-Based Steamers

Boiler-based steam cookers are connected to a central boiler, which delivers steam to the heating compartment. Steam that does not condense on the food escapes as a mixture of steam and condensate through a drain or venting. In addition, some water is continuously bled off from the steam cooker to help reduce and manage scale build up. Most manufacturers indicate that water supplied to the steam cooker should be under 50 parts per million (ppm) of total dissolved solids (TDS), otherwise bleed off must be increased. Boiler-based steam cookers also use large amounts of water to further condense the steam and to cool (temper) the condensate water to around 140^{o}F before it enters the sewer system.

Connectionless Boilerless Steamers

Unconnected (connectionless) boilerless steam cookers have an individual reservoir where water is heated below the steam trays to create the steam. These types of steam cookers are manually drained and refilled and do not require a dedicated drain for condensate or the addition of cooling (tempering) water. A small amount of steam is vented through the top of the steam cooker, but what is not vented or condensed on the food returns as condensate to the reservoir.

Connected Boilerless Steamers

Connected boilerless steam cookers have a float valve that maintains the water level in the reservoir, but unlike the boiler-based steam cookers, there is no continuous flow of water.

Water Use Information – *Steam Cookers*

Most boiler-based steam cookers offer a standby setting that maintains the boiler in a ready-to-use state. In many instances, the condensate cooling (tempering) water will continue to flow even when the steam cooker is in standby mode, particularly if the condensate cooling water is manually controlled. Some boiler-based steam cookers allow the condensate cooling water to be turned off while the steamer is in standby mode. Steamers that are timer-controlled will automatically switch into standby mode at the end of the set cook time, minimizing the amount of water wasted while the unit is not in use.

The connected boilerless steam cookers are usually as efficient as the connectionless models.

Energy Star® has developed voluntary criteria to qualify energy- and water-efficient steam cookers to earn the Energy Star® label[83] to address efficiency and advances in commercial steam cookers.

Operation, Maintenance, and User Education BMPs – *Steam Cookers*

For optimum steam cooker efficiency, consider the following:

- Use batch production as opposed to staged loading of food pans (i.e., do not repeatedly open the door to load and unload food pans).
- Where possible, fill the steam cooker to capacity instead of cooking one pan in a multi-pan steamer.
- Keep the doors closed while the steamer is operating.
- Use only as many steamer compartments as needed.
- Use a timer to ensure that the steam cooker returns to standby mode after use.
- Turn the steam cooker off during long periods of non-use. This will reduce water and energy use associated with keeping the steam cooker in stand-by mode.
- Repair any leaks. Remove any deposit buildup from the boiler on boiler-based models.

Retrofit BMP Options – *Steam Cookers*

A condensate return system may be installed to direct the condensate back into the central boiler system for reuse when using a boiler-based steam cooker. This process will improve both water and energy efficiency because the condensate can be used as boiler makeup water. Packaged condensate return systems can be

[83] USEPA. n.d.g. "U.S. Environmental Protection Agency Energy Star® Program: Commercial Steam Cookers." http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COC

purchased from most steam equipment suppliers; plumb them directly into an existing system. Insulating condensate return lines will further improve their efficiency.

There are currently no retrofit options available on the market to increase the water efficiency of boilerless steam cookers.

Replacement BMP Options – *Steam Cookers*

Steam cookers come in several sizes with varying numbers of boiler pans. Choose a steam cooker that is of the appropriate size for the food service needs of the facility. A steam cooker that is larger than necessary may waste water and use excessive energy to heat unused compartment space.

Choose models that are Energy Star® qualified[84] when purchasing a new steam cooker or replacing an existing one. Energy Star® steam cookers meet cooking efficiency and maximum idle rate requirements and can typically save about 90 percent of the water used by a traditional steam cooker.

The cost differential between connectionless and boiler-based steamers is small. However, boiler-based steamers must have both water and sewer hookups and a Reduced Pressure Zone (RPZ) backflow preventer, which can add several thousand dollars to the total installed cost of the steamer. In addition, the backflow preventer must be tested annually.

Savings Potential – *Steam Cookers*

Energy Star® qualified steam cookers can achieve a 90 percent reduction in water use and use half as much energy as standard steam cookers.[85] Traditional boiler-based steam cookers may use as much as 40 gallons of water per hour. Switching to an Energy Star® qualified steam cooker can reduce that water use to 3.0 gallons of water per hour or less. Assuming the steam cooker is used and operating 6.5 hours per day, 360 days per year,[86] an Energy Star® qualified steam cooker may save as much as 86,000 gallons and 3,000 kWh per year.[87]

Several methods and tools can be used to calculate facility-specific water, energy, and cost savings for replacing an existing boiler-based steam cooker with an Energy Star® qualified model. In addition to the equations below, you can use one of the Food Service Technology Center's life cycle and energy cost calculators.[88]

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[84] USEPA. n.d.g.
[85] USEPA. n.d.g.
[86] Harris R. 2008. *Turning up the Heat on Commercial Kitchen Water Savings.* www.energystar.gov/ia/partners/downloads/meetings/water_Richard_Harris.pdf
[87] USEPA. n.d.c. "Commercial Kitchen Package for Businesses and Operators: Commercial Equipment Savings Calculator."
[88] Food Service Technology Center. 2013g. "Life-Cycle & Energy Cost Calculators." www.fishnick.com/saveenergy/tools/calculators/

To estimate facility-specific water savings and Payback, use the following information:

Boiler-Based Steam Cooker Retrofit or Replacement

Current Water Use

Identify the following information and use Equation 7.17 below to estimate the current water use of a steam cooker:

- Flow rate of the existing steam cooker
- Average daily use time
- Days of food service operation per year

Equation 7.17

Water Use of Steam Cooker (gallons/year) = Flow Rate per Hour (gallons/hour) X Daily Use Time (hours/day) X Days of Operation per Year (days/year)

Water Use After Retrofit or Replacement with Energy Star® Qualified Steam Cooker

Use Equation 7.17 to estimate the water use after retrofitting a boiler-based system or replacing an existing steam cooker, and substitute the flow rate of the new recirculating configuration or the Energy Star® qualified steam cooker for the flow rate of the existing steam cooker.

Water Savings

Determine the expected water savings by subtracting the water use after steam cooker retrofit or replacement from the current cooker water use.

Payback

Use Equation 7.18 below to calculate the simple Payback from retrofitting or replacing an existing steam cooker, and identify the following information:

- Purchase and installation cost of the retrofit or replacement steam cooker.
- Water savings as calculated in above.
- Facility-specific cost of water and wastewater.

Equation 7.18

Payback (years) = Equipment and Installation Cost ($) / [Water Savings (gallons/year) X Cost of Water and Wastewater ($/gallon)]

Savings Potential - California – *Steam Cookers*

A 2005 report by the Food Service Technology Center (FSTC)[89] estimated that approximately 25,000 compartment food steamers were installed in the State of California. As of 2005, the FSTC went on to estimate that the boilerless (connectionless) equipment only represented less than five percent of that total, the remainder being boiler-based units. The FSTC concluded that about 60 percent of the installed base were viable candidates for replacement with the very efficient units, or about 15,000 steamers,[90] Assuming 86,000 gallons of water saved per year per unit, as identified above, an estimated 3,960 af of annual water savings could be achieved if the 15,000 units are replaced.

7.1.1.9 Steam Kettles

Overview – *Steam Kettles*

Steam kettles are either boiler-based or self-contained cooking appliances that use circulating steam to perform tasks similar to traditional stockpots, including boiling pasta and simmering sauces. Steam kettles may be preferable to traditional stockpots due to their rapid, uniform cooking and ease of control.

Steam kettles have a double wall that covers at least half of the height of the sides of the kettle. Steam is circulated within this double wall, or "jacket," and it then condenses to transfer heat to the food product by means of conduction. Steam kettles range in size from 0.5 gallon to more than 200 gallons each.[91] Steam kettles may also be designed with tilting capability, strainers, and covers.

Steam kettles are often selected for use in large food service facilities because, as with steam tables, temperatures can be more easily controlled, thereby preventing food scorching. However, they should only be installed only where large-volume food preparation justifies the water and energy use.

Types of Equipment – *Steam Kettles*

Boiler-Based

Boiler-based steam kettles rely on an external central boiler to deliver steam. These types of steam kettles are commonly found in industrial facilities with centrally located boilers. Boiler-based steam kettles require a regular

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[89] Fisher-Nickel, Inc. and Koeller and Company, 2005. *Evaluating the Water Savings Potential of Commercial "Connectionless" Food Steamers, Final Report.* This report describes the very comprehensive field study of actual steamer installations and their water and energy consumption. Funded by Pacific Gas & Electric, East Bay Municipal Utilities District, and the Metropolitan Water District of Southern California, the fieldwork tracked water and energy consumption at 12 different food service operations in northern and southern California.

[90] It should be noted that not all boiler-based units could be replaced, due the need in some establishments for high production capacity, something the boilerless steamers are not yet equipped to provide.

[91] Cornell University New York State Agricultural Experiment Station. 2007. *Steam Kettles in Food Processing: Small Scale Food Entrepreneur*. www.nysaes.cornell.edu/necfe/pubs/pdf/FactSheets/FS_SteamKettles.pdf

"blowdown" to remove condensate on the steam supply line and can consume more than 100,000 gallons of water per year. Returning condensate to the boiler as makeup water can reduce this water consumption.[92]

Self- Contained

Self-contained steam kettles rely on their own heat source to generate steam under pressure (Figure 7.4). Self-contained steam kettles use less water and energy than boiler-based steam kettles, because they do not require significant blowdown water. Boiler water must be dumped at the end of the day to prevent mineral build up. They also require de-liming on a regular basis and regular manual venting and refilling.[93]

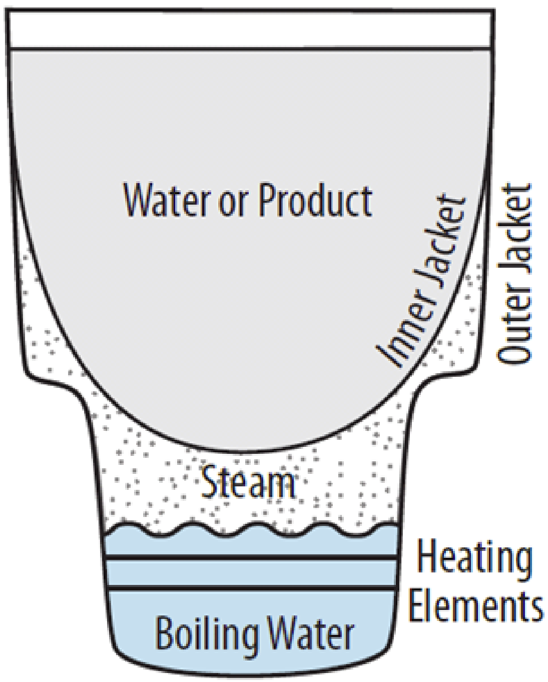


Figure 7.4 - Self-Contained Steam Kettle

The American Society for Testing and Materials (ASTM International) developed a performance test for direct steam and self-contained gas or electric steam kettles. *ASTM F1785-97*, Standard Test Method for Performance of Steam Kettles, measures the energy consumption and cooking performance of steam kettles. This test method can be used to choose an appropriately sized kettle based on the operation's food output and can maximize kettle efficiency.

Operation, Maintenance, and User Education BMPs – *Steam Kettles*

[92] East Bay Municipal Utility District. 2008. *Watersmart Guidebook—A Water-Use Efficiency Plan Review Guide for New Businesses*. Page FOOD6.
[93] Cornell University New York State Agricultural Experiment Station. 2007.

Consider the following for optimum steam kettle efficiency:

- Regularly monitor self-contained steam kettle water levels and maintain control components to ensure efficient operation.
- Turn the steam kettle down or off between uses.
- Secure the steam kettle lid whenever possible to reduce the amount of energy required for simmering and boiling.
- If using a boiler-based steam kettle, ensure that the central boiler system is maintained properly in accordance with the *Boiler and Steam Systems BMP*.

Retrofit BMP Options – *Steam Kettles*

The major water-saving potential for boiler-based steam kettles is for the condensate to be retained and returned to the boiler.

A condensate return system can be installed to direct the condensate back into the central boiler system for reuse (Figure 7.5). This process will improve both water and energy efficiency because the condensate can be used as boiler makeup water. Packaged condensate return systems can be purchased from most steam equipment suppliers; plumb them directly into an existing system. Condensate return systems cost about $3,000. There are additional costs for piping and other installation requirements. Insulating condensate return lines will further improve efficiency.

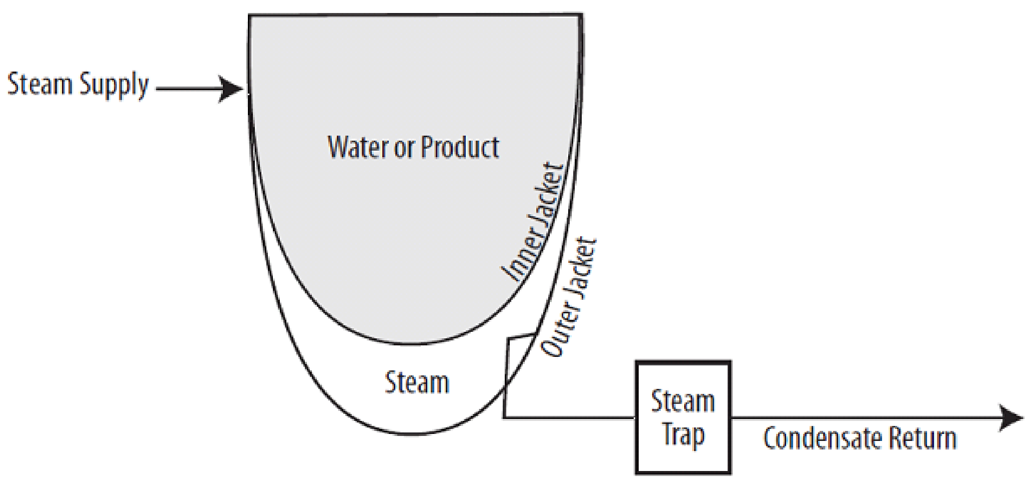


Figure 7.5 - Boiler-Type Steam Kettle

There are currently no retrofit options available on the market to increase the efficiency of self-contained steam kettles.

Replacement BMP Options – *Steam Kettles*

When purchasing a new steam kettle or replacing an old one, consider the steaming needs of the kitchen. For smaller steaming needs, consider self-contained steam kettles without an external boiler, which use less water and energy than boiler-based steam kettles. If daily operations require a boiler-based steam kettle, consider a model with a condensate return system. Choose a steam kettle with a properly sized steam trap to prevent inadvertent dumping of condensate.

Savings Potential – *Steam Kettles*

Retrofitting or replacing existing steam kettles can yield operational water savings. For a boiler-based steam kettle, water savings achieved by returning the condensate to the boiler can be substantial. However, actual water savings are difficult to approximate because the water use of a steam kettle varies based upon its size and the pressure of the steam. According to the East Bay Municipal Utility District, condensate return systems cost approximately $3,000 and have an estimated product life of ten years.[94] To estimate facility-specific water savings and Payback, use the following information:

Boiler-Based Steam Kettle Retrofit or Replacement

Current Water Use

Identify the following information and use Equation 7.19 below to estimate the water use of a steam kettle:

- Flow rate of the existing steam kettle calculated using the capacity of the kettle (gallons) and the pressure of the steam in pounds per square inch (psi)
- Average daily use time in the food service operation
- Days of food service operation per year

Equation 7.19

Water Use of Boiler-Based Steam Cooker (gallons/year) =
Flow Rate per Hour (gallons/hour) X Daily Use Time (hours/day)
X Days of Operation per Year (days/year)

Water Use After Retrofit or Replacement

Use Equation 7.19 to estimate the water use after retrofitting or replacing an existing steam kettle, and substitute the flow rate of the new configuration or new system for the flow rate of the existing steam kettle.

Water Savings

Determine the expected water savings by subtracting the water use after steam kettle retrofit or replacement from the current kettle water use.

[94] East Bay Municipal Utility District. 2008. *Watersmart Guidebook—A Water-Use Efficiency Plan Review Guide for New Businesses*. Page FOOD6.

Payback

Use Equation 7.20 below to calculate the simple Payback from replacing an existing steam kettle, identify the following information:

- Purchase and installation cost of the replacement steam kettle
- Water savings as calculated above
- Facility-specific cost of water and wastewater

Equation 7.20

Payback (years) = Equipment and Installation Cost ($) /
[Water Savings (gallons/year) X Cost of Water and Wastewater ($/gallon)]

7.1.1.10 Wok Stoves

Overview – *Wok Stoves*

A wok stove is a Chinese pit-style stove that has a wok (or multiple woks) recessed into the stove top, allowing heat to be fully directed onto the bottom of the wok.

Types of Equipment – *Wok Stoves*

Conventional Wok Stove

Conventional wok stoves use water for both cooling and cleaning.[95] 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. Figure 7.6 illustrates the design of a water-cooled wok stove.

[95] Sydney Water. 2005a "Save Water, Money, and the Environment - Wok Stoves." www.sydneywater.com.au/Publications/Factsheets/Wok_stove_fact_sheet.pdf

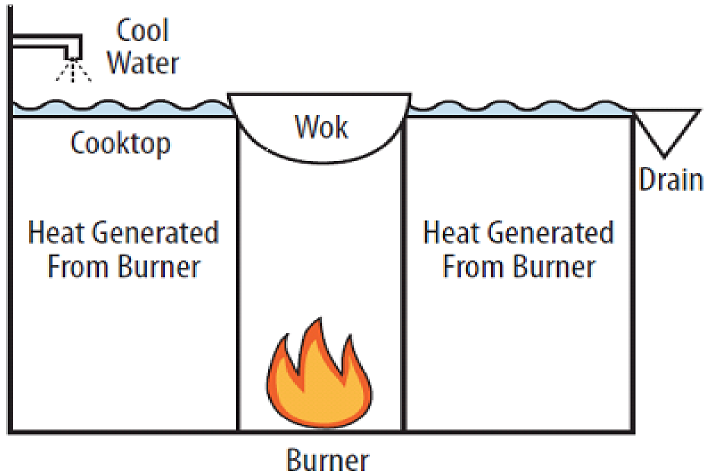


Figure 7.6 - Water-Cooled Wok Stove

Waterless Wok Stove

Waterless wok stoves, a relatively new technology, are air cooled. These wok stoves function by creating an air gap between the burner chimney and ring at the top of the stove so that the heat can be released directly from beneath the cook top and vented to the kitchen exhaust (Figure 7.7). Waterless wok stoves can further reduce water use if they are outfitted with a rinsing spout that shuts off the water supply when it is not needed for wok cleaning.

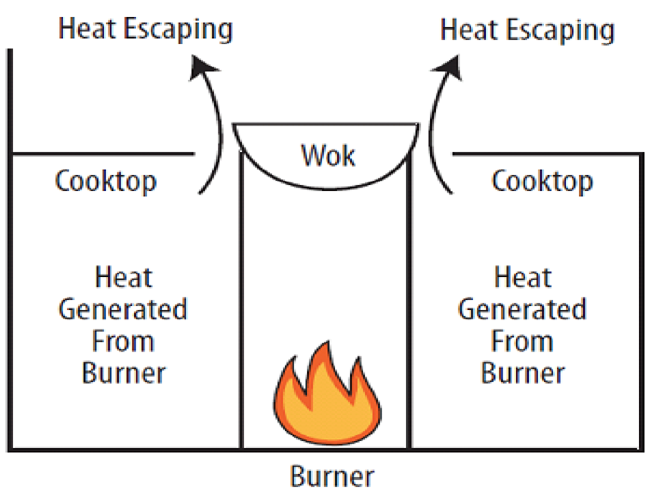


Figure 7.7 - One Type of Air-Cooled Wok Stove

Water Use Information – *Wok Stoves*

Advancement in wok stove technology provides chilled water to the wok stove by connecting to the building's chilled water loop or uses a point-of-use chiller to reduce the temperature of the cook top. This type of wok stove has an internal backup water-using system in the event that the recirculated chilled water is not available.

Some conventional wok stoves are outfitted with a reservoir to provide water used for cooking, which is typically left running even when it is full. Waterless wok stoves may have a mechanism to limit both the flow rate and duration of flow to this reservoir.[96]

Facilities could save 90 percent of the water required for cooking and cleaning by replacing conventional wok stoves with waterless models and/or reducing the flow rate and duration of rinse and reservoir spouts.

Operation, Maintenance, and User Education BMPs – *Wok Stoves*

Consider the following for optimum wok stove efficiency:

- Encourage cooking staff to turn off rinse and reservoir spouts when not in use.
- Inspect and ensure that the shutoff valves for the rinse and reservoir spouts are in working order.
- Shut off the cooling water when the wok stove is not in use, especially at the end of each day.
- Routinely check cooling water lines for leaks and corrosion.

Retrofit Options – *Wok Stoves*

Check if rinse spouts can be replaced with spouts that automatically shut off or that can switch off when pushed back away from the wok if retrofitting an existing conventional wok stove.

Replacement BMP Options – *Wok Stoves*

Look for waterless models, which will be air-cooled instead of water-cooled, when purchasing a new wok stove or looking to replace an existing conventional wok stove. Waterless wok stoves may use about two percent more energy than a conventional wok stove,[97] but they can save more than 90 percent of the water used. Also, look for waterless models that have automatic shutoff rinse and reservoir spouts and/or knee-operated timer taps to limit both the flow rate and duration of the flow.

[96] Alliance for Water Efficiency. 2010g. "Waterless Wok Introduction." www.allianceforwaterefficiency.org/1Column.aspx?id=700
[97] Koeller J. and Gauley B. 2010. "2010's Top-5 New and Innovative Water Efficient Products." http://forms.iapmo.org/newsletter/green/2010/05/2010_Top5.asp

Savings BMP Potential – *Wok Stoves*

During the course of a 12-hour day, a conventional wok stove with one burner can use more than 700 gallons of water. In addition to the water used for cooling, the woks must also be rinsed between uses, which can require 500 to 800 gallons of water per day, particularly if the rinsing spout is left constantly running. Overall, studies have shown that daily average water use of a conventional wok stove is about 1,400 to 2,000 gallons per day.[98] Therefore, savings could add up to more than $3,500 in avoided water and sewer costs each year, which could provide payback for the cost of the new equipment in as few as one to two years.[99]

Water savings can be achieved through two mechanisms: eliminating the use of cooling water by switching from a water-cooled to an air-cooled waterless wok stove *or* by reducing the flow rate and duration of use of rinse and reservoir spouts. To estimate facility-specific water savings and payback, use the following information:

Conventional Wok Stove Retrofit

Woks must be rinsed between uses and reservoir spouts are often filled to provide water used in cooking. Reducing the flow rate of rinse and reservoir spouts and the duration of their use can significantly reduce this water use. Use the following information to estimate water savings and payback potential that may be achieved with this type of retrofit:

Current Water Use

Use Equation 7.21 below to estimate the current water use of the existing wok stove rinse and reservoir spouts, identify the following information:

- Flow rate of each rinse and reservoir spout
- Average daily use time of rinse and reservoir spouts
- Days of food service operation per year.

Equation 7.21

Water Use of a Wok Stove Rinse and Reservoir Spout (gallons/year) = Flow Rate (gpm) X Daily Use Time (minutes/day) X Days of Facility Operation (days/year)

[98] Sydney Water. *Wok Stoves*. www.sydneywater.com.au/Publications/Factsheets/Wok_stove_fact_sheet.pdf.

[99] Estimate assumes an annual savings of approximately 500,000 gallons; from Sydney Water. Wok Stoves. www.sydneywater.com.au/Publications/Factsheets/Wok_stove_fact_sheet.pdf. Also assumes a water and sewer rate of $7.16 per 1,000 gallons; from Raftelis Financial Consulting. 2008. *Water and Wastewater Rate Survey*. American Water Works Association.

Water Use After Retrofit

Use Equation 7.21 to estimate the water use of more efficient rinse and reservoir spouts, and substitute the flow rate of the retrofit rinse and reservoir spouts.

Water Savings

Determine the expected water savings by subtracting the water use after retrofit of the spouts from the current water use.

Payback

Use Equation 7.22 to calculate the simple Payback from retrofitting an existing wok stove with more efficient rinse and reservoir spouts, identify the following information:

- Equipment and installation cost of the retrofit rinse and reservoir spouts
- Water savings as calculated from the step above
- Facility-specific cost of water and wastewater

Equation 7.22

Payback (years) = Equipment and Installation Cost ($) /
[Water Savings (gallons/year) X Cost of Water and Wastewater ($/gallon)]

Conventional Wok Stove Replacement

Switching to a waterless wok or one that uses recirculated chilled water can eliminate the use of single-pass cooling water, thereby reducing the wok stove's total water use by as much as 90 percent,. This could result in savings of nearly 230,000 gallons per year. Waterless wok stoves cost approximately $10,000 to $12,000, excluding installation. As such, it is unlikely that a conventional food service operation can recoup the initial cost of the equipment in an acceptable period of time. Use the following information to estimate water savings and payback potential that may be achieved by replacing a conventional wok stove with a waterless wok stove or one that uses recirculated chilled water.

Current Water Use

Use Equation 7.23 to estimate the water used for cooling of a waterless wok stove, identify the following information:

- Flow rate of the cooling water: this flow rate is typically one gpm
- Average daily use time
- Days of food service operation per year

Equation 7.23

Water Use of Wok Stove Cooling Water (gallons/year) = Flow Rate (gallons/minute) X Daily Use Time (minutes/day) X Days of Facility Operation (days/year)

Water Savings

Determine the expected water savings by subtracting the water use after replacement with a waterless wok from the current water use.

Payback

Use Equation 7.22 above to calculate the simple Payback from replacing an existing conventional wok stove with a waterless unit, identify the following:

- Equipment and installation cost of the replacement waterless wok stove or one using recirculated chilled water. Units using chilled water cost over $10,000, excluding installation. Verify costs before deciding to replace an existing conventional wok stove.
- Water savings as calculated using above.
- Facility-specific cost of water and wastewater.

7.1.2 Fabric Cleaning and Washing Equipment

Overview

Equipment used in commercial laundry operations depends upon the type of laundry facility, the total quantity and type of laundry to be cleaned, and the cleaning frequency needed. Several different CII applications exist, each of which uses a different type of wash equipment:

- Self-service (coin- or card-operated) commercial laundromats provide a centralized location where individual consumers can bring their personal laundry. These types of laundry facilities typically use commercial single-load, residential-style washers and multi-load washers not commonly found in homes.
- On-premises laundries - OPLs (institutional), on the other hand, are onsite facilities dedicated to washing fabrics used at the location. They are typically found in facilities such as hotels, food and beverage manufacturers, hospitals, nursing homes, incarceration facilities, athletic facilities, and universities.
- Industrial laundries are typically centralized contract laundries that launder fabrics from other businesses, usually in high volume, such as uniform, diaper, and linen services, as well as other specialized apparel and fabrics.

Industrial laundries and on-premises laundries tend to use large, multi-load washers and washer extractors. These same operations may also use tunnel washers. Specific types of commercial laundry equipment are discussed in more detail below.

Technical Feasibility

All of the practices, products, and technologies described within this report section have been in existence for an extended period of time and found to be technically feasible. In each case, however, economic feasibility must be evaluated within the context of the physical condition and demands of the specific property or building being considered for high-efficiency fabric cleaning operations.

Types of Equipment

Commercial Coin- and Card-Operated Washers

Commercial coin- and card-operated, single-load washers are similar to conventional, residential-style clothes washing machines. Top-loading, soft-mount (not bolted to the floor) machines have dominated this market, although they are being phased out and replaced by more efficient, front-loading machines. Multi-load machines are now appearing in many laundromats (supplementing single-loaders) to achieve economies of scale (reduced machine footprint, greater water and energy efficiency, and increased revenue per square foot of store). Multi-load machines may also be top- or front-loaded, hard mount (bolted to the floor) or conventional soft mount machines with capacities often exceeding 80 pounds per load (as compared to less than 20 pounds per load for a conventional single-load machine).

Washer Extractors

Washer extractors are similar to multi-load washers, but they can be significantly larger, with capacities ranging from 30 to 800 pounds of laundry per load. Commonly used in OPLs,[100] washer extractors remove water and detergent from clothes using high-speed, centrifugal force spin cycles and are only configured with a horizontal front-loading axis. Washer-extractors are designed to wash everything from relatively clean hotel towels and bedding to heavily soiled items from nursing homes and commercial kitchens. One significant difference between a washer extractor and a coin- or card-operated commercial washer is the ability to significantly vary the number of wash cycles. For example, washing lightly soiled sheets at a hotel may only require a three-cycle operation consisting of wash (detergent), bleach, and rinse cycles. More heavily soiled laundry may require additional cycles, including a first flush, an alkali cycle to adjust the pH, a wash cycle, a bleach cycle, several rinse cycles, another pH adjustment to return the pH to neutral, and a final rinse cycle. With each cycle, some machines have the ability to adjust water levels and the amount of hot or cold water used. This illustrates the importance of the equipment operator separating laundry by

[100] Koeller and Company, 2005. *Evaluation of Potential Best Management Practices – On-Premise Laundries.*

its level of soil to determine the amount of water used for the total wash operation.

Most washer extractors require two to four gallons of water per pound of fabric cleaned, depending upon the machine, the number of wash cycles used, and the water level settings. Equipment costs vary depending upon washer capacity, and range from $3,000 to $20,000.

Tunnel Washers

Since their introduction in the late 1960s, tunnel washers have become progressively more reliable. Though extremely expensive (many in excess of $1 million), they are now common in major hotel, hospital, cruise ship, and other high-volume laundry applications.[101] Tunnel washers are large volume, continuous batch washers with long chambers and a series of compartments through which the laundry is pulled for soaking, washing, and rinsing. In addition to being used in some OPLs, tunnel washers are also used in off-site industrial laundry operations serving institutional users, such as hospitals, prisons, hotels, motels, and restaurants. They are capable of handling up to 2,000 pounds of laundry per hour. Figure 7.8 provides an illustration of tunnel washer configuration.

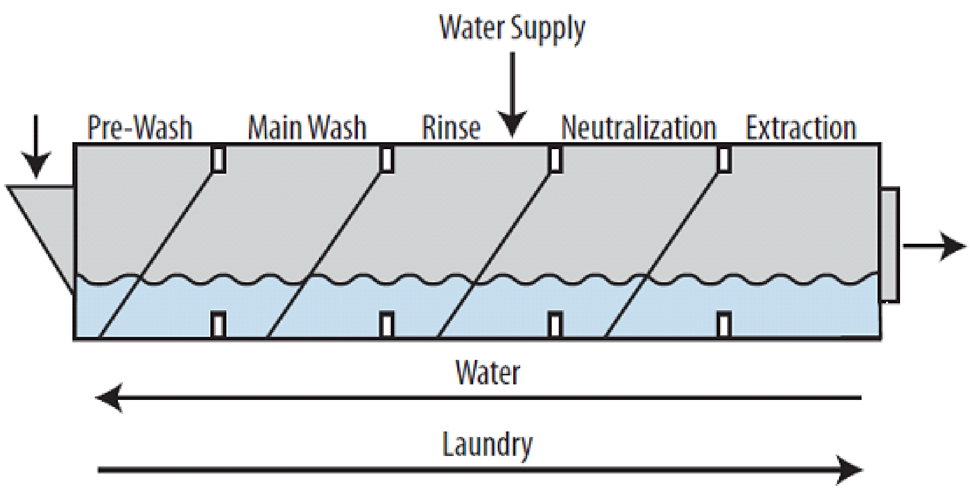


Figure 7.8 - Tunnel Washer

Ozone Laundry Systems

Ozone laundry systems can be used in a variety of OPLs. With these systems, ozone is injected into the wash as a powerful oxidant that reacts with dirt and organic materials. It also provides disinfection and whitening properties. Ozone can reduce the amount of detergents and other chemicals needed, lessening the amount of rinsing required.

[101] Wikipedia. 2011. "Tunnel Washers." en.wikipedia.org/wiki/Tunnel_washer

Ozone systems are especially attractive where water/sewer costs are less than $4.00 per thousand gallons, and where annual laundry volume is relatively small. Ozone laundry systems are best suited for wash classifications in the medium and light range, generally not for heavy soil. Although some manufacturers claim that satisfactory results have been obtained in heavy soil laundering, most manufacturers will not venture into applications with large percentages of heavy soil or they exclude the mix of heavy soil from their savings calculations. Care must be taken to not attempt treating the heavy soil portion with ozone, as it must be laundered with conventional chemistry and high-temperature water.

Since ozone works best in ambient water temperatures, the water is not heated. Therefore, the water heating energy savings over conventional laundry systems is approximately 80 percent in most applications. Actual energy savings realized will depend upon the proportion of loads that must be washed with standard chemistry in high temperature, such as food and beverage linen, mop heads, and bar rags. Other benefits include chemical savings, less wear and tear on linens, shorter wash cycles, and potential labor savings.

Water Use Information

Recent advances to reduce water use in commercial laundry equipment include more water efficient equipment, water recycling (internal and external to the machines), and ozone technologies.

Commercial Coin- and Card-Operated Washers

Single-Load Clothes Washers

The EPAct of 2005 and subsequent rulings require that commercial coin- or card-operated single-load, soft-mount residential-style laundry equipment meet the following[102] requirements:

- Top loading machine: Water factor (WF) of 8.5 gallons per cycle per cubic foot of capacity and a modified energy factor (MEF) of at least 1.6 cubic feet per kWh per cycle.
- Front loading machine: WF of 5.5 gallons per cycle per cubic foot of capacity and an MEF of at least 2.0 cubic feet per kWh per cycle.

Multiple-Load Clothes Washers

Some commercial laundromats are equipped with coin- or card-operated multi-load capacity washers in addition to the single-load machines. These types of machines are not regulated for water use by EPAct 2005 or DOE.

Energy Star® has developed voluntary criteria to further qualify high-efficiency clothes washers and address efficiency and advances in commercial clothes

[102] These updated requirements are effective January 8, 2013. Refer to: USEPA. 2013. "Building Technologies Office, Appliance and Equipment Standards: Commercial Clothes Washers." www1.eere.energy.gov/buildings/appliance_standards/commercial/clothes_washers.html

washers. As of January 8, 2013, Energy Star® qualified washers (http://www.energystar.gov/products) must not exceed a WF of 4.5 gallons per cycle per cubic foot of capacity and must have an MEF of no less than 2.2.[103]

Unlike the conventional machines, multi-load machines must be programmed to control settings (e.g., number of cycles, water levels per cycle). These settings can dictate the amount of water used by the machine and can be adjusted to improve efficiency.

Washer Extractors

Washer extractor efficiency is usually measured in gallons of water per pound of fabric, as opposed to gallons per cubic foot for commercial coin- or card-operated washers. Today's high-efficiency washer extractors reuse water multiple times within the wash-rinse cycle to achieve both water and energy efficiency.

Tunnel Washers

Tunnel washers are more water-efficient because the water moves in a counter-flow direction to the laundry, starting with the last rinse, so water is used through several cycles of the wash before being sent to the drain (Figure 7.8). Tunnel washers are costly to purchase and install, but are capable of saving more water than washer extractors and require less operation and maintenance labor. Tunnel washers typically use two gallons of water or less per pound of fabric.

Ozone Washing Systems

Studies indicate that a minimum of 15 percent to 20 percent water and sewer savings can be achieved in many applications with the use of ozone washing systems. Isolated opportunities may yield 30 percent to 35 percent savings in water consumption and sewer discharges. Some manufacturers claim savings up to the 50 percent - 60 percent range. Caution is very important in estimating savings with ozone laundry systems. Ozone laundry systems can cost between $10,000 and $25,000; paybacks are generally less than two years.

Rinse Water Recovery Technologies

One of the concepts used in laundries is rinse water recovery. This type of system works by diverting water recovered from rinse-only cycles into a large holding tank near the laundry wash line. Whenever a washer calls for water in a soak, suds, or wash cycle, the water stored in the rinse water holding tank is pumped into the washers. These systems are typically successfully in installed in institutional properties, such as Veterans Administration hospitals and state prisons. These systems are not typically found in commercial laundry

[103] For information on Energy Star®-qualified commercial clothes washers see: USEPA. n.d.h. "U.S. Environmental Protection Agency's Energy Star® Program: Commercial Clothes Washers for Consumers." http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=CCW

applications because they involve high initial cost and very long payback periods, often making them unattractive in commercial settings.

Operation, Maintenance, and User Education BMPs *– Fabric Cleaning and Washing*

Consider the following to maximize the efficient operation of commercial laundry machines:

- Only operate washers with full loads. For washer extractor and tunnel washer applications, use a laundry scale to weigh loads to ensure the machine is filled to capacity.
- Separate and wash laundry based upon the extent to which materials are soiled. Also consider separating laundry by the number of cycles needed.
- In consumer applications (laundromats), install only front-loading, high-efficiency machines (single load and multi-load), and set those machines to maintain the manufacturer-rated WF (or less).[104]
- 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.
- Use detergents specially formulated for high-efficiency clothes washers.
- Avoid excessive backflushing of filters or softeners; backflush only when necessary.

Retrofit BMP Options *– Fabric Cleaning and Washing*

There are two main retrofit options to reduce water use associated with existing laundry equipment— water reuse/recycling and ozone systems.

Water Reuse/Recirculation

Simple or complex recirculate systems can be added to coin- or card-operated multi-load washers and washer extractors to recirculate a portion or all of the water for reuse in the next wash. Simple recirculation systems recover discharge from the final rinse in a multi-cycle operation for use in the first rinse of the next cycle. The water from these systems rarely needs treatment prior to reuse, so potential water savings are generally between 10 to 35 percent. Complex recirculation systems treat reclaimed water from wash and rinse cycles for use in all cycles of the next load and can save more than 85 percent of water used.[105]

[104] East Bay Municipal Utility District. 2008. *WaterSmart Guidebook: A Water-Use Efficiency Plan Review Guide for New Businesses.*
[105] Koeller and Company. 2005. *Evaluation of Potential Best Management Practices – On-Premise Laundries*.

Complex recirculation systems usually require water treatment before reuse and are costly to install and maintain.

It is important to evaluate space constraints when considering water reuse/recycling options. Space may be unavailable to accommodate additional recycling equipment or storage tanks. Recycling may also require adjustments in chemicals and detergents. Therefore, contact the chemical supply vendor during the planning process.

Ozone Systems

Ozone systems can be installed on all types of existing commercial laundry machines as retrofits, although they are not as common as a retrofit for tunnel washers. As noted earlier, ozone systems work well on lightly soiled laundry, but are not recommended for heavily soiled laundry. In these applications, conventional washing, detergents, and hot water work best. See the Figure 7.9 for ozone system configuration.

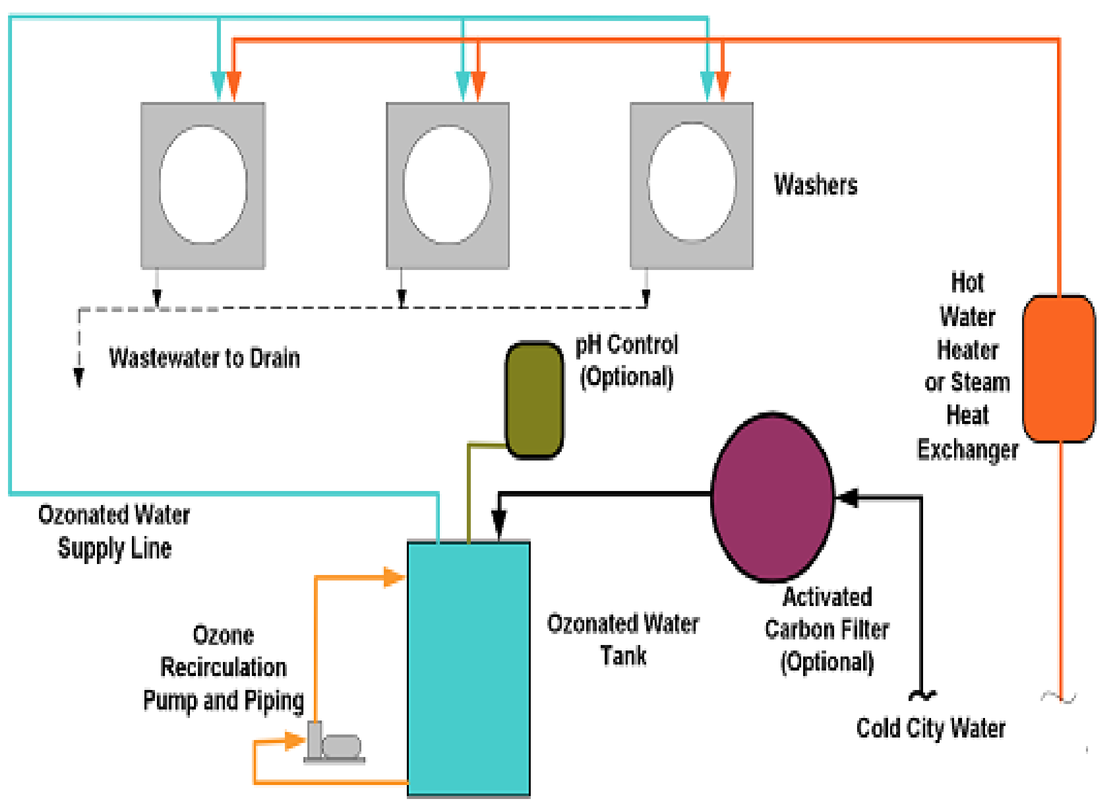


Figure 7.9 - Ozone Laundry Systems

Replacement Options

Consider the following when installing new laundry equipment or replacing existing equipment:

- Select new coin- or card-operated single-load clothes washer models that are Energy Star®-qualified (http://www.energystar.gov/products). Energy Star®-qualified washers use significantly less energy, water, and detergent compared to standard models.
- When installing new multi-load washers, choose models that use no more than 6.0 gallons per cycle per cubic foot of capacity.
- Choose machines with built-in water recycling capabilities that can store the rinse water from the previous load for use in the next load when installing new or replacing old washer extractors. These types of washer extractors can use less than 2.5 gallons of water per pound of fabric.
- For very large industrial or commercial laundries, consider replacing old washer extractors or multi-load washers with tunnel washers if large volumes of laundry will be processed.
- Ensure that large commercial laundry equipment is easily programmable so it uses no more water than required for the degree of soiling of the items being washed.
- Choose new machines that support remote diagnosis by the manufacturer to minimize maintenance costs and time associated with troubleshooting equipment problems.

Savings Potential

Water savings can be achieved through retrofitting existing laundry equipment to recirculate wash water or reduce the amount of water required for rinsing, or by replacing existing laundry equipment with more efficient equipment. To estimate facility-specific water savings and Payback, use the following information:

Coin- or Card-Operated Washer or Multi-Load Washer Retrofit

Use the following information to estimate water savings and payback potential that may be achieved with recycling or ozone retrofits. Water savings can vary based upon the water use and use patterns of the existing laundry equipment and the type of retrofit selected.

Current Water Use

Use Equation 7.24 below to estimate the current water use from a commercial coin- or card-operated washer or multi-load washer, identify the following information:

- Washer's water factor (WF) in gallons per cycle per cubic foot of capacity. Coin- or card-operated washers installed since the early 1990's will have a WF of 9.5 or less.
- Capacity of the washer.
- Average number of cycles per load.

- Average number of loads per year.

Equation 7.24

$$\text{Water Use of a Commercial Coin- or Card-Operated Washer or Multi-Load Washer (gallons/year)} = \text{Water Factor (gallons/cycle/ft}^3\text{ capacity)} \times \text{Washer Capacity (ft}^3) \times \text{Number of Cycles (cycles/load)} \times \text{Number of Loads (loads/year)}$$

Water Savings

Studies have documented water savings for retrofits with a simple recycling system, retrofits with a complex recycling system, and ozone system retrofits. To estimate water savings that may be achieved from retrofitting existing laundry equipment, multiply the water use of the existing laundry equipment (Equation 7.24) by the savings potential for the appropriate retrofit option indicated in Table 7.13 (Equation 7.25).

Table 7.13 - Potential Water Savings from Commercial Laundry Retrofit Options

Retrofit Option	Water Savings Potential[106]
Retrofit with simple recycling system	10–35%
Retrofit with complex recycling system	85–90%
Retrofit with ozone system	10–25%

Equation 7.25

$$\text{Water Savings from Commercial Laundry Retrofit (gallons/year)} = \text{Current Water Use (gallons/year)} \times \text{Water Savings Potential (\%) from Retrofit in Table 7.14}$$

Washer Extractor or Tunnel Washer Retrofit

Existing washer extractors or tunnel washers can also be retrofitted to recirculate and reuse a portion of the wash or they can be retrofitted with an ozone system.

Current Water Use

Use Equation 7.26 below to estimate the current water use from a washer extractor or tunnel washer, identify the following information:

- Washer's water efficiency in gallons per pound of fabric.
- Average number of pounds of fabric per load.
- Average number of loads per year.

[106] East Bay Municipal Utility District. 2008.

Equation 7.26

Water Use of a Washer Extractor or Tunnel Washer (gallons/year) = Water Efficiency (gallons/pound of fabric) X Pounds of Fabric per Load (pounds /load) X Number of Loads (loads/year)

Water Savings

Use Equation 7.25 to calculate the water savings that can be achieved from retrofitting an existing washer extractor or tunnel washer: multiply the water use of the existing laundry equipment, calculated using Equation 7.26, by the savings potential for the appropriate retrofit option indicated in the Table 7.13 above.

Coin- or Card-Operated Washer or Multi-Load Washer Replacement

Coin- or card-operated washer or multi-load washers can be replaced with more efficient laundry equipment. Look for washers with the Energy Star® designation.

Current Water Use

Use Equation 7.24 to estimate the current water use of a coin- or card-operated washer or multi-load washer.

Water Use After Replacement

Use Equation 7.24 to estimate the water use of a more-efficient, replacement commercial coin- or card-operated washer or multi-load washer: substitute the water factor and washer capacity of the replacement equipment. Energy Star® qualified coin- or card-operated washers will have a WF of 6.0 or less. An efficient multi-load washer will have a WF of 8.0 or less.

Water Savings

Calculate the expected water savings by subtracting the water use after replacement from the current water use.

Washer Extractor or Tunnel Washer Replacement

Existing washer extractors or tunnel washers can be replaced with more efficient laundry equipment.

Current Water Use

Use Equation 7.26 to estimate the current water use from a washer extractor or tunnel washer.

Water Use After Replacement

Use Equation 7.26 to estimate the water use of a more-efficient, replacement washer extractor or tunnel washer by substituting the new washer's water efficiency. Existing washer extractors can be replaced by machines with built-in water recycling capabilities that use less than 2.5 gallons of water per pound of fabric. Efficient tunnel washers typically use two gallons of water or less per pound of fabric.

Water Savings

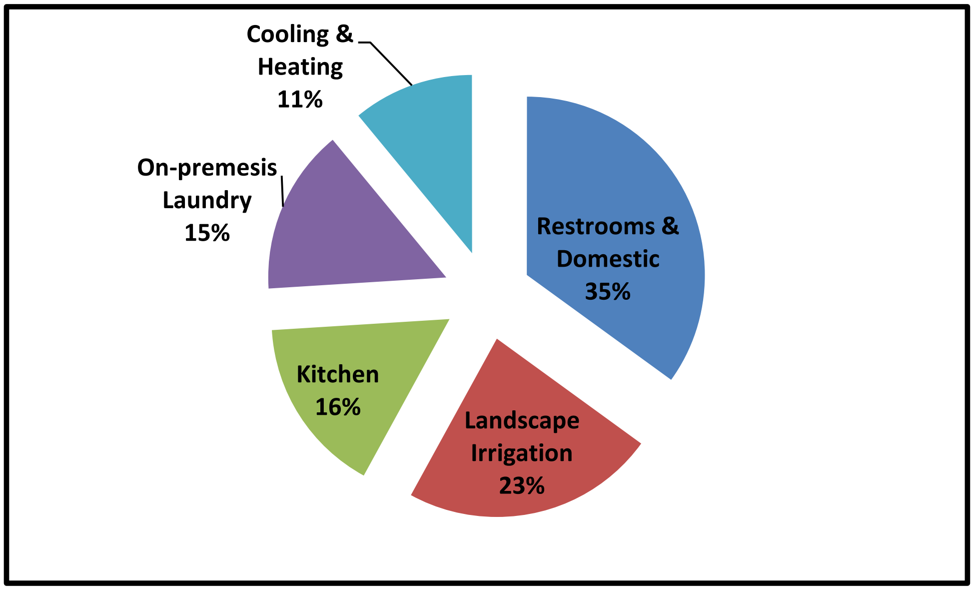
Calculate the expected water savings by subtracting the water use after replacement from the current water use.

7.1.3 Hospitality: Lodging - Hotels and Motels

Overview

The lodging industry in California encompasses approximately 6,500 establishments, each with an average of roughly 150 rooms.[107] The largest lodging facilities may be part of a mixed-use property and include residential apartments, retail stores, recreation facilities, landscaping, and office space at the same site, but this is not typical of most establishments.

Each activity within a hotel or motel has its own special need for water. Smaller facilities have guest-room water demands similar to those of the larger properties, but do not usually have recreation facilities and heavily irrigated landscapes. Typically, the largest lodging properties require water for guest rooms; on-premise laundries; Heating, Ventilating and Air Conditioning (HVAC) systems; public restrooms; ice machines; food service; recreation; landscape; and maintenance (Figure 7.10).



Source: East Bay Municipal Utility District, 2008. *Watersmart Guidebook – A Water-Use Efficiency Plan Review Guide for New Businesses.*

Figure 7.10 - Typical Water Use in Lodging

7.1.3.1 Restrooms and Plumbing

Appropriate water-saving technologies exist for all restroom fixtures, both in the public areas and guest rooms. Refer to report Section 7.3.6 General Building Sanitary and Safety Applications, for a discussion of water use efficiency opportunities and BMPs for restrooms and other operations in lodging facilities.

[107] California Hotel and Lodging Association. n.d. www.calodging.com

Non-potable, treated water may be used for fixture flushing (toilets and urinals only) and landscape irrigation applications, where codes and health departments permit, and if it is available. Refer to report Section 7.3.1 Alternate Onsite Sources of Non-Potable Water, 7.3.5 Commercial Landscape, and Section 9 Public Infrastructure Needs for Recycled Water for information and BMPs related to these topics.

> Overall, restrooms and domestic functions account for about 33 percent of water used at lodging facilities, cooling and heating systems account for about 11 percent (with cooling towers and boilers as the primary systems accounting for this use) on-premise laundries account for about 15 percent, kitchen operations account for about 16 percent, and landscaping accounts for the remainder (about 23 percent) of water use at lodging facilities

Additional BMPs to be considered in guest rooms:

- Prohibit multiple showerhead installations in a shower stall.
- Substitute showers for bathtubs. Where bathtubs are necessary, use low-volume tubs.
- Use low flow showerheads.

7.1.3.2 Cooling and Heating Systems

Water use related to cooling and heating amounts to 11 percent of total water consumption in the typical lodging facility[108]. Cooling towers and boilers are the primary systems accounting for this use. Refer to Section 7.3.3, Thermodynamic Processes, for information and BMPs related to this topic.

7.1.3.3 On-Premise Laundries

On-premise laundries account for 15 percent of all water consumption in the typical lodging property. Refer to Section 7.1.2, Fabric Cleaning and Washing Equipment, for a discussion of water use efficiency opportunities and BMPs for on-premise laundries in lodging facilities.

7.1.3.4 Floor Cleaning

BMPs for floor cleaning include:

- Discourage the use of open hoses for cleaning. While wet methods may be used, install self-closing nozzles and limit flow rates to five gpm. Also refer to Section 7.1.1.4, Commercial Food Service, Washing and Sanitation, for further information on floor cleaning, available equipment, and BMPs .
- Install drains close to areas where liquid discharges are expected.
- Arrange equipment for easy use of a mop and squeegee system or floor-cleaning machine.

7.1.3.5 Ice Machines

Ice machines installed on guest room floors, as well as in the central kitchen, use water for ice, and sometimes, for cooling the compressor. BMPs include:

[108] East Bay Municipal Utility District. 2008.

- Select Energy Star® qualified ice-making machines that are air-cooled, using remote heads to expel warm air outside the workspace and customer areas. Air-cooled machines are preferred over cooling-tower loops.
- Select energy-efficient flake or nugget machines rather than cube-ice machines. If cube-ice machines are used, those that meet CEE Tier 2 or 3 efficiency standards are preferred.
- Also refer to Section 7.1.1.5, Commercial Food Service, Commercial Ice Machines for more information on available equipment and their efficiencies.

7.1.3.6 Kitchen Operations

Onsite kitchens in typical lodging facilities consume about 16 percent of the potable water use by the facility. For BMPs and equipment options associated with food service, refer to Section 7.1.1, Commercial Food Service.

7.1.3.7 Submetering

Separate metering of water-using systems and building areas is recommended, where possible, in order to ensure that the costs of water use and wastewater disposal are accurately tracked. Tracking actual use through a building management system connected to a series of submeters can disclose operating issues (e.g., leaks, equipment malfunctions) that might have previously remained undiscovered. For a full discussion of submetering and BMPs associated with that topic, refer to Section 7.3.2, Building Meters, Submeters, and Management Systems.

7.1.3.8 Landscape

Landscape irrigation represents 23 percent of water use in the typical lodging property. It is important to ensure the use of climate-appropriate plant materials in the landscape and to install and monitor efficient irrigation systems that apply only the amount of water necessary. For further information and BMPs related to landscape and landscape irrigation, refer to Section 7.3.5, Commercial Landscaping.

7.1.3.9 Other

Other recommended BMPs for lodging facilities include:

- Install automatic shutoff and solenoid valves on all hoses and water-using equipment.
- Encourage guests to engage in “green” practices for bed linens and towels to avoid unnecessary laundry use.
- Conspicuously mark fire-protection plumbing so no connections will be made other than those for fire protection.

- Install flow-detection meters on fire services to reveal unauthorized water flows.

7.1.4 Medical and Laboratory Equipment and Processes

Overview

Hospitals, dental offices, laboratories, aquariums, and research facilities are found in most large communities. All of these facilities have water uses such as restrooms, landscape, water treatment, and often cooling towers and boilers that are common to many types of facilities. BMPs and discussion on water use for these operations can be found in Section 7.3.6 General Building Sanitary and Safety Applications, 7.1.1.5 Commercial Food Service, Commercial Ice Machines, 7.1.4.4 Commercial Food Service, Washing & Sanitation, 7.3.3 Thermodynamic Processes, 7.3.5 Commercial Landscape, 7.3.8 Water Treatment, and 7.3.7.5 Pools, Spas, and Fountains, Filtration. They also have equipment and operations not commonly found in other facilities, including:

- Sterilizers
- Instrument, glassware, cages, racks, and bottle washers
- Vacuum systems
- Hood systems
- Vivarium and Aquarium operations
- X-ray and photo film developing

This section will discuss each of these six types of equipment or operations.

7.1.4.1 Sterilizers

Overview – *Sterilizers*

Sterilization of surgical instruments, fluids, pharmaceuticals, equipment, and medical supplies is an integral part of modern medical and laboratory practice. Over the years, different sterilization techniques have been used, such as:

- Chemical (ethylene oxide, peroxides, ozone, etc.)
- Radiation
- Dry heat
- Steam sterilization

Since the first three techniques do not require substantial amounts of water, this discussion focuses on steam sterilizers.

Figure 7.11 - Front of Typical Steam Sterilizer

Types of Equipment – *Sterilizers*

Steam sterilizers and autoclaves may be divided into four categories. The first three are for medical and laboratory type facilities and include (1) table top, (2) freestanding gravity-type, and (3) freestanding vacuum-type systems. The fourth is autoclaves used in industrial operations, which is not covered in this discussion.

Figure 7.12 - Sterilizer Being Loaded with Surgical Packs

Steam sterilizers are common in hospitals and biological or medical laboratories. The Center for Urban Water Conservation Council (CUWCC) reports that there over 8,400 medical steam sterilizers in California.[109] Steam sterilizers have two major configurations: tabletop and freestanding.

Tabletop-Type Sterilizers

Tabletop-type sterilizers have a filled water reservoir and a heating element to make steam. They use little water.

Freestanding Sterilizers

Freestanding sterilizers include both gravity- and vacuum-type systems. In both, steam is injected into a closed chamber housing the instruments or equipment to be sterilized. Steam used for this purpose must be "clean steam", meaning that the water used to make the steam has been demineralized. Both types have application in the medical, pharmaceutical, science, and engineering laboratories.

In both cases, the sterilizer chamber is surrounded by an outer chamber that is also filled with steam to help keep the whole cavity hot. As the steam in the outer chamber condenses, it is discharged through a steam trap to the sanitary drain.

- **Gravity-Type.** In the gravity-type, steam pushes air out of the chamber filling the top of the chamber with steam. The air is said to be “drained” by gravity since it weighs more than the steam.
- **Vacuum-Type.** With the vacuum type, a vacuum pump draws the air out. The vacuum type dries the sterilized materials more quickly than the gravity type.

Water Use Information - *Sterilizers*

Freestanding-type sterilizers, which are the most common found in medical facilities, use large quantities of water in their operation. Table-top sterilizers, on the other hand, use only small amounts of water, and the other types use little if any. Freestanding sterilizers use water in three ways:

[109] Center for Urban Water Conservation Council (CUWCC). 2004. *BPMP – Year One: Chapter IV Sterilizer Savings Assessment.*

Steam Generation

The first is steam generation and consumption to sterilize equipment, which, in most cases, represents the least amount of water use. Only a few gallons (5 to 12 gallons depending on model and size) get used per complete sterilization cycle.

Tempering Water

A major water use for older sterilizers is associated with plumbing code regulations that prohibit water hotter than 140°F from being discharged to a sanitary sewer. For models made before the mid 1990s, water was simply plumbed to run continuously down the drain, commonly with flow rates of 0.3 to 1.5 gpm. The purpose of this continuous flow was to have water available at any time the steam trap opened to cool the condensate as it entered the drain (water tempering). The sterilizer steam traps only discharge at the most, a couple of quarts of water, when opened, and this occurs infrequently during the day. Since the mid 1990's, tempering kits have been included as standard devices. These kits have solenoid valves connected to thermal sensors that only open and allow water to flow when condensate is actually flowing. Retrofit kits are available for older models. The most water efficient and energy efficient practice is to return the condensate to the boiler, however, most hospitals are not equipped to do this.

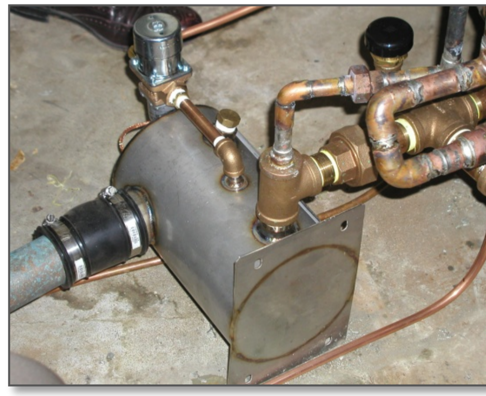


Figure 7.13 - Example of a Retrofit Water Tempering Device

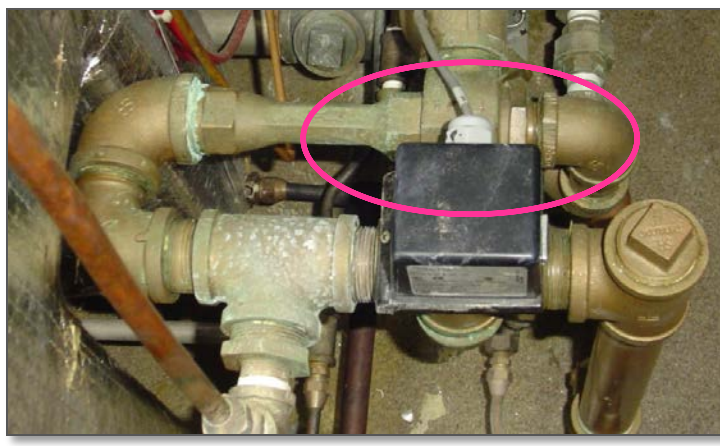


Figure 7.14 - Venturi Vacuum System on a Sterilizer

Vacuum Generation

The way in which a vacuum is created significantly affects the amount of water used for this operation. In the past, a simple venturi system was used to create a vacuum (Figure 7.14). These systems can use 6 to 18 gallons per minute according to the CUWCC Sterilizer Savings Assessment.

Operation, Maintenance, and Use Education BMPs – *Sterilizers*

- If possible, choose something other than a free-standing steam sterilizer, such as a chemical, radiation, or dry heat sterilizer or even a table-top steam sterilizer.
- Ensure that free-standing steam sterilizers are equipped with water tempering devices, that steam is returned to the boiler, or condensed using a chilled water condenser.
- Where not cost prohibitive, consider stand-alone boilers on each autoclave.

- Prohibit the use of venturi vacuum systems on vacuum sterilizers.
- Use dry vacuum systems wherever allowed by the FDA 510K regulations.

Retrofit BMP Options – *Sterilizers*

There are two retrofit approaches to reduce water use of steam sterilizers. One is to reduce the amount of tempering water necessary to cool the steam condensate that is discharged. This can be done by replacing the standard valve with a temperature actuated valve or by diverting steam condensate to a small holding tank to allow it to naturally cool prior to discharge down the drain. An even more water efficient strategy is to install individual boilers on each autoclave so the condensate can be returned directly, but since these boilers typically use electricity, energy costs rise.

The other approach is to capture and reuse steam from the vacuum system or use dry vacuum systems wherever allowed by the FDA 510K pre market regulations.

Replacement BMP Options - *Sterilizers*

Free-standing steam sterilizer may be replaced with another kind of sterilizer including chemical, radiation, dry-heat, or tabletop steam sterilizers; all of which use less water than a free-standing sterilizer. An older (pre-1990's) free-standing steam sterilizer can also be replaced with a more current one equipped with a tempering kit or connected to the building's chilled water system.

Potential Water Savings - *Sterilizers*

Based on the CUWCC Sterilizer Savings Assessment and work done at the University of Washington in Seattle, adding a water tempering kit to older models can reduce water use for this purpose by 68 to 98 percent and can save 1,500 to 3,000 gallons a day.[110] The installed cost for these retrofit kits ranges from $2,500 to $5,500 per kit.

Liquid ring vacuum systems in steam sterilizers can reduce water use by about 75 percent compared to conventional Venturi pumps. The retrofit liquid ring vacuum systems cost over $20,000 installed. Table 7.14 summarizes the impact installing a liquid ring vacuum pump on total water use.

[110] CUWCC. 2004.

Table 7.14 - Comparison of Vacuum System Water Use for Steam Sterilizers*

Based on ten uses a day, and 250 days per year			
Venturi Ejector Water Use (gpm)	**Gallons Used per Cycle**	**Venturi Gallons per Year**	**Liquid Ring Gallons per Year**
6	189	495,000	123,750
11	363	907,500	226,875
18	594	1,485,000	371,250

*Source: California Urban Water Conservation Council report, PBMP-Year One-Chapter VI-Sterilizer Savings Assessment

In research facilities and industrial operations, dry vacuum systems reduce water use to zero although these systems cost more than liquid ring pumps. (See the section on vacuum systems, below, for additional discussion.

7.1.4.2 Vacuum Systems

Vacuum systems are used throughout the medical and scientific community as well as in all types of industries. The most rudimentary "vacuum pump" is a venturi system, also called an aspirator system. Aspirators are found in many high school and college laboratories that only use them for a few hours each semester. Because of their infrequent use, these pumps are not the focus of this BMP, but using aspirator or venturi systems on frequently used equipment, such as steam sterilizers, is an extremely wasteful practice Discussed in Section 7.1.4.1, Medical and Laboratory Equipment and Processes, Sterilizers. Mechanical pumps may be used for medical, dental, and other low vacuum laboratory applications of 0.01 millibars (0.0074 millimeters of mercury). The end use determines pump size. Dental office pumps range from 1.0 to 4.0 horsepower (hp), while a central vacuum pump in a medical facility requires 5.0 to 20.0 hp.

Figure 7.15 - A Dry Vacuum System at a Dental Office

Vacuum pumps can use water in two ways: for pump cooling or for creating a seal.

Types of Equipment – *Vacuum Systems*

Vacuum pumps can either be "dry" or "wet", based on how the vacuum seal is generated. Wet pumps use a closed impeller that is sealed with water to generate the vacuum. Dry pumps do not use water to generate the seal for the vacuum, so they do not connect to a water supply. Instead, they create vacuums with turbines (fans) or use positive displacement devices, such as vane pumps, claw pumps, or piston pumps.

Dry systems tend to be the most energy efficient. A review of product literature shows energy savings in the range of 25 to 50 percent. However, dry systems cost more to purchase. A typical dental liquid ring pump, for example, costs about $2,000, while dry systems cost from $5,000 to $7,500 for the same dental clinic. In addition, dry pumps must be vented since they use air instead of water as the moving agent.

Water Use Information – *Vacuum Systems*

The amount of water that may be saved is significant. Literature shows that a typical dental liquid ring vacuum uses approximately one-half-gallon minute per horsepower, so a two-horsepower pump would use approximately 1.0 gpm. An office that is open for eight hours uses 480 gallons. For larger medical installations, the relationship of water to horsepower is similar, but the pumps are much larger.

Some special laboratory facilities that produce acid fumes may have to use a liquid ring pump to prevent pump corrosion. In these cases, water recirculation systems may be used. In these systems, a liquid ring pump recirculates water through the vacuum pump, and that water is cooled either by air or a chilled water loop. A portion of the water must be continuously discharged to prevent chemical build-up. Typically, these units can reduce water use by 50 percent to 75 percent depending on the chemicals involved.

BMP Options – *Vacuum Systems*

- Use dry vacuum systems for all medical and dental processes.
- Eliminate pass-through cooled equipment. Use only air cooled pumps or those connected to a cooling tower loop or chilled water systems (see Thermodynamic Processes), especially for central vacuum systems that serve as an entire facility (e.g. hospitals).
- Only use liquid ring pumps for conditions where acid fumes and other very corrosive materials are being handled.
- If a liquid ring vacuum pump must be used, consider a non-potable source of water such as an onsite source or recirculated water.

7.1.4.3 Laboratory Fume Hoods

Overview – *Fume Hoods*

A fume hood is a ventilated enclosure where hazardous materials can be safely handled to limit exposure. Fume hoods draw contaminants within the work area away from the user through a ventilation system in order to remove them from the building. Most hood exhausts can be directed to the outside without additional treatment. These hoods do not use water to clean the exhausted gases (Figure 7.16). However, in some cases, contaminants that pose a hazard or pollution risk must be removed using either a dry or wet "scrubber system."

Figure 7.16 - A Typical Hood System in a Lab

The type of system chosen will depend on the substances in need of removal. Table 7.15 summarizes some of these choices.

Table 7.15 - Fume Hood Scrubber Systems

Filtering mechanism	How does it work?	How is contaminant removed?	Does it use water?	What are the special considerations?
Wet scrubber	Packed bed system which is wetted with recirculated scrubbing liquor dissolves contaminants in air and releases cleaned air	Scrubbing liquor with dissolved contaminants is blown down and the liquor is periodically replenished with fresh water	Yes	None
Inert adsorbents	Inert adsorbents, such as activated carbon, activated alumina, and molecular sieves, adsorb contaminants	Spent adsorbent must be changed or regenerated regularly	No	Adsorbent systems are not effective in removing high concentrations of contaminants (i.e., spills inside the hood). These systems require a consistent check on contaminant concentrations and maintenance of the adsorbent.
Chemically active adsorbents	Inert adsorbents impregnated with a strong oxidizer, such as potassium permanganate, which react with and destroy organic vapors	Spent adsorbent must be changed or regenerated regularly	No	Adsorbent systems are not effective in removing high concentrations of contaminants (i.e., spills inside the hood). These systems require a consistent check on contaminant concentrations and maintenance of the adsorbent.

Wet scrubbers pass water and solution of reactive chemicals over a packed medium as exhaust gas is forced or drawn through the medium with fans. The water and solution of reactive chemicals are recirculated through the system, but water is evaporated in the process, and some water must be bled off to prevent the buildup of chemicals and salts in the system. Figure 7.17, below, shows the pumps and back side of a hood scrubber system.

Perchloric acid, a corrosive liquid, poses a specific hazard. While not combustible, under some circumstances it may act as an oxidizer and present an explosion hazard. Organic materials are especially susceptible to spontaneous combustion if mixed or contacted with perchloric acid.

Special perchloric acid wash-down system hoods must be used to control these fumes and wash perchloric acid deposits from the duct linings. To prevent corrosion and reduce explosive perchlorate build-up, perchloric acid fume hoods use a system of nozzles to wash down the fume hood and exhaust system surfaces after each period of use. Older perchloric acid hoods ran water continuously for this process. The flow of water in newer hoods can be controlled to operate only when the hood vent fan is operating.

Figure 7.17 - Fume Scrubber for a Microelectronics Lab

BMP Options – *Fume Hoods*

- Use dry hoods to the maximum extent possible
- Only choose scrubber systems if necessary
- If a hood scrubber system must be used, select a type that recirculates water
- Control scrubber blowdown with a conductivity controller or other appropriate control device
- Use an alternate, non-potable water source for the scrubber wherever possible

In all cases, the hood should be operated according to instructions for that hood.

7.1.4.4 Instrument, Glassware, Cage, Rack, and Bottle Washers

Overview – *Instrument Washers*

Laboratory and medical facilities must wash various types of equipment of all sizes and types, including glassware in labs, surgical instruments in hospitals, and animal cages at vivariums and animal research facilities. In all cases, the equipment must be thoroughly cleaned and disinfected. In many cases, the equipment or instruments are secondarily disinfected using a steam sterilizer.

Types of Equipment – *Instrument Washers*

<u>Washers - Disinfectors</u>

Washer - Disinfectors are used to clean surgical and medical instruments before they are sterilized. They are typically found in central sterilizations operations in hospitals. These operations are usually abbreviated as "Central Sterile" or "CS" operations. There are stand-alone batch washers for smaller operations and large tunnel washers that resemble conveyor dishwashers in operation. A review of product literature shows that water and energy conservation have become major selling points for the current generation of surgical and medical instrument washer - disinfectors. Better instrumentation and computer control along with better design are cited as the reasons for these increases in efficiency.

Figure 7.18 - Batch and Conveyor (Tunnel) Washer - Disinfectors in Central Sterile Operations

Washers – Cage, Rack, and Bottles in Vivariums

Cage, rack, and bottle washers are found in vivariums and animal research facilities. The equipment ranges from conveyor washers for mice and rat cages, which closely resemble conveyor dishwashers, to large compartment washers that can hold carts of cages or large primate cages. BMP information is provided as part of the USEPA's "Labs for the 21st Century" program.

Figure 7.19 - Small Cage Washer

Operation, Maintenance, and User Education BMPs – *Instrument Washers*

Washers - Glassware

For glassware washers, no specific efficiency standards have been set, but major manufacturers are beginning to offer more energy and water efficient models. In the interim, consider following these BMPs:

- Only run glassware washers when full. Fill each glassware washer rack to maximum capacity.
- Operate the glassware washer at or near the minimum manufacturer recommended flow rate.
- Use detergents that clean most effectively to simplify rinsing.
- If the number of rinse cycles can be chosen, select the minimum number of rinse cycles to meet the desired level of cleanliness.

Washers - Disinfectors

Until water efficiency standards are established, the BMPs for this type of operation is to only operate when needed and review literature for water and energy efficiency when purchasing new equipment.

Washers - Cage, Rack, and Bottles in Vivariums

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 makeup or for cleaning cage racks and washing down animal rooms.[111]

Retrofit BMP Options – *Instrument Washers*

Washers – Glassware

Consider installing a water recycling system that reuses rinse cycle wastewater as wash water in the next load.

Washers – Cage, Rack, and Bottles in Vivariums

Retrofit existing cage and rack washers to make use of counter-current flow system to reuse final rinse water from one cage-washing cycle in earlier rinses in the next washing cycle.

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[111] http://www1.eere.energy.gov/femp/program/waterefficiency_bmp12.html#dss

Replacement BMP Options – *Instrument Washers*

When purchasing a new glassware washer or replacing an existing one, look for models with these features:

- Cycle selection that allows users to optimize rinse cycles for both effective and efficient cleaning.
- Reuse final rinse water as wash water for the next load.
- Water intake monitoring to adjust the amount of water used based on load size.

Washers – Cage, Rack, and Bottles in Vivariums

- Replace older inefficient cage and rack washers with more efficient models. Look for models that recirculate water through four cleaning stages using a counter-current rinsing process. In counter-current rinsing, the cleanest water is used only for the final rinsing stage. Water for early rinsing tasks (when the quality of rinse water is not as important) is water previously used in the later stages of rinsing operations.
- Use tunnel washers for small cage cleaning operations.

7.1.4.5 Vivariums and Aquariums

Overview – *Vivariums and Aquariums*

Aquariums, vivariums (research mice facilities), and large animal research facilities are found at most universities and pharmaceutical research facilities.

Vivarium Cleaning

Vivariums and other animal care facilities require regular cleaning and care. The washing of cages, bottles, and feeding containers is covered under the section on washing and disinfecting (refer to Section 7.1.4.4, Instrument, Glassware, Cage, Rack, and Bottle Washers). The care and washing of the facilities and floors often requires a hose down. For large animals, slotted floors with manure rakes are sometimes used.

Vivarium Animal Watering

Automatic animal watering systems provide drinking water to laboratory animals. There are two types of automated animal watering equipment that differ in their method of bacterial build-up prevention: flushing animal watering systems and recirculating animal watering systems. Flushing animal watering systems use a periodic, high-pressure flow to “flush” and remove bacteria from piping. Residual chlorination is typically used to further control bacterial growth. Recirculating animal watering systems control bacteria, by means of a constant flow of water treated with ultraviolet disinfection or other methods before distribution for animal watering. Flushing systems use more water than recirculating systems because water is discharged to the drain after the flushing cycle is complete.

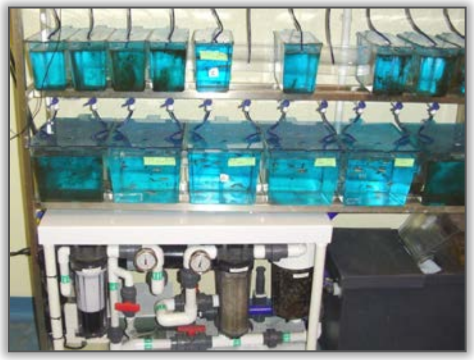


Figure 7.20 - Filtration System for Ichthyology Lab Aquariums

Aquariums

Aquariums are common in any research facility working with fish and aquatic plants and animals. For smaller systems, good filtration systems significantly reduce water use. For larger aquariums, the principles are similar but the equipment is much larger and special treatment systems are sometimes needed as seen in Figure 7.21 (sea foam remover) and Figure 7.22 (large sand filtration systems). Large aquariums often capture the backwash from these larger filters, treating and filtering it to recover as much water as possible.

Figure 7.21 - Sea Foam "Fractionator"

BMP Options – *Vivariums and Aquariums*

Vivarium Cleaning

Consider the following for optimum vivarium cleaning efficiency:

- Use squeegees and brooms to first clean an area to substantially reduce the amount of water needed for floor washing.
- Choosing hose nozzles with the minimum flow rates that accomplish the cleaning, increasing pressure to reduce water use, and use of manual floor cleaning equipment can all help reduce water use
- Design floors and walls to be easily cleanable.

Figure 7.22 - Large Aquarium Sand Filters

Vivarium Animal Watering

Consider the following for optimum animal watering system efficiency:

- For animal watering systems that use flushing, minimize the number of flushing cycles while ensuring sufficient control of bacterial growth.
- Consider collecting and reusing wastewater from animal watering systems for other purposes within the facility, matching an end use with the level of water quality that exists or that can be achieved through water treatment.
- Before choosing an automatic watering system, consider the following issues: automatic watering systems require regular observation of the systems and the animals if not properly

maintained, they pose the risk of cage flooding or clogged valves, and they do not allow for monitoring of animal water intake.

Aquariums

- Include the proper use of filtration equipment, use water treatment systems to remove specific contaminants that may be unique to the situation, and institute proper care and cleaning of aquarium surfaces.

7.1.4.6 Photographic and X-Ray Equipment

Overview – *Photographic and X-Ray*

Film Development

Traditional film processing is extremely water-intensive, with water required for both the image development and printing process. Old 35-mm film could use as much as 30 gallons of water per roll developed. Requirements in the late 1970s to recover silver and other heavy metals at film process centers began the process of reducing water use. Modern 35 mm film processing equipment, such as that found at pharmacies and department stores, uses only a few ounces of water to develop a roll of film.

Digital technology represents a more significant development since it has eliminated the need for film development. Water conservation considerations for film development, including large frame X-ray film development, must be tempered by the fact that extensive use of wet processes may not even exist in 20 years, except for special "artistic" endeavors. Dry printing processes similar to laser printing are also available.

X-Ray Operation

Water is sometimes also used for equipment cooling in old X-ray equipment. Some X-ray film processing machines require a constant stream of cooling water flowing at a rate of 0.5 to 2.5 gpm to as much as 3.0 to 4.0 gpm[112] in order to ensure acceptable image quality. Cooling water with a flow rate as low as 0.5 gpm can discharge more than 250,000 gallons of water annually. In the past, special water saving recirculation equipment that only operates the cooling system and the film rinse purge systems when needed was available, but with the advent of modern digital technology and the rapid disappearance of old film type equipment, sales of this equipment have plummeted.

The new digital X-ray technology is rapidly replacing the old film-based equipment because of its medical value for radiology. Just like home digital pictures, digital X-rays can also be enhanced to see specific detail, and they can be sent by e-mail to family physicians and others.

[112] Footnote text?

New medical digital equipment is very expensive, potentially costing more than one million dollars to convert a large medical center radiology department to digital equipment. Water savings, alone, would not be a major cost savings for this conversion; it is being driven by the need of medical facilities to have the most up-to-date equipment.

BMPs Options – *Photographic and X-Ray*

- If old film type processing equipment is being used, install a WaterSaver kit.
- Encourage the switch to digital equipment.

7.1.5 Office Buildings

Overview

Office buildings may combine residential apartments, hotels, retail stores, and office space into a mixed use structure. Each end use has its own special needs for water. Typically, large buildings require water for HVAC (cooling), restrooms, food service, and maintenance.

7.1.5.1 Restrooms and Plumbing

High-efficiency plumbing fixtures and fittings are critical to achieving water use efficiency, since restrooms and related domestic uses are the primary water consumers in office buildings.

Appropriate water-saving technologies exist with all restroom fixtures, both in the public areas and tenant spaces. Refer to Section 7.3.6, General Building Sanitary and Safety Applications, for a discussion of water-use efficiency opportunities and BMPs for restrooms and other operations in office buildings.

If available, and where codes and health departments permit, non-potable, municipal recycled water may be used for fixture flushing (toilets and urinals only) and landscape irrigation applications. Refer to report Section 7.3.1 Alternate Onsite Sources of Non-Potable Water, 7.3.5 Commercial Landscape, and **S**ection 9, Public Infrastructure Needs for Recycled Water, for information and BMPs related to these topics.

7.1.5.2 Cooling and Heating Systems

Overview – *Cooling and Heating Systems*

Water use related to cooling and heating amounts to about 28 percent of total water consumption in the typical office building. Cooling towers and boilers are the primary systems accounting for this water use.

<u>Cooling Systems</u>

Modern office buildings need to remove heat generated by the occupants, as well as from computers, lights, kitchens, and other operations. Energy-efficient equipment may reduce such waste heat, which is usually removed by a central refrigeration system and compressor. The compressor may be air-cooled or connected via a circulating loop to a cooling tower or evaporative condenser. As warm water from the compressor is directed through the cooling tower, some water evaporates, cooling the remaining water, which returns to cool the equipment. Refer to Section 7.3.3.1 Cooling Systems

However, the most important measures to improve the efficiency of cooling systems are to:

- Conserve energy to reduce the amount of waste heat generated.
- Use non-water based cooling equipment and processes, if possible.
- Reduce system losses and keep system maintained.
- Use alternative sources of non-potable water, if feasible.
- Manage controls to maximize recirculation and reuse.

<u>Heating Systems</u>

Steam boilers and hot-water boilers provide heat and hot water in some buildings. Closed-loop systems return water and steam condensate to the boiler for reuse, saving energy and water. Open-loop systems expend the water or steam without return to the boiler. Several water-efficiency actions are available to optimize water use for heating systems, as identified in Section 7.3.3.2 Heating Systems: Boilers.

However, the most important BMPs include:

- Energy efficiency
- Minimize system losses
- Maximize recirculation/cycles of concentration before discharge of blowdown water

7.1.5.3 Water Treatment

Water treatment is used in many commercial operations, including food services, laundries, pharmacies, and food service operations, all of which can be present within a multi-tenant office building. Refer to Section 7.3.8, Water Treatment, for details. However, the most important measures to improve the efficiency of water treatment include the following:

- For all filtration processes, install pressure gauges to determine when to backwash or change cartridges, followed by backwash based upon pressure differential.
- Set recharge cycles by volume of water treated or by using conductivity controllers for all ion-exchange and softening processes.
- Avoid the use of clock timers for softener-recharge systems.
- Use water treatment only when necessary.

7.1.5.4 Kitchen

Onsite commercial kitchens in office facilities can account for a significant proportion of the potable water use by the facility. For BMPs and equipment options associated with food service, refer to report Section 7.1.1, Commercial Food Service.

7.1.5.5 Ice Machines

Ice machines use water for ice and sometimes for cooling the compressor. BMPs include the following:

- Select Energy Star® qualified ice-making machines that are air-cooled, using remote heads to expel warm air outside the work space and customer areas. Air-cooled machines are preferred over cooling-tower loops.
- Select energy-efficient flake or nugget machines rather than cube-ice machines. If cube-ice machines are used, those that meet Consortium for Energy Efficiency (CEE) Tier 2 or 3 efficiency standards[113] are preferred; avoid products that are water cooled.
- Refer to report Section 7.1.1.5, Commercial Food Service, Commercial Ice Machines, for more information on available equipment and their efficiencies.

[113] Consortium for Energy Efficiency. 2011. *High-Efficiency Specifications for Commercial Ice Machines.*

7.1.5.6 Floor Cleaning

BMPs for floor cleaning include:

- Discourage the use of open hoses for cleaning. When wet methods are to be used, install self-closing nozzles, limiting flow to five gpm.
- Install drains close to areas where liquid discharges are expected.
- Refer to report Section 7.1.1.4, Commercial Food Service, Washing and Sanitation for further information on floor cleaning, available equipment, and BMPs.

7.1.5.7 Submetering

Tracking actual use through a building management system connected to a series of submeters can disclose operating issues (e.g., leaks, equipment and process malfunctions) that might have otherwise remained undiscovered. In addition, separate metering of individual units (tenants), building water-using systems (e.g., cooling towers), or building areas (e.g., food service, landscape) is recommended wherever feasible to ensure that the costs of water use and wastewater disposal are equitably distributed among the tenants and accounted for accurately. In general, meter indoor water use separate from outdoor water use wherever feasible. For a full discussion of submetering and BMPs associated with that topic, refer to report Section 7.3.2, Building Meters, Submeters, and Management Systems.

7.1.5.8 Landscape

Landscape irrigation represents 27 percent of water use at the typical office building site. It is important to ensure the use of climate-appropriate plant materials in the landscape and to install and monitor efficient irrigation systems that apply only the amount of water necessary. Wherever possible, meter indoor water use separate from outdoor water use. For further information and BMPs related to landscape and landscape irrigation, refer to report Section 7.3.5, Commercial Landscape.

7.1.5.9 Other

Other recommendations include installing automatic shutoff and solenoid valves on all hoses and water-using equipment.

7.1.6 Prisons and Correctional Facilities

Overview

Correctional facilities are a major component in the institutional water use sector. They fall into the following NAICS Codes:

Table 7.16 - NAICS Codes for Correctional Facilities

NAICS*	Description
922140	Correctional boot camps
922140	Correctional institutions
922140	Detention centers
922140	Honor camps, correctional
922140	Houses of correction
922140	Jails (except private operation of)
922140	Penitentiaries
922140	Prison farms
922140	Prisons
922140	Reformatories
922150	Pardon boards and offices
922150	Parole offices, publicly administered
922150	Probation offices, publicly administered
922150	Public parole offices
922150	Public probation offices
922150	Rehabilitation services, correctional, government
*NAICS - North American Industrial Classification System	

California houses over 290,000 prisoners and detainees in Federal, State, and local facilities. According to the California Department of Corrections and Rehabilitation (CDCR), about 170,000 of these people reside in state facilities. California is home to approximately 500 correctional facilities. Table 7.17 shows the types of facilities based on State and Federal records.

Table 7.17 - Correctional Facilities in California

Type of Facility	Number in State
Federal	15
State Prisons	33
State (Other Facilities)	28
Local Facilities	540+
TOTAL	**625+**
*Source: California Department of Corrections and Rehabilitation - Corrections Year at a Glance 2011, and CALIFORNIA COUNTY JAILS & STATE PRISONS CORRECTIONAL FACILITIES	

Water Use Information

Prisons are much like small cities. They have living, eating, medical, laundry, manufacturing, boilers and cooling towers, and industrial operations. Table 7.18 summarizes the types of water use found in prisons and provides the references to applicable sections in the document that describe BMPs for that use.

Table 7.18 - Water Uses Found at Prisons and Correctional Facilities

Type of Use	Section Describing BMP for Use
Employee restroom facilities	7.3.6 General Building Sanitary and Safety Applications
Medical/dental facilities	7.1.4 Medical and Laboratory Equipment and Processes
Food service	7.1.1 Commercial Food Service
Inmate restroom facilities	7.3.6 General Building Sanitary and Safety Applications
Inmate showering facilities	7.1.3 Hospitality: Lodging – Hotels and Motels
Laundries and clothes washers	7.1.2 Fabric Cleaning and Washing Equipment
Cooling towers and boilers	7.3.3 Thermodynamic Processes
Water treatment: filtration and other processes	7.3.8 Water Treatment, 7.3.7.5 Pools, Spas, and Fountains, Filtration
Cogeneration and energy facilities	7.2.2.6 Power Plants
Wastewater treatment	7.3.8 Water Treatment
Prison industries	7.2 Industrial Sectors, 7.3.4 Cleaning Industrial Vessels, Pipes and Equipment
Prison farms, greenhouses, and gardens	7.3.5 Commercial Landscape
Pools and recreational facilities	7.3.7 Pools, Fountains, and Spas
Landscape irrigation	7.3.5 Commercial Landscape
Vehicle washing	7.1.9 Vehicle Washing
Educational facilities	7.1.8 Schools and Educational Facilities
Leaks, metering, and unaccounted for water	7.3.2 Building Meters, Submeters, and Management Systems
Reclaimed water	9.0 Public Infrastructure Needs for Recycled Water
Alternate onsite sources of water	7.3.1 Alternate Onsite Sources of Non-Potable Water

Some ways that water is used in prison is unique in its wastefulness. In his book, *Unquenchable: America's Water Crisis and What to do About It*, author Robert J. Glennon talks about toilet telegraphs, the use of toilets to reduce boredom, and toilets as a means of disposing of contraband, often causing minor flooding. In fact, he reports that toilets are sometimes flushed 100 times a day. The main point is that prisoners are locked in their cells for over 20 hours a day with plenty of time to invent ways to use (waste) water. Audits of prisons by Water Management Inc. have shown that prisoners often flush the toilets in their cells 15 to 20 times a day. For regular sanitation uses, one person should flush five to six times a day.

BMP Options

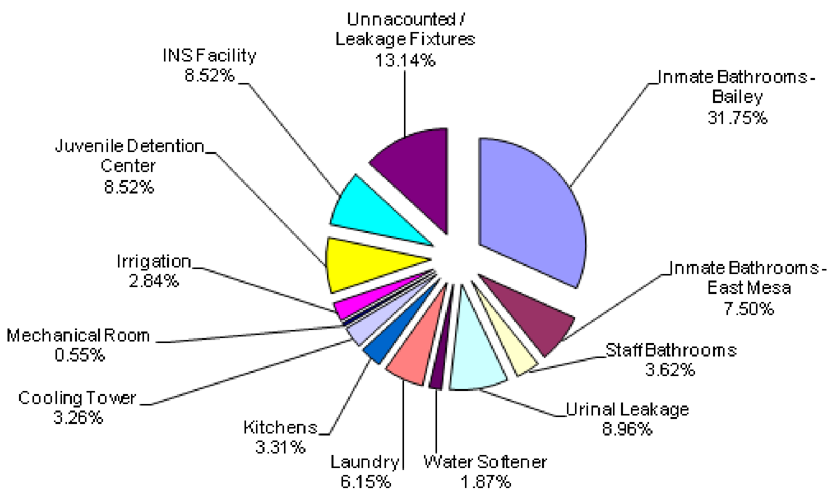
In addition to those BMPs identified under the sections addressing specific types of water use (see Table 7.20), one best management practice unique to prisons is the use of flush valves that limit the number of flushes that a can occur in a given amount of time, thus eliminating much of this excessive flushing. A number of California prisons have used these valves, saving significant volumes of water.

Savings Potential – California

The Otay Water District has made a concerted effort to work with correctional facilities in their service area in San Diego County: the R.J. Donovan Correctional Facility, a State Prison, and the George F. Bailey Detention Center & East Mesa Detention Facilities.

Before the water conservation effort, the Donovan facility used over 885 af/yr (290 million gallons per year). For the Donovan facility, a water conservation audit showed that just the potential indoor savings were in the range of 84 million gallons per year (Table 7.19), a 29 percent reduction in indoor use. With all measures in place – indoor, outdoor, and managerial – water use had declined to under 450 af/yr (145 million gallons per year), or a 45 to 50 percent drop, by 2010.

For the George F. Bailey Detention Center & East Mesa Detention Facilities, reductions were similar. Based on the first nine months of water use for 2010, compared to a similar period in 2009, water use has decreased more than 50 percent. Figure 7.23 shows the breakdown of indoor water use and facility operations water use for the detention facilities. Measures taken include all those found in Table 7.19 for the Donovan facility.



Source: Information provided by William Granger and Rhianna Pensa, Otay Water District, San Diego County, California

Figure 7.23 - Bailey and East Mesa Water Distribution

Table 7.19 - Proposed Water Conservation Measures at the Donovan State Prison

Measures	Quantity	Gallons/Year Savings	Annual Savings	Installed Cost	Payback with Incentives
Inmate Bathroom Fixtures Facility 1-4					
I-CON Electronic Bathroom Controls	2092	57,834,260	$421,039	$1,851,420	4.0
I-CON Electronic Shower Controls	176	13,094,010	$114,812	$155,760	1.0
I-CON Electronic Faucet Controls	500	5,840,000	$51,207	$442,500	8.3
Inmate Bathroom Fixtures – Facility 5					
Replace commercial toilets	26	1,790,592	$12,714	$26,185	1.9
Replace urinal flush valves	4	156,160	$1,109	$2,026	1.8
Install flow reducers for faucets	44	78,022	$554	$2,577	4.7
Common Area Bathrooms Facility 1-5					
Replace common area toilets	267	2,797,729	$19,865	$237,700	10.7
Replace common area urinals	23	468,096	$3,324	$9,965	3.0
Replace common area faucet aerators	265	68,270	$591	$4,770	8.1
Laundry					
Ozone Laundry System	1	1,750,000	$38,704	$151,429	2.8
Kitchen					
Kitchen Pre-rinse spray Nozzles	8	175,200	$1,789	$0	-
Total		**84,052,339**	**$665,706**	**$2,884,331**	**4.6 years**

Source: Information provided by William Granger and Rhianna Pensa, Otay Water District, San Diego County, California

The CDCR has implemented a system-wide initiative to reduce water use as part of the State mandate Executive Order S-06-08 that declared a state of drought in California. CDCR set a goal of reducing water consumption by 20 percent statewide, and the results have been significant. The following is a news release by the CDCR in 2009 (see actual news release at the end of this segment). The prison system continues to make progress.

News Release from the CDCR April 3, 2009

California Prisons Reduce Water Consumption by 21 Percent Through Comprehensive Drought Response Plan

SACRAMENTO – Today the California Department of Corrections and Rehabilitation (CDCR) announced it has achieved a 21 percent annual reduction in its water usage, saving 2.4 billion gallons of water– enough to fill approximately 65,000 swimming pools.

CDCR's water conservation program began in 2006 with a pilot project to install "flush meters" on toilets in selected prisons. In 2008, under the direction of Governor Schwarzenegger's Executive Order S-06-08 declaring that California is in a state of drought, CDCR set a goal of reducing water consumption by 20 percent statewide. On February 27, 2009 Governor Schwarzenegger declared a state of emergency on water shortage in response to three years of drought conditions.

"As California's largest state agency and a major water user, Corrections has taken steps to drastically reduce water consumption and prepared a comprehensive drought response plan in anticipation of another dry summer," said CDCR Secretary Matthew Cate. "CDCR's expansive water savings program has reviewed water usage in our 33 prisons and correctional facilities across the state. We are reducing water consumption on a massive scale through a combination of methods including conservation, elimination of nonessential use, retrofits, and increased efficiencies. Through the efforts of our wardens and staff across the state, we have achieved the Governor's goal for our agency of reducing consumption by 20 percent, and are continuing to search for new and innovative means to lessen the impact of the drought."

To comply with the Governor's Executive Order, CDCR has enacted the following measures:

- Flush meters have been installed at nearly one-third of all adult institutions, with more under construction in 2009. Institutions with flush meters result in a 27 percent average annual savings of water, versus 17 percent for institutions without flush meters.
- Institutions are now reporting monthly water consumption to CDCR Headquarters.
- Prisons and other facilities have enacted low-or-no-cost water conservation methods.
- Headquarters has distributed a "Best Management Practices Water Management & Conservation" document to all institutions that covers:
    - eliminating nonessential water use;
    - modifying practices for water efficient landscaping;
    - leak detection and repair – building systems and equipment;
    - water-efficient irrigation; and
    - laundries and vehicle washing.
- Onsite Water Consumption Surveys have been initiated at prisons.
- CDCR has identified other opportunities for additional water savings through operational modifications and best practices in inmate housing, kitchens, grounds and laundries.
- Additional water conservation projects have been launched.

"This is just the beginning," said Deborah Hysen, CDCR's Chief Deputy Secretary, Facility Planning, Construction and Management Division which oversees the effort. "Through a centralized reporting process and basic surveys we are conserving more water than ever before. As the drought continues we hope to enact additional water savings programs."
CDCR's water conservation efforts are part of its agency-wide environmental resource conservation program. CDCR is on-track to achieve the goal laid out by the Governor of reaching a 20 percent reduction in energy usage by 2015. These savings will be realized through the use of solar photovoltaic power plants, implementing peak load reduction programs, and by installing the latest in lighting technology. CDCR has been recognized as a national leader and as the first state government agency member of the Climate Registry.

7.1.7 Retail, Grocery Stores and Food Markets

Overview

Grocery Stores and Food Markets

Grocery stores and food markets typically use water for a variety of operations: spraying fresh vegetables with cold water, ice machines, deli operations, food preparation and restaurant service, restrooms, photo processing, floor cleaning, and cooling refrigeration equipment with cooling towers and evaporative condensers. Ice is often used in vegetable displays to maintain product freshness and to enhance aesthetic appeal.

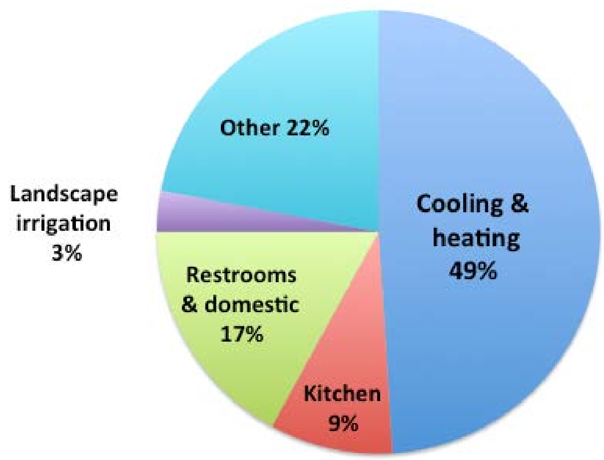


Figure 7.24 - Typical Water Use in Grocery Stores

General Retail

In the general retail sector, water use is directed more at sanitary applications – restrooms and cleaning – and, in most cases, landscape.

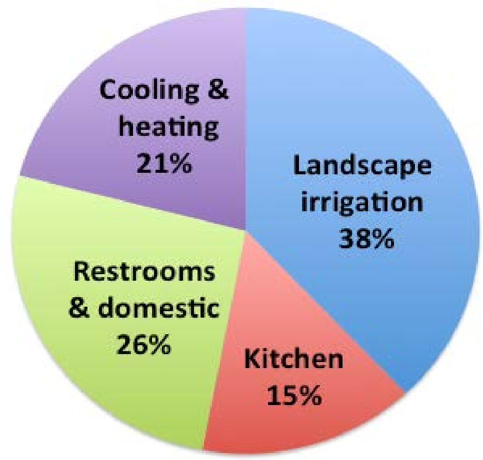


Figure 7.25 - Typical Water Use in Retail & General Commercial

Source: East Bay Municipal Utility District. 2008. *Watersmart Guidebook – A Water-Use Efficiency Plan Review Guide for New Businesses*.

Multi-Tenant Commercial

Multi-tenant commercial structures, such as mixed-use strip malls that are also occupied by medical activities, such as dentists, physicians, and clinics, distribute water differently depending on the types of occupants.

7.1.7.1 Cooling and Heating Systems

Grocery Stores and Food Markets

Water use related to cooling and heating accounts for 49 percent of total water consumption in the typical grocery store. Freezers, refrigeration and cooler operations, and comfort air conditioning equipment are often linked to remote refrigeration equipment. According to recent studies of grocery stores in California, half the water used at facilities with cooling towers is used by the cooling towers themselves. In other parts of the South and Southwest, air cooling, typically with multiple rooftop units, is more common.[114] The use of multiple rooftop units allows a grocery to continue to operate even if one or two units are down for repair. The use of air-cooling also eliminates the cost of building and operating a cooling tower. However, air-cooled units are generally less energy-efficient than systems using cooling towers, especially under full- or base-load conditions.

Refer to report Section 7.3.3 Thermodynamic Processes for a full discussion and information and BMPs related to this topic.

General Retail

In the general retail sector, water use for cooling and heating is estimated at 21 percent of total use. However, the same recommendations and BMPs apply. Refer to report Section 7.3.3 Thermodynamic Processes for a full discussion and information and BMPs related to this topic.

7.1.7.2 Kitchen Operations

In addition to traditional groceries, some grocers offer prepared food for take-out and eat-in. Preparation of food for sale and the resulting scullery operations are areas that use large amounts of water. Selecting energy-efficient kitchen equipment helps reduce waste heat, which also has implications for water use.

Scullery Operations

Water consumption for dishwashing and other scullery operations can be reduced through the following BMPs:

- Use only efficient pre-rinse spray valves (1.6 gpm maximum) for dish rinsing.
- Use strainer (scrapper) baskets in place of garbage disposals (grinders).

[114] Refer to Section 7.3.3 on Thermodynamic Processes for further information.

- Install ENERGY STAR® automatic dishwashers meeting efficiency standards set by the Consortium for Energy Efficiency (CEE).
- Install steam doors on dishwashers.

Food Preparation

For food preparation, several best practices offer opportunities for improved water efficiency:

- Select combination ovens that use no more than 15 gallons of water per hour and comply with the California energy rebate list.
- Instead of steam tables, install dry heating tables.
- Thaw food in refrigerators. Avoid thawing food under running water.
- Return and reuse condensate from all boiler-type steam kettles.
- Size steam traps for proper operation to avoid dumping condensate.
- Insulate condensate-return lines.
- Use pasta cookers with a simmer mode and automatic over-flow-control valves. Restrict flow to 0.5 gpm.
- Use connectionless or boilerless steamers consuming no more than three gallons per hour.
- Install in-line restrictors that reduce "dipper well" flows to under 0.3 gpm where permitted.

For additional information on these and other BMPs in the kitchen, refer to report Section 7.1.1, Commercial Food Service.

> Restrooms and domestic uses account for about 44 percent, cooling and heating (mostly in cooling towers and boilers) account for about 12 percent, landscaping and irrigation account for about 31 percent, and kitchen and other uses account for about 13 percent of total water consumption in the typical school.

7.1.7.3 Ice Machines

Ice machines may be located in vending areas for customers, as well as in the central kitchen of a grocery or food market. These machines use water for the ice itself and sometimes for cooling the compressor. These BMPs apply:

- Select Energy Star® qualified ice-making machines that are air-cooled, using remote heads to expel warm air outside the workspace and customer areas. Air-cooled machines are preferred over cooling-tower loops.
- Select energy-efficient flake or nugget machines rather than cube-ice machines. If cube-ice machines are used, those that meet CEE Tier 2 or 3 efficiency standards are preferred.
- Refer to report Section 7.1.1.5, Commercial Food Service, Commercial Ice Machines, for more information on available equipment and their efficiencies.

7.1.7.4 Restrooms and Plumbing

Appropriate water-saving technologies exist for all restroom fixtures. Refer to report Section 7.3.6, General Building Sanitary and Safety Applications, for a discussion of water use efficiency opportunities and BMPs for restrooms and other operations.

Use non-potable, treated water for fixture flushing (toilets and urinals only) and landscape irrigation applications, if available and where codes and health departments permit. Refer to report Section 7.3.5, Commercial Landscape and Section 9, Public Infrastructure Needs for Recycled Water, for information and BMPs related to these topics.

7.1.7.5 Floor Cleaning

BMPs for floor cleaning include:

- Discourage the use of open hoses for cleaning. When wet methods are used, install self-closing nozzles, limiting flow to five gpm. Refer to report Section 7.1.1.4, Commercial Food Service, Washing and Sanitation, for further information on floor cleaning, available equipment, and BMPs.
- Install drains close to areas where liquid discharges are expected.
- Arrange equipment for easy use of a mop and squeegee system or floor-cleaning machine.

7.1.7.6 Submetering

Tracking actual water use through a building management system connected to a series of submeters can rapidly disclose operating issues such as leaks and equipment malfunctions that might have remained undiscovered for a period of time. Furthermore, accountability for individual water use and the associated water and sewer costs by each tenant often leads to the implementation of water efficient practices by those tenants, reducing overall property water consumption.

- Separate metering of water-using systems and building areas is recommended where possible to ensure accurate tracking of the costs of water and wastewater disposal, particularly in multi-tenant commercial applications where tenancy is divided among disparate users with widely different water use demands.
- For a full discussion of submetering and BMPs associated with that topic, refer to report Section 7.3.2, Building Meters, Submeters, and Management Systems.

7.1.7.7 Other

Other recommended BMPs for grocery and retail facilities include:

- Install automatic shutoff and solenoid valves on all hoses and water-using equipment.
- Use self-contained “mini labs” that require no plumbing or washing for onsite photo processing.
- Conspicuously mark fire-protection plumbing so no connections will be made other than those for fire protection.
- Install flow-detection meters on fire services to reveal unauthorized water flows.

7.1.8 Schools and Educational Facilities

Overview – *Schools and Educational Facilities*

Schools, colleges, universities, and vocational institutions use water in many ways, including some that are similar to those of the following sectors: lodging, food service, laundry, and office buildings. They have in common many of the water-using systems and equipment common in those sectors, such as restrooms and sanitary functions, food service equipment, image processing, water purification, on-premise laundries (colleges and universities), vacuum systems, cooling towers and boilers, and cleaning, as well as the industrial processes taught in many of the vocational schools and classes. Figures 7.26 and 7.27 depict the amount of water used for general schools and educational facilities, functions and operations. This discussion highlights the key water-using elements of typical schools.

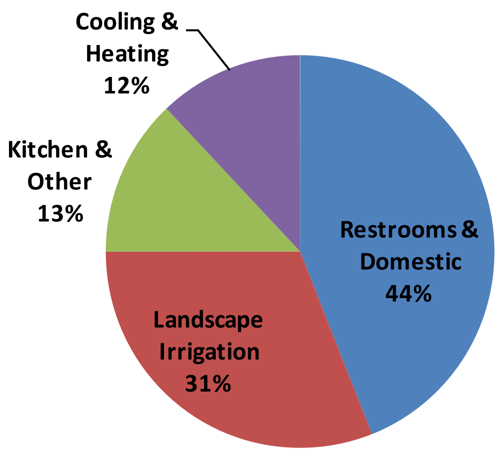


Figure 7.26 - Typical Water Use in Schools (excluding colleges & universities)
Source: East Bay Municipal Utility District, 2008. Watersmart Guidebook – A Water-Use Efficiency Plan Review Guide for New Businesses.

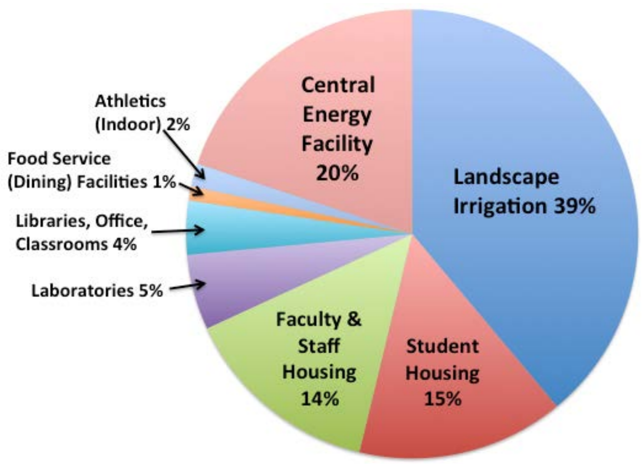


Figure 7.27 - Typical Water Use in Colleges and Universities

7.1.8.1 Restrooms and Plumbing

Restrooms and related domestic uses are the major water consumers in schools. Appropriate water-saving technologies exist with all restroom fixtures. Refer to report Section 7.3.6, General Building Sanitary and Safety Applications, for a discussion of water use efficiency opportunities and BMPs for restrooms and other plumbing operations in school facilities.

Non-potable, treated water may be used for flushing toilets and urinals and landscape irrigation applications, if available, and where codes and health departments permit. Refer to report Section 7.3.5, Commercial Landscape, and Section 9, Public Infrastructure Needs for Recycled Water, for information and BMPs related to these topics.

7.1.8.2 Cooling and Heating Systems

Water use related to cooling and heating, mostly in cooling towers and boilers, accounts for about 12 percent of total water consumption in the typical school.

Cooling Systems

Modern schools need to remove heat generated by the occupants, as well as the computers, research laboratories, lights, kitchens, and other operations, usually by means of a central refrigeration system and compressor. The use of energy-efficient equipment may reduce such waste heat. The compressor may be air-cooled or connected with a circulating loop to a cooling tower or evaporative condenser. As warm water from the compressor is directed through the cooling tower, some water evaporates, cooling the remaining water, which returns to cool the equipment. Refer to Section 7.3.3.1 Cooling Systems

However, the most important measures to improve the efficiency of cooling systems are to:

- Conserve energy to reduce the amount of waste heat generated.
- Use non-water based cooling equipment and processes, if possible.
- Reduce system losses and keep system maintained.
- Use alternative sources of non-potable water, if feasible.
- Manage controls to maximize recirculation and reuse.

Heating Systems

Steam boilers and hot-water boilers provide heat and hot water in some buildings. Closed-loop systems return water and steam condensate to the boiler for reuse, saving energy and water. Open-loop systems expend the water or steam without return to the boiler. Several water-efficiency actions are available to optimize water use for heating systems, as identified in Section 7.3.3.2 Heating Systems: Boilers.

However, the most important BMPs include:

- Energy efficiency
- Minimize system losses
- Maximize recirculation/cycles of concentration before discharge of blowdown water

7.1.8.3 On-Premise Laundries

On-premise laundries exist in nearly every major college and university in California. Refer to report Section 7.1.2, Fabric Cleaning and Washing Equipment and Technologies, for a discussion of water use efficiency opportunities and BMPs for on-premise laundries in schools.

7.1.8.4 Special Facilities

Laboratories

Many school laboratories use aspirators and venture pump systems. For laboratories, choose dry-vacuum systems rather than liquid-ring pumps. For vacuum and compressor systems, use air-cooled, radiator-cooled, chilled-loop, or cooling-tower systems. Sterilizers in laboratories should be equipped with water tempering devices. Water used by cage, glassware, and bottle washers in laboratories should comply with the requirements outlined elsewhere in this report. For further details on these and other items of laboratory equipment, refer to report Section 7.1.4 Medical and Laboratory Equipment and Processes.

Photographic and X-Ray Equipment

For photography and medical and other imaging, try to use digital technologies that allow images to be displayed on electronic video screens and stored in computer files. Where film imaging is required, use self-contained “mini-lab” developing units that require no special plumbing or washing to develop the film. For paper or film image copies use laser or ink-jet printing. For further details on these and other imaging BMPs, refer to report Section 7.1.4.6 Medical and Laboratory Equipment and Processes, Photographic and X-Ray Equipment.

7.1.8.5 Floor Cleaning

BMPs for floor cleaning include:

- Discourage the use of open hoses for cleaning. While wet methods may be used, install self-closing nozzles that flow to five gpm. Also refer to report Section 7.1.1.4, Commercial Food Service, Washing and Sanitation for further information on floor cleaning, available equipment, and BMPs.
- Install drains close to areas where liquid discharges are expected.
- Arrange equipment for easy use of a mop and squeegee system or floor-cleaning machine.

7.1.8.6 Submetering

Separate metering of water-using systems and building areas is recommended, where possible, to ensure that the costs of water use and wastewater disposal are accurately tracked. Tracking actual use through a building management system connected to a series of submeters can disclose operating issues such as leaks and equipment malfunctions that might have remained undiscovered. For a full discussion of submetering and BMPs associated with that topic, refer to report Section 7.3.2, Building Meters, Submeters, and Management Systems.

7.1.8.7 Residence Halls (college and university)

For college and university on-campus residence halls, refer to the report Section 7.1.3 Hospitality: Lodging – Hotels and Motels and 7.3.6 General Building Sanitary and Safety Applications.

7.1.9 Vehicle Washing

Overview

This section addresses vehicle washing. It includes commercial carwashes open to the public; fleet operations, including car, truck and bus washes; and washes for trucks and light vehicles that leave industrial sites to enter the public thoroughfare. Stand-alone businesses providing these services, categorized under NAICS 811192, include mobile carwash systems and detailing shops that offer hand washing. Some businesses, like car dealerships, vehicle rental companies, convenience stores, or service stations often have the same equipment, but they are not listed under this NAICS classification. Similarly, quarries, cement or asphalt companies with wheel or truck wash equipment are classified under their principal business type rather than this code.

According to the 2007 Business Census, businesses falling under the NAICS 811192 category provided $1 billion of economic activity and almost 24,000 jobs in California. While water use data is not aggregated on a statewide basis for this industry, some municipal water agencies track customer water use by class on gallons per vehicle (gpv) basis. These data provide an estimate of statewide water demand when multiplied by the average number of washes per business type.

> A 2006 Potential Best Management Practice Report by the CUWCC indicated that a statewide requirement for reclaim (water reuse) systems in all new conveyor and in-bay automatic vehicle wash systems has a potential for water savings totaling 22,877 acre-feet per year (af/yr) by 2020.

This section only addresses the wash equipment associated with cleaning the exterior of the vehicle. Water uses and BMPs associated with domestic uses of water found at the businesses can be found in Section 7.3.6 General Building Sanitary and Safety Applications, and water uses associated with businesses that are co-located with a carwash can be found in sections appropriate to that business. In addition, some vehicle washes have landscaped areas, and the water uses associated with those landscapes are addressed in Section 7.3.5 Commercial Landscape.

Water Use Information

In 2006, the CUWCC estimated that the total water use for all commercial vehicle washes would be approximately 60,000 af by 2020 based upon the growth rate in dedicated vehicle wash businesses from the 1997 to 2002 California business census figures. This estimate included commercial vehicle washes available to the general consumer and vehicle wash systems at car dealerships. It did not include washing of vehicles leaving industrial sites for which there are no centralized data sources.

Types of Vehicle Wash Processes

The most common types of vehicle washes are divided into three classes by the International Carwash Association: conveyor, in-bay automatic, and self-serve.[115] This section deals with general and particular patterns of water use and BMPs applicable to all three types of vehicle washes.

- Self-service vehicle washes use a hand-held wand, though there may also be a brush for the wash cycle.
- For in-bay automatic washers, all processes are performed through a set of nozzles, except in those cases where brushes are used in the wash cycle.
- In a conveyor vehicle wash, separate spray arches and/or brushes perform these steps.

Truck and bus washes use the same types of equipment only on a larger scale, typically combining the spray wands of a self-service or tunnel with the arches of a conveyor wash.

Another market sector, which is not well studied, entails the water used by detailing or hand washing businesses. A survey of commercial vehicle washes in 1999 found that five percent of respondents operated hand washes.[116] Anecdotal observation suggests that hand washing and detailing businesses have grown as a sector of the carwash industry, although there are no firm numbers on water use or size of market.

Wash Process

Water use in vehicle washes is controlled by type of equipment, water pressure, speed, nozzle size, and presence or lack of an onsite reclamation system. Typically, car washes are divided into specific stages in which water is delivered by different equipment, at different rates, and of different quality. The four basic phases are pre-wash, wash, application of finish products, and rinse. In some vehicle washes, the drying stage presents an opportunity to save water and reclaim it for use in the earlier stages of the wash.

- Pre-wash cycles are usually performed by a handheld spray wand or fixed nozzles designed to knock loose dirt and grit off a vehicle prior to the wash cycles.

- The wash cycle(s) use detergent or surfactants and high-pressure sprays or brushes. In the conveyor or in-bay automatic washes, the brushes may be in the form of strips of cloth on a spinning axle or a curtain of cloth that is pulled from side-to-side over the vehicle. Reclaimed water, when used, is typically used in the pre-wash and/or wash cycles.

[115] Brown C. 2000. *Water Conservation in the Professional Carwash*.
[116] Billings A. 2000.

- Rinse cycles may use high- or low-pressure sprays, and in some cases, they may include water treated for greater clarity. When reverse osmosis water treatment is used for the rinse water, the reject water may be reclaimed for use in the pre-wash or wash cycles.

7.1.9.1 Self-Service Carwash

Overview – *Self-Service Carwash*

Self-service vehicle washes are typically coin-operated with customer operated spray wands and brushes. The wash facility typically contains four to six wash bays and a central equipment room that houses water process equipment. The customer controls whether and for how long to use low-pressure or high-pressure settings, as well as whether to use a spray wand or brush. As a result, the carwash owner/operator does not have direct control over the water use at the facility.

Water Use Information – *Self-Service Carwash*

Studies of vehicle wash water use efficiency have shown that on average, self-service carwashes use the least amount of water, 15 gpv.

BMP Options – *Self-Service Carwash*

- With a fixed pricing structure for the initial purchase of several cycles plus the ability to purchase additional time (usually at a 25¢ per unit), the customer has a direct monetary incentive to move as quickly as possible, thus conserving water.
- In addition to water used in the pre-soak and wash cycles, many self-service operations also offer a spot-free rinse. As with in-bay automatics, reject water from the reverse osmosis (RO) unit may be used in landscape watering if landscape exists.[117]

Because customers wash their own vehicles unattended, self-service operators sometimes find evidence of dumping of oils or other organic materials in the wastewater. Such dumping is expensive, difficult to remedy, destructive of filters, and is a disincentive to use reclaim water in self-service washes (refer to Section 7.1.9.5 Reclaim).

7.1.9.2 In-Bay Automatic

Overview – *In-Bay Automatic*

"In-bay automatics" have a wash bay in which the customer stays in the vehicle as spray nozzles, brushes, or a combination of both, carry out the individual cycles. The vehicle remains stationary during the process and the carwash machinery is moved over the vehicle by a gantry. In-bay automatics have the greatest variety in basic design with some machines comprising an entire

[117] However, since reclaim is not typically used in self-service washes, except where required by law, reuse of RO reject water is not typically an option in self-service carwashes.

moveable arch, others having vertical and horizontal arms suspended from the gantry; and, yet others with spinning arms attached to the gantry.

Water Use Information – *In-Bay Automatic*

The International Carwash Association study of 2002 found average in-bay automatic water consumption per vehicle to be 42.9 gallons, although differences in equipment produce great variability among sites.

BMP Options – *In-Bay Automatic*

- Optimize nozzle size, number and alignment, flow rates, and timing because these all affect water use in the in-bay automatic vehicle washes.
- Many in-bay automatic operations also offer a spot-free rinse, which is typically obtained with reverse osmosis (RO) or deionization (DI) equipment, BMPs for water treatment systems found in commercial carwashes are discussed in more detail in Section 7.3.8, The Water Treatment Systems.
- Choose friction components because as with the conveyor vehicle wash, in-bay automatics that use brushes or cloth use less water than frictionless or “touch-free” vehicle washes.
- Use laser sensors to identify the length of the vehicle, thus limiting the gantry movement and timing of wash based upon the sensor signals.

Since all of the water flows to one pit, and all of the chemicals mix together, reclaim systems can be more costly and a bigger challenge to maintain than in conveyor carwashes.

7.1.9.3 Conveyor

Overview – *Conveyor*

The conveyor wash, which is usually installed in a tunnel, includes a series of cloth brushes or curtains and arches from which water is sprayed while the vehicle is pulled through the tunnel on a conveyor chain. In friction carwashes, the wash cycle is accomplished with brushes or soft cloth curtains. Some “touchless” carwashes use only spray nozzles. In full service conveyor carwashes, hand drying usually follows the conveyor; likewise, the pre-soak is often done by hand, sometimes with handheld wands similar to those found at self-service carwashes.

Many full-service conveyor carwashes offer towel drying as a service. In many older vehicle washes, the sinks for washing the towels are designed to have a constant flow of water through them. Some conveyor washes, referred to by the industry as “exterior-only,” do not offer drying or detailing services, thus eliminating this water use.

Water Use Information – *Conveyor*

The most recent national survey of carwash businesses reported that 73 percent of conveyors use friction components in the wash.[118] California specific data were not available and, thus, not separated out in the report.

Because of the speed of the conveyors and the more prevalent use of reclaim systems (56 percent of sites) conveyor systems use an average of 34 gpm.

BMP Options – *Conveyor*

- Choose conveyors with friction components because they use less water than frictionless washes because the brushes or curtains pick up water and detergent from the pre-soak of vehicles as the day proceeds.[119]
- Because timing is a critical component in carwash water efficiency, properly calibrated conveyors, nozzles are timed to turn on as the vehicle passes under the arch and to shut off as the vehicle exits each arch. Each arch is on for a matter of seconds, so conveyors can process 90 or more vehicles per hour.
- Proper nozzle alignment and pressure also help to maintain efficiency.
- Further water efficiency may be obtained by the orientation of blowers after the final rinse. When properly aligned, they push water back into the tunnel after the final rinse arch. As a result, water that would otherwise be carried out of the tunnel flows back into sump, where it can be reused in carwashes with reclaim systems.
- In towel washing sinks, installing a float ball valve to stop the flow of water when it reaches an optimum level is an effective water efficiency measure.
- For towel washing, replacing older flow-through sinks or replacing top loading washing machines with front loading machines will cut water consumption by 40 percent or more.

7.1.9.4 Truck, Bus, and Fleet Washes

Overview – *Truck, Bus, and Fleet Washes*

The type of equipment used to wash trucks, buses, utility vehicles, and heavy equipment is similar to that described above except larger in scale. Some commercial truck wash operations are coin operated, charging customers by the length of the vehicle, usually at a cost per foot of length. Due to differences in vehicle size and shape, hand held wands are prevalent in truck washes. Fleet washing of light passenger vehicles (such as in an auto dealership or at a rental

[118] Billings A. 2000. *Almanac for the Year 2000.*, Auto Laundry News, 48 (18).
[119] Kobrick, JD, et al. 1997. *Water uses and conservation opportunities in automatic carwashes: A City of Phoenix Study*.

agency) is typically done with either in-bay automatic or hand held wands and brushes.

Water Use Information – *Truck, Bus, and Fleet Washes*

Industrial or construction-related uses often must remove greater amounts of dirt and grease. As a result, they use more water per vehicle than a typical carwash.

One modified type of equipment is a drive through arch, similar to those found in conveyors, but where the driver controls the speed at which they move under the arch. These systems are referred to as "drive through tunnels," though sometimes the arch is found without a surrounding building. Electronic or magnetic sensors turn the arch on and off as the vehicle enters and leaves the arch. Thus, the speed of the vehicle driving under the arch influences the amount of water used.

In 2006, the Irvine Ranch Water District (District) surveyed 24 automobile dealerships to determine the car washing equipment being used.[120] They found that 87.5 percent of automobile dealers have onsite vehicle wash facilities in their service areas: 62.5 percent had self-service type wands; 20.8 percent had in-bay automatics or drive-through type washes;[121] and 4.2 percent had conveyors. The ICA study did not include fleet washes, but it would be reasonable to estimate that they use about the same amount of water per vehicle as their commercial counterparts.

7.1.9.5 Reclaim

Overview – *Reclaim*

Onsite capture and re-use of water in vehicle washes is referred to as reclaim water. Specific equipment and steps in the process of reclaim include capture of the water in pits or troughs below the cars, treatment of the water through filtration and disinfection, storage of the reclaim water, and delivery of the reclaim water to specific cycles in the vehicle wash. The types of equipment used include paper filters, sand filters, or centrifugal filters. Disinfection and odor control is carried out by use of ozone, chlorine injection, or UV systems. For additional details on the uses and management of water treatment equipment please refer to that section of the report.

Water Use Information – *Reclaim*

The data from the 2002 ICA study showed that the lowest amount of water recirculated in a carwash was nine percent of total gpv, with the highest being 82 percent of water used per vehicle.[122] This large range in percentages of reclaim

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[120] Koeller J and Brown C. 2006. *Evaluation of Potential Best Management Practices Vehicle Wash Systems*.
[121] No studies of water use in drive-through facilities have been published, but due to the slower speed of the vehicle proceeding through a drive-through arch, an industry representative anticipates water use to resemble an in-bay automatic more than a conveyor. Sartor B., Former Chair of ICA. -personal communication, April 2006.
[122] Brown C. 2002, p. 39.

water demonstrates the difficulty in providing accurate estimates without more details on the types of reclaim systems anticipated and the associated costs of making modifications to the existing facility.

Self Serve and Reclaim

Reclaim systems are not usually used by self-service carwashes because of the relatively few gallons per vehicle used by self-service customers. However, a closed-loop reclaim system can be used in self-service carwashes where there is no discharge to the sanitary sewer and all discharge is restricted. In these situations, it is not uncommon for the self-service to be staffed onsite to prevent customers from dumping oil or other materials, which would damage the reclaim equipment in the pits.

In Bay Automatics and Reclaim

Reclaim equipment companies generally acknowledge that in-bay automatics provide a more expensive challenge to reclaim systems, since all chemical products, from cleaning to finish, as well as oil and grease and contaminants from the road, winds up in the same separator tank. The water needs to be treated to remove all constituents that would interfere with its eventual reuse in the wash. The 2002 ICA water use study also found a wide variation in reclaim usage rates in in-bay automatics with a low of 12 percent per wash and a high of 82 percent per vehicle washed. The 2002 study found that 25 percent of in-bay automatic washes in the United States have a reclaim system.[123]

Conveyors and Reclaim

In conveyor systems, the length of the tunnels can provide opportunities to reclaim rinse water separately from wash water, necessitating different levels of treatment. This flexibility can create more cost-effective reclaim opportunities. For example, more difficult-to-treat chemicals that are used in small quantities, such as those in waxes or finish products, may be routed away from the principal reclaim system. Likewise, final rinse water may be reclaimed and reused with less treatment. The wide variety of ways that reclaim can be performed in conveyor carwashes results in a broad range of reclaimed water usage measured as a percentage of total water used per vehicle in the 2002 ICA study. The lowest amount of reclaim water used in a conveyor wash with reclaim was nine percent per wash and the highest was 74 percent. The 2002 study also found that 56 percent of conveyor washes in the United States have a reclaim system.[124]

Large Vehicles and Reclaim

Reclaim also has an important role in industrial uses and for large vehicles as noted above. The controlled access to such facilities allows for more innovative treatment of the water, such as longer residence times and use of enzymes. Rainfall can be captured to replenish systems, so closed-loop systems can

[123] Brown C., 2002.
[124] Brown C. 2002,

approach 100 percent nonpotable water use. A bus wash reclaim system in Seattle, for example, which was partially funded by the Seattle Public Utilities, achieved in excess of 80 percent efficiency and saved more than 200 gallons per vehicle. Similar results could be expected for other large vehicle reclaim systems, but studies on this sector have not been performed.

Other considerations

Vehicle wash operators typically pay a sewer discharge rate that covers the costs of treating the materials that are washed off the vehicles including grit, oils and metals, and the detergents or cleaning products the facility has added. Thus oil and grit separation tanks are standard features of a vehicle wash, and reclaim equipment has added value because it helps reduce the volume of discharge per vehicle.

Recycled water from municipal sources is not typically delivered to commercial car washes. However in California, the Marin Municipal Water District (MMWD) has done so. MMWD currently serves two commercial car washes with recycled water. Two issues have dominated use of recycled water in these car washes: pathogens and spotting on cars due to TDS. To address the Department of Public Health (DPH) concerns about pathogens, the car washes have been equipped with a device that automatically delivers periodic chlorine shock treatment. Also, ozonation systems are commercially available to address this issue. Spotting was addressed initially with an RO system, but MMWD reduced its recycled water TDS such that spotting on cars is now effectively managed with ion exchange and/or surfactants.

Savings Potential – California

A 2006 Potential Best Management Practice Report by the CUWCC indicated that a statewide requirement for reclaim systems in all new Conveyor and In-Bay Automatic vehicle wash systems has a potential for water savings totaling 22,877 af/yr by 2020. In-bay automatics make up more than two-thirds of the potential savings at 16,580 af/yr, and conveyors represent 6,297 af/yr potential savings by 2020. Because of difficulties in the use of reclaim systems in self-service carwashes as discussed earlier, this category was not included in the estimated savings.

7.2 Industrial Sectors

The Industrial Sectors includes BMPs focused on a subset of California industries that CII Task Force members identified as being significant water users, and therefore, worthy of attention in order to identify water savings opportunities. Each of these sections was developed by the Working Group or Subcommittees of the CII Task Force. Much of the focus on these sections is on processes that control the use of water within a facility; therefore, it is important to note that actual water savings potential in the field will be affected by the size of a business and by the type of processes used.

Geographic location in the state will also affect the water use efficiency potential due to wide variations in evapotranspiration, temperature, and rainfall levels throughout the state. This variability as it applies to specific BMPs is explained within each section of Volume II, along with the general water user information and gross potential for water savings.

7.2.1 BMPs for Industrial Operations

Overview

Industrial operations are unique, even more so, than commercial and institutional operations. Although the processes are generally the same in a specific type of industry, the uniqueness comes from the configuration or layout of the actual facility and the design of equipment, which is often proprietary. The following three concepts should serve as guiding principles when considering industrial facilities:

- **One size does not fit all** – For any given industry, there may be a dozen potential BMPs. Not all will be applicable. In many cases, establishing one BMP will make another one inapplicable because they will "be saving the same water."
- **Every facility is unique -** Analyzing potential Payback is unique to each plant and situation. Unlike many commercial situations, manufacturing plants vary in manufacturing techniques and design, even within the same industry. As a result, what may work at one vegetable processing plant may not be applicable at another.
- **The list should be used only as a guide -** The intent of the industrial operations BMPs is to provide a list of possible measures that facilities can adopt for their specific situation.

The purpose of this chapter is to:

- Look at the importance of industrial operations to the State of California
- Examine how water is used in general
- Look at six examples of how water is used in selected major industrial sectors in the State

- Present detailed descriptions of BMPs in each of these industries that are applicable to all industries

In this section, six industries are chosen for discussion and to provide examples of water-using operations that are generally found in other industries.

California Industries

California leads the nation in commercial output. California ranks as the eighth largest economy in the world. According to U.S. DOC information, the state's economic output in 2008 was $1.85 trillion. Figure 7.28 shows the distribution of that output over the various economic sectors in California.

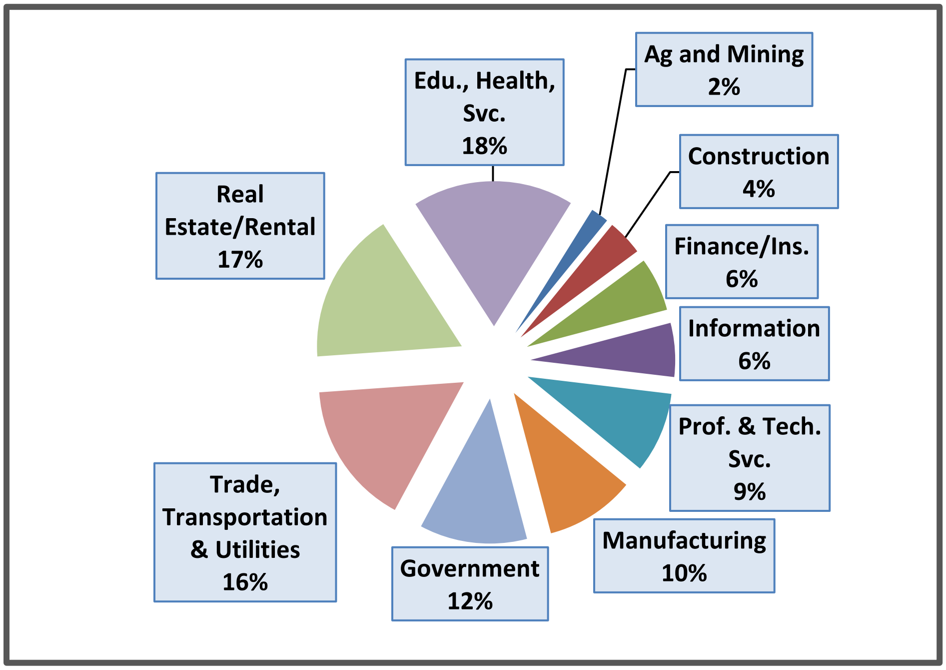


Figure 7.28 - California's Gross Domestic Output in 2005

The manufacturing sector employed 1.197 million Californians in 2009 and produced over $443 billion in total shipments based on the U.S. Census of Manufacturers. Figures 7.29, 7.30, and 7.31 summarize employment and shipments by each of the major sectors. Value added, approximately the difference between raw materials and shipment, represents the "worth" added by the manufacturing process. Value added in 2009 was $225 billion while workers earned over $63.6 billion, which averages to a little over $53,000 dollars annually for each worker.

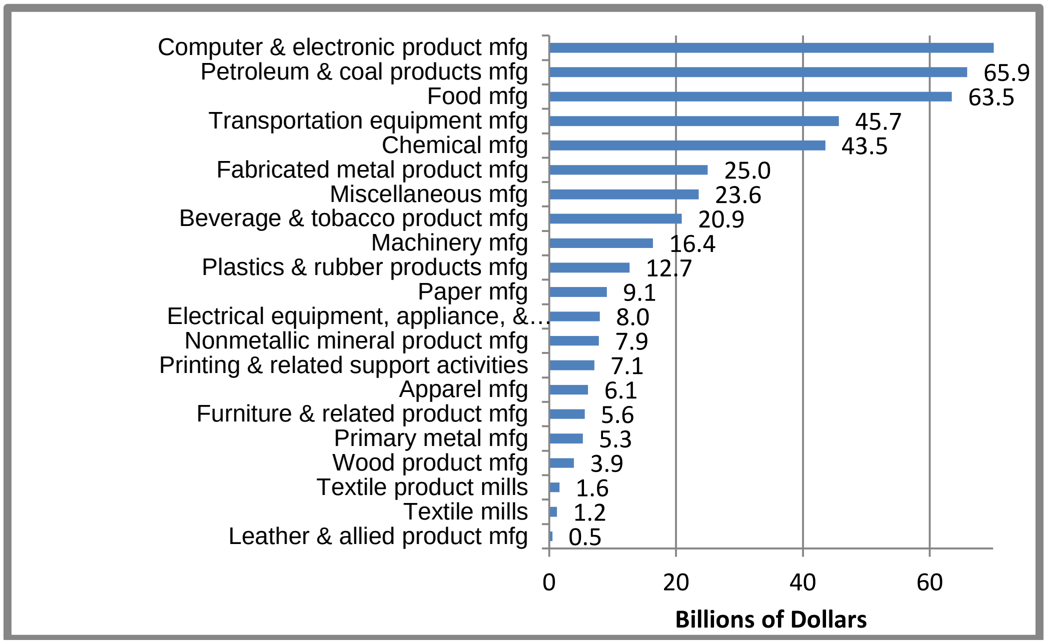


Figure 7.29 - Employment by Manufacturing Sector in California – 2009

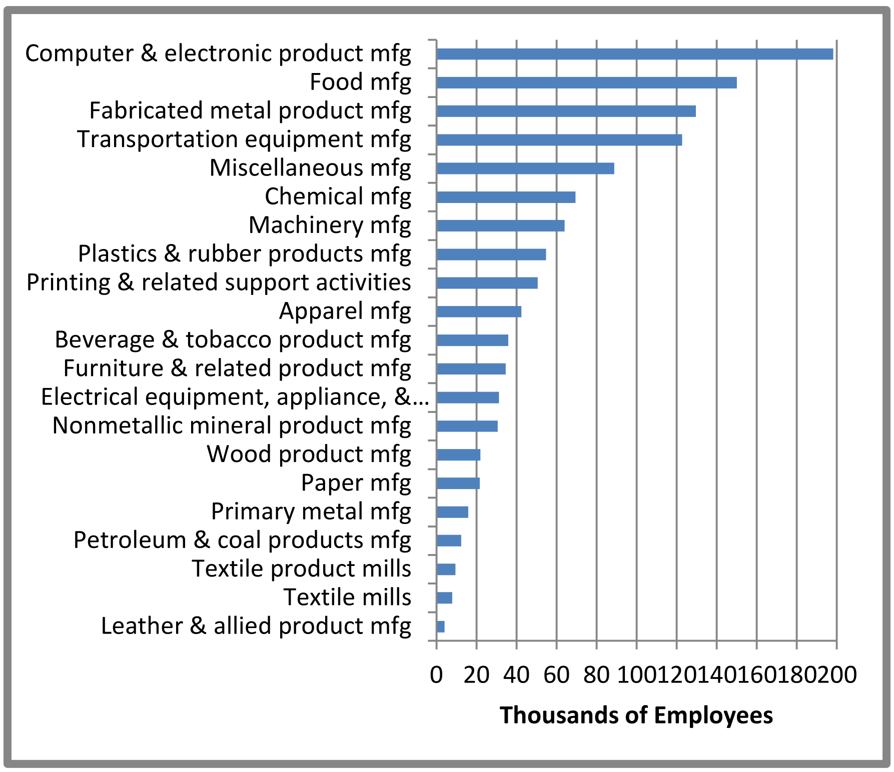


Figure 7.30 - Value of Shipments in California – 2009

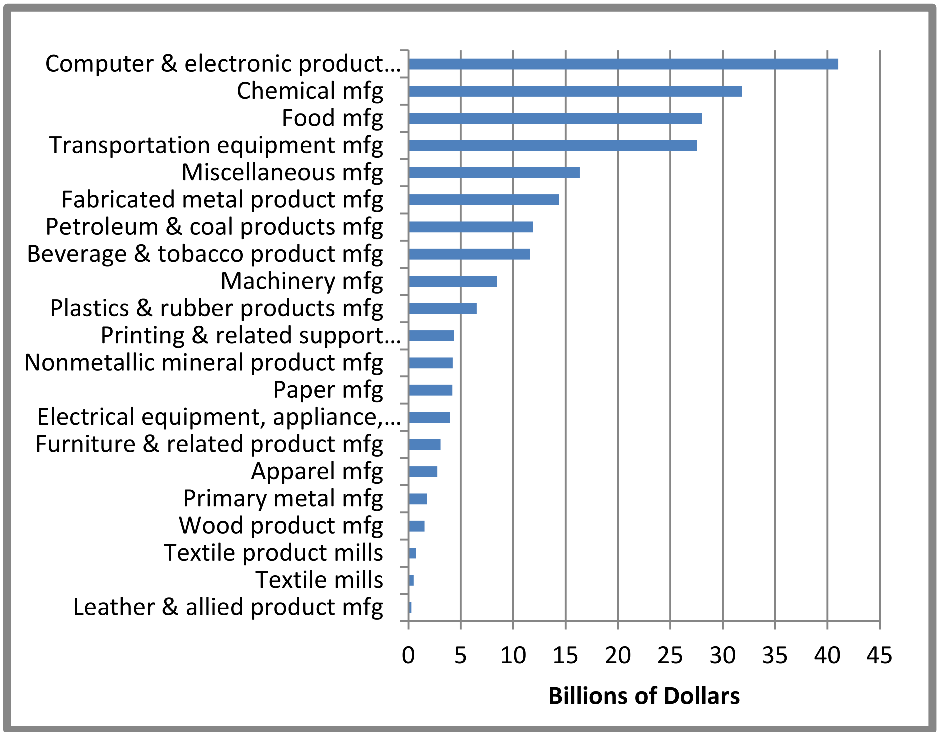


Figure 7.31 - Value Added by Sector in California - 2009

The beverage industry discussion will be included in the food processing sector. Prior to the 1990s, the classification system for commercial activities was known as the SIC system. The new NAICS has replaced the SIC system. In the new system, beverages are separated from the food processing system and combined into a new category of Beverages and Tobacco under the NAICS code of 312 with Beverages being 3121 and Tobacco being 3122. Because of confidentiality concerns, the U.S. DOC does not list California dollar production at the four-digit level, but combines it at the 312 level, which includes tobacco. However, it does give employment information at the four-digit level. This information shows that 99 percent of employees work in the beverage sector; therefore, NAICS 312 is used to represent this sector in the above material. The new NAICS codes also better delineated the Computer and Electronics Manufacturing sector to reflect current market conditions.

Table 7.20 - Old SIC Codes Compared to New NAICS Codes

Industrial Sector	NAICS*	SIC*
Food mfg	311	20
Beverage & tobacco product mfg	312	20
Textile mills	313	22
Textile product mills	314	22
Apparel mfg	315	23
Leather & allied product mfg	316	32
Wood product mfg	321	24
Paper mfg	322	26
Printing & related support activities	323	27
Petroleum & coal products mfg	324	29
Chemical mfg	325	28
Plastics & rubber products mfg	326	30
Nonmetallic mineral product mfg	327	32
Primary metal mfg	331	33
Fabricated metal product mfg	332	34
Machinery mfg	333	35
Computer & electronic product mfg	334	36
Electrical equipment, appliance, & component mfg	335	36
Transportation equipment mfg	336	37
Furniture & related product mfg	337	25
Miscellaneous mfg	339	39
***NAICS - North American Industrial Classification, SIC - Old System Numbers		

Table 7.21 summarizes the ranking of the industrial sectors in California by value of shipments, employment, and value added. This information shows that from an economic perspective, the major industries are computers and electronics, chemicals, food processing, transportation equipment, fabricated metals, and petroleum.

Table 7.21 - California Industrial Economic Ranking by Three Indicators

Rank	Value Added	Value of Shipments	Employment
1	Computer & electronic products	Computer & electronic products	Computer & electronic products
2	Chemicals	Petroleum & coal products	Food processing
3	Food processing	Food processing	Fabricated metal product
4	Transportation equipment	Transportation equipment	Transportation equipment
5	Miscellaneous	Chemicals	Miscellaneous
6	Fabricated metal product	Fabricated metal product	Chemicals
7	Petroleum & coal products	Miscellaneous	Machinery
8	Beverage & tobacco	Beverage & tobacco	Plastics & rubber products
9	Machinery	Machinery	Printing
10	Plastics & rubber products	Plastics & rubber products	Apparel
11	Printing	Paper	Beverage & tobacco
12	Nonmetallic mineral products	Electrical equipment, appliance, etc.	Furniture
13	Paper	Nonmetallic mineral products	Electrical equipment, appliance, etc.
14	Electrical equipment, appliance, etc.	Printing	Nonmetallic mineral products
15	Furniture	Apparel	Wood products
16	Apparel	Furniture	Papers
17	Primary metals	Primary metals	Primary metals
18	Wood product	Wood products	Petroleum & coal products mfg
19	Textile product mills	Textile product mills	Textile product mills
20	Textile mills	Textile mills	Textile mills
21	Leather & allied product	Leather & allied product	Leather & allied product
Source: U.S. Dept. of Commerce - Census of Manufacturers			

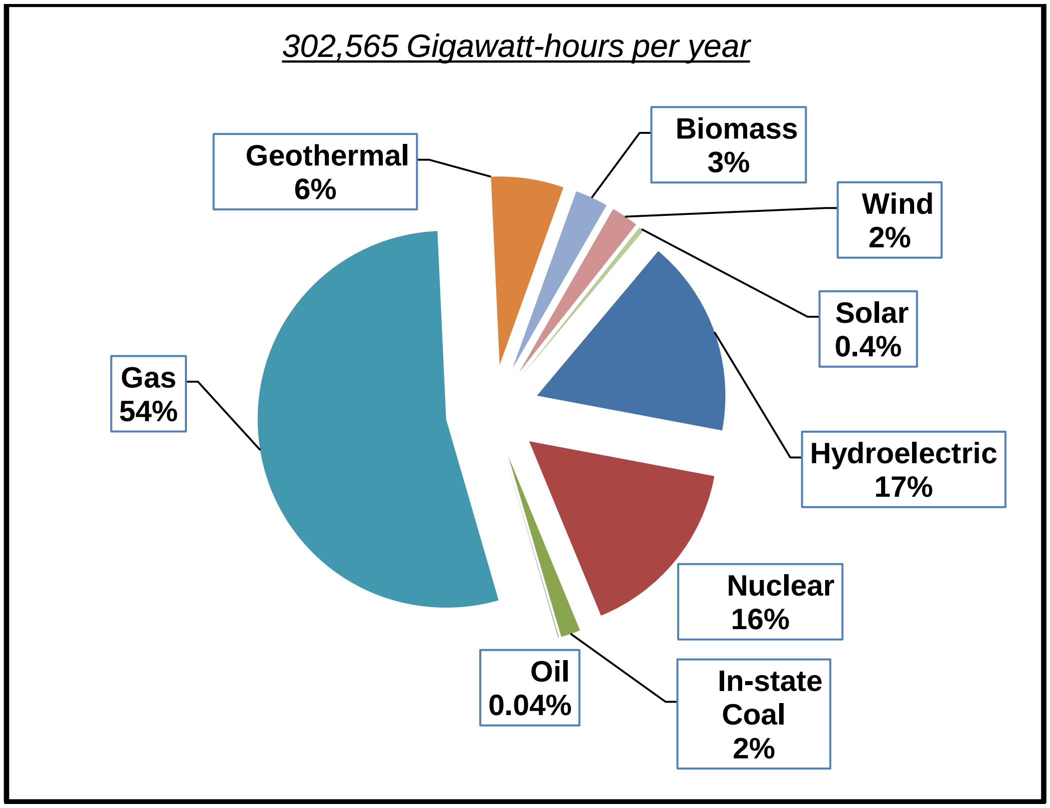


Figure 7.32 - Electric Power Production in California - 2010

Types of Equipment/Processes

Industrial water is used in eight basic ways:

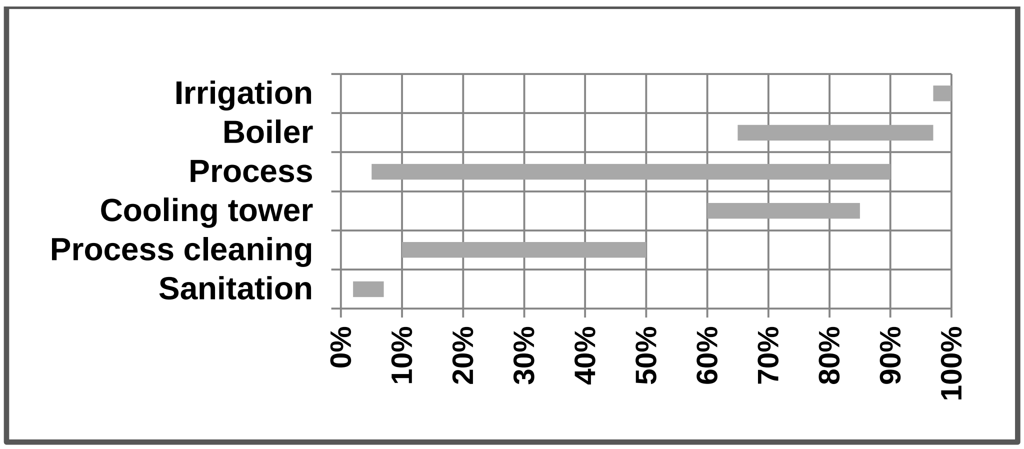
- Cooling & boilers
- Cogeneration and energy recovery
- Process
- In-plant conveyance
- Cleaning
- Environmental controls
- Sanitation
- Irrigation of landscape

Water Use Information

To properly evaluate industrial water using operations, two terms must be defined: use and consumption.

- **Use** means the total water purchased or withdrawn from a fresh or saline body of water or from a well.
- **Consumption** refers to water that is included in the product, evaporated, or otherwise not returned as an effluent from the facility. Some food processors, especially fruit and vegetable processors and wineries, use their effluent for crop irrigation. In the final analysis, the water is consumed for crop production, but not in the facility.

The percent of water use that is consumed and not returned depends on the type of use, the industry, and the specific process. For example, in efficient carbonated beverage (soda) manufacturing, total water use per gallon of soda produced is about 1.7 gallons. This figure includes one gallon in the product and 0.7 gallons used in the plant. In petroleum refineries, over 75 percent of the water use is typically for cooling towers and boilers. Figure 7.33 shows that the amount of water consumed in various types of industrial and commercial operations can vary considerably.



Based on Unpublished Research by H.W. (Bill) Hoffman & Associates.

Figure 7.33 - Percent of Water Used that is Typically Consumed in Industrial and Commercial Operations

One of the consequences of water consumption is that the remaining water contains the concentrated minerals and salts that were in the water source and the chemicals that were added.

When examining industrial use, the potential available water sources will impact overall costs. Industry can often use water unsuitable for other uses. Saline water from coastal areas is often used for cooling, and recycled water and water from onsite sources can often be beneficially reused.

To better understand the breadth of water use in industry, this section describes seven industrial sectors selected to highlight the different types of water use. **The seven industrial sectors described in this report are:**

1. The aerospace industry, including making of engine components, metal finishing, and plastic extrusion and molding.
2. Plating, Printed Circuit Boards, and Metal Finishing.
3. Food processing and beverage industries, including fruit and vegetable processing, wine making, and poultry processing.
4. The High-Tech Industry.
5. The petroleum refining and petrochemical industries.
6. Pharmaceuticals, including drug production and the emerging biotechnology industries.
7. Power Plants.

Technical Feasibility

Industrial water efficiency efforts can result in significant water and monetary savings to the industrial water user. All of the BMPs discussed in the industrial BMP sections are technically feasible and have been successfully employed elsewhere.

However, the technical feasibility may be limited by a number of parameters. Water quality, available space, regulatory and code requirements, and technical limitations to a specific industry or process may limit the application of BMPs. These factors are different for each type of industry, even between similar facilities producing the same products.

Benefits and Cost

Determining the costs and benefits of each BMP depends on a number of factors. In most cases, the solutions must be engineered to the specific facility design and layout. For example:

- The cost of two-inch diameter industrial piping within a facility depends on the type of pipe material used, the length of the pipe needed, and the hurdles it must overcome to be installed along with the labyrinth of other piping in the plant. The cost per foot of pipe can be as low as $25 to more than $300. The same variations exist for similar types of equipment.
- A pigging system launcher and retriever (see section describing clean-in-place applications) can typically be purchased for $20,000

to $35,000 depending on the size and application. But this figure represents only a starting point.

The installation of a water recirculation system to recover process water from wafer manufacturing in a microelectronics fabrication facility (fab). For a large fabrication, recycling could save half a million gallons of water a day or more, but costs could range from a few hundred thousand dollars to several million dollars depending on plant design.

The benefits of a given BMP also depend on a number of factors including:

- The cost of water and wastewater source for that plant.
- Associated energy savings or costs.
- The value of any products recovered or saved as a result of the BMP.
- Potentially incurred labor, solid waste, air quality, or related costs.

Other important factors include:

- The degree to which a facility has already implemented water efficiency measures.
- The specific type and model of process equipment used within the same industry.
- The life expectancy of the plant, process, or equipment to be modified.

Case studies will be presented in this section to illustrate the feasibility and record potential costs and savings for specific examples. Where cost ranges for specific measures are available, they are included in the text for each BMP section.

7.2.2 Industry-Specific Information

7.2.2.1 Aerospace Industries in California

Overview – *Aerospace and Metal Finishing Industries*

The aerospace industry includes a variety of industrial operations associated with the production and maintenance of aircraft, missiles, space vehicles, and the equipment and services that serve that sector. The industry encompasses both military and commercial aviation through original equipment manufacturing and reworking, which includes the maintenance, repair, and modification of existing aircraft.

Metal finishing is the principal water using operation in aircraft production. Many of the operations common to this industry are found in industries that produce metals and plastics and that contain motors and controls. These products include appliances, boats, vehicles, and many types of commercial equipment.

BMPs applicable to the aerospace and metal finishing industry are equally applicable to these other industries.

The aerospace industry is part of the transportation sector according to the NAICS 336. Figure 7.34 shows the predominance of the aerospace industry in California over other transportation equipment sectors.

Figure 7.34 - Transportation in California in 2009 - NAICS 336

Figure 7.35 shows the distribution of the value of shipments for the aerospace industry in California based on the 2007 U.S. Census of Manufacturers.

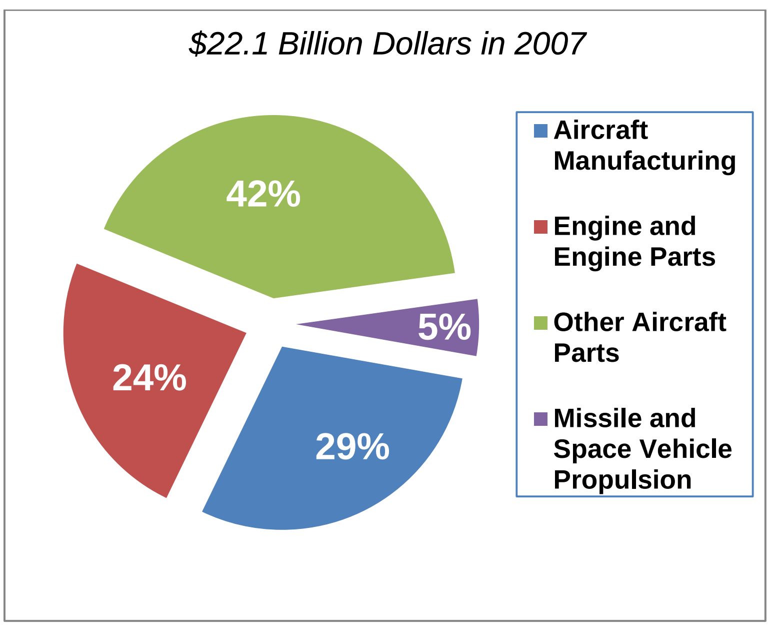


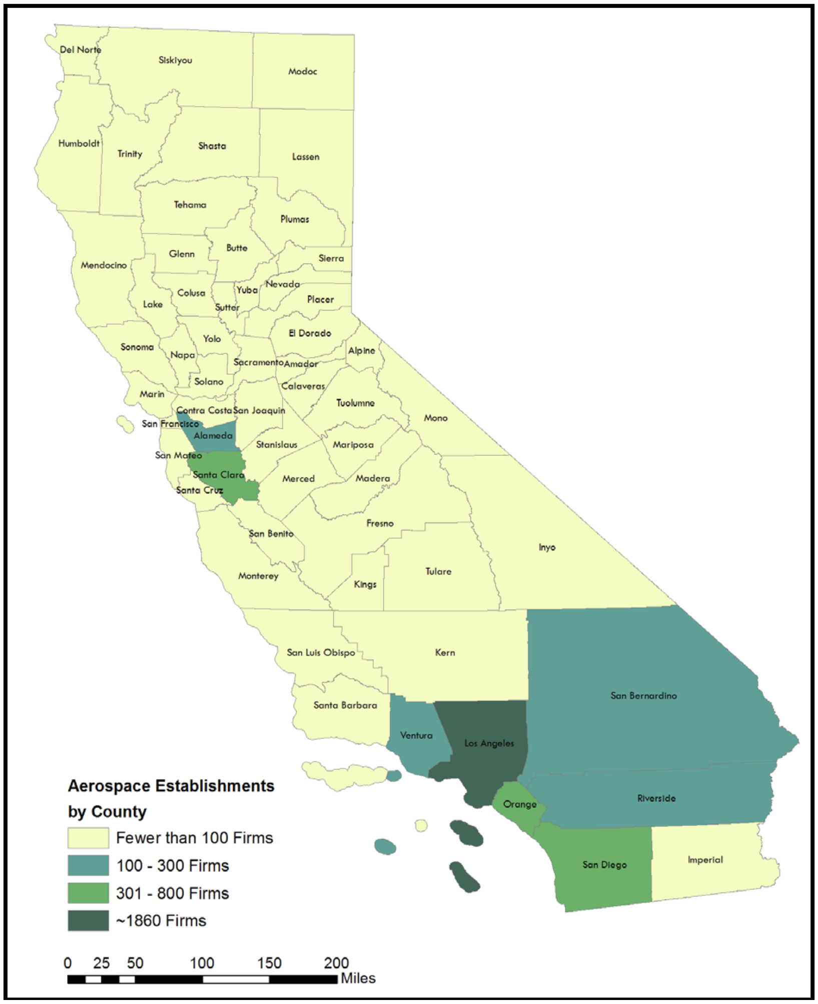
Figure 7.35 - Value of Shipments of Aerospace Industry in California

Based on U.S. DOC data, employment in this sector increased from 70,297 employees in 2007 to 79,098 employees in 2009. Likewise, the value of shipments rose from $22.1 billion in 2007 to $28.4 billion in 2009 in California. Table 7.22 summarizes employment and the value of shipments for 2007.

Table 7.22 - California Aerospace Industry in 2007

(i) NAICS	Description	Value Added (Billions of dollars)	Employment (Thousands)
336411	Aircraft Manufacturing	6.5	13.3
336412	Engine and Engine Parts	5.3	23.4
336413	Other Aircraft Parts	9.2	29.5
336414	Guided Missiles and Space Vehicles	0.1	0.1
336515	Missile and Space Vehicle Propulsion	1.1	4.1
	TOTAL	22.1	70.3

As Figure 7.36 shows, most of California's aerospace industry is located in Southern California and the Silicon Valley in the San Francisco Bay Area. According to the publication, "Aerospace Manufacturing and Support Industries in California – 2010," actual manufacturing has declined but the research, design, repair, and refurbishment of electronics and the warfare aspects of the industry and space research continue to be very active.



Source: Aerospace Manufacturing and Support Industries in California - 2010

Figure 7.36 - Aerospace Establishments in California

The industry includes the following operations:

- Design of all types
- Administration
- Academic research
- Testing and Research
- Laboratory
- Academic
- Manufacturing
- Engines and propulsion systems
- Air frames
- Electronics
- Structural parts

- Life support and interior
- Avionics
- Metal working
- Metal finishing
- Rework and refurbishing
- Paint removal
- Parts cleaning
- Hydro blasting & plane washing
- Processes like those in manufacturing

Many industries support the aircraft industry and use water in their operations. These include:

- Hardware manufacturing - NAICS 332510
- Machine shops - NAICS 332710
- Precision turned product manufacturing - NAICS 332721
- Bolt, nut, screw, rivet, and washer manufacturing - NAICS 332722
- Fluid power valve and hose fitting manufacturing - NAICS 332912

These industries are recognized as major contributors to the Aerospace industry in California. They use water for casting, milling, machining, and related uses. Many have cooling towers and other process equipment. Water efficiency is important to these industries, but they are not included in the overall discussion of the aerospace industry.

Figure 7.37 shows the interaction between the different components of the aerospace industry.

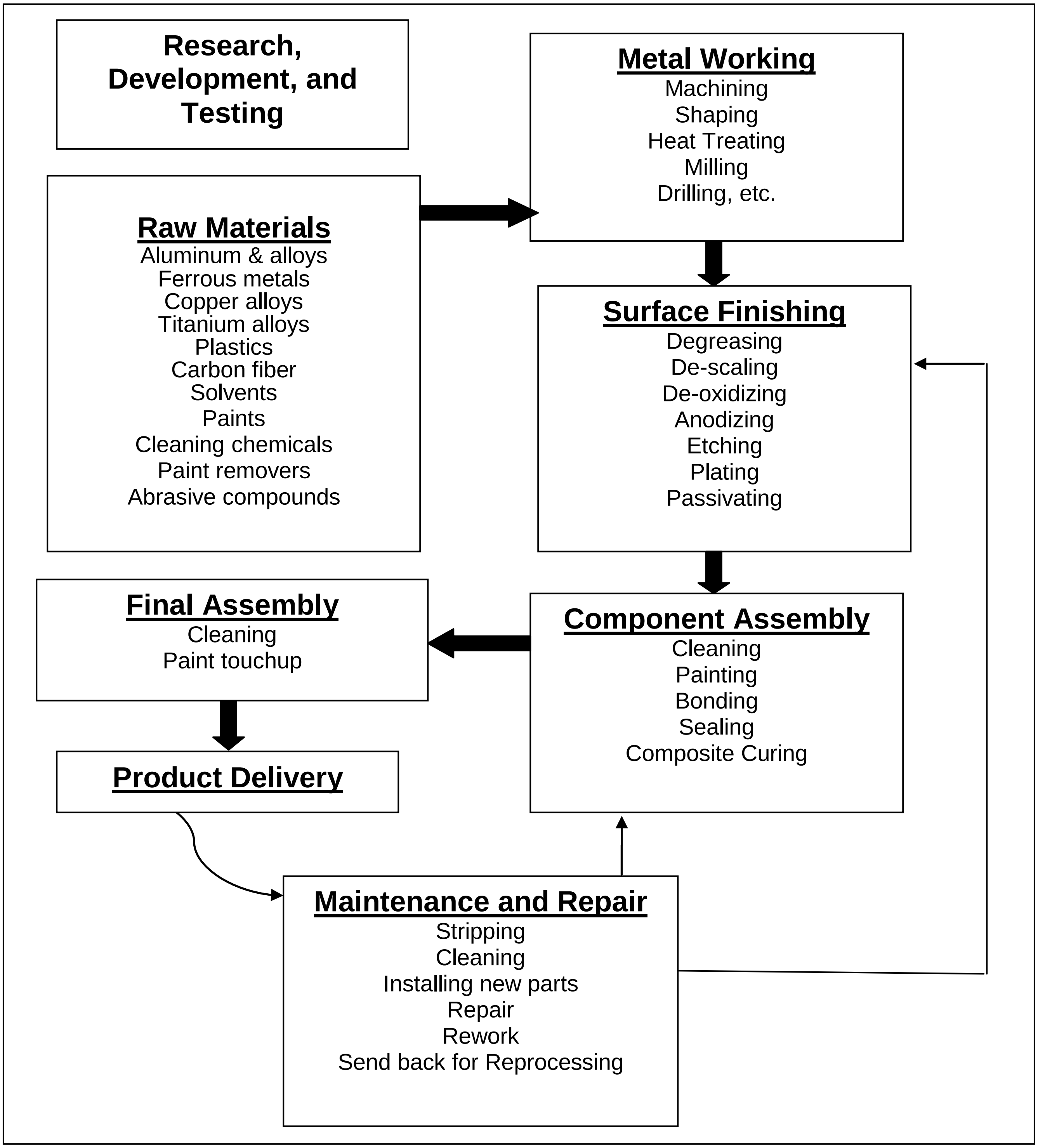


Figure 7.37 - Aerospace Manufacturing Process

Types of Equipment and Operations – *Aerospace*

Aircraft manufacturing also employs many aspects of metal finishing (refer to Figure 7.37). Section 7.2.2.2 Plating, Printed Circuit Board, and Metal Finishing, discusses water use and BMPs for these metal finishing operations.

Water uses commonly found in aerospace and similar manufacturing industries include:

Molding and Casting

Many metal parts are made by either pouring or injecting a material into a mold or form. Water may be used both to make the mold material, such as a wet sand mold, or for cooling the molds after injection. Any material that can be melted – such as metals, plastics, and ceramic materials – can be molded or cast into a desirable shape. The investment or lost wax method of casting involves making a wax mold that is coated in a slurry of clay; the clay is then dried and the wax melted out to form the mold.

Milling and Cutting

Milling and cutting are common practices in engine manufacturing, metalworking, and production of subassemblies with forged, stamped, or cast parts. Water is principally used in three main technologies:

- Electric Discharge Machining - Micro electrical discharge milling of cemented tungsten carbide (WC-Co) using a deionized water spray and a bipolar pulse. This method of machining generally uses kerosene or deionized water as the working fluid.
- Water Jet Cutting and Milling - Water jet cutting uses a high speed jet of water containing abrasives to cut metals, ceramics, and other hard substances.
- Cutting and Milling Fluids - Turning, mechanical milling and grinding, drilling, taping, and sawing of metals all use cooling and cutting oils. Most are water-soluble oil-water mixtures. Air, CO2, nitrogen, oils, and gels may be used in place of oil-water mixtures, but all have cost considerations and limited applications.

Welding

Resistance processes, such as spot welding use water or a brine solution for tip cooling and for cooling when tungsten arc welding. Air or water may be used to cool tungsten arc welding torches and other arc welding devices.

Quenching of Metals

When quenching, there are four types of media: air, brine (salt water), oil, and water. Quenching is the final step in metal heat treating and annealing.

Aircraft Parts, Stripping and Cleaning

Parts stripping and cleaning is a necessary step before hydraulic systems, engine parts, and other components may be refurbished and repaired.

Paint removal is a routinely employed process to remove old paint from aircraft before repainting. Organic solvent strippers have been replaced with water-based caustic compounds as well as various particles, thermal, and high-pressure water systems.

- Caustic-based chemical stripping removes paint, but must use water to clean the stripped parts. Some systems use high-pressure water in conjunction with chemicals. The resulting wastewater-caustic mixtures are routinely filtered and recirculated. Very high-pressure water systems that do not use chemicals or abrasives are also used, but they use large amounts of water.
- Dry paint removal methods use a wide range of materials, including walnut shells, plastic pellets, sodium bicarbonate, carbon dioxide pellets, intense light, and heat.

Air Scrubbing

Air scrubbers are used in many of the manufacturing and maintenance operations to remove fumes and particulates that would cause air pollution or health and safety hazards if not controlled. Water is used in most scrubber systems.

Painting

Painting with solvent-based paints has been all but eliminated in most industrial processes and replaced with water-based paints or with electrostatic dry paint systems and other dry coat processes. Water is used to clean equipment and for the paint solvent. Systems that filter and recirculate cleaning water are available. Where water curtains are used to capture paint particles in spray booths, the water needs to be filtered and recirculated.

Water Use Information – *Aerospace*

Because of the industry's diversity, almost every conceivable type of water use occurs at some place in this sector. Normal uses range from landscape, cooling towers, boilers, sanitation, food service, and even laundry and swimming pool operations. Cleaning of all types is commonplace, including vehicle washing. Some operations even include medical and laboratory functions. These water uses and their BMPs are discussed in other sections of this report.

Annual water use estimates for the aerospace and metal finishing industries are unavailable. The diversity of this industry and the decline in actual manufacturing of aircraft in California all indicate that this sector's water use is declining. Establishing metrics for such a diverse industry is not possible without, at the very least, an inventory of current water use.

Technical Feasibility – *Aerospace*

The BMPs described in this section are applicable to manufacturing facilities and research laboratories/testing facilities associated with aerospace industries. All of the BMPs are currently being successfully employed at various facilities. However, their economic viability depends on specific facility design, cost of utilities, and a number of related factors. Additionally, what works at one facility may not necessarily work or be economically practical at another similar facility.

BMP Options – *Aerospace*

Section 7.2.2.2, Plating, Printed Circuit Board, and Metal Finishing describes BMPs for metal finishing and plating. BMPs for landscape (Section 7.3.5), cooling towers (Section 7.3.3), boilers (Section 7.3.3), sanitation (Section 7.3.6), food service (Section 7.1.1), laundry (Section 7.1.2) , swimming pool operations (Section 7.3.7), vehicle washing (Section 7.1.9), medical and laboratory operations (Section 7.1.4), and other similar uses are described in their respective sections.

The section on Types of Equipment and Operations – Aerospace, above, describes six common water using activities in the aerospace industry. BMPs for each of the six water using areas include:

Molding and Casting

Water saving opportunities depend on the type of molding and casting process used.

- Sand molds are a "standby" of the industry. The sand can be held together either with water or resin; where resins can be used, water use can be eliminated.
- Investment casting involves making a watery slurry of clay. In all cases where water is used, alternative methods are available.
- Mold cooling should only be done with either air or a closed cooling loop system.

Milling and Cutting

- Electric Discharge Machining - Use kerosene instead of water where feasible.
- Water Jet Cutting and Milling - Recirculate water and abrasives
- Cutting and Milling Fluids - Air, CO_2, nitrogen, oils, and gels can be used in place of oil-water mixtures, but all have cost considerations and limited applications

Welding

- Where possible, use welding techniques that do not require cooling water or brine.

- Spot welding and tungsten arc welding tips should be air cooled where feasible.

Quenching of Metals

When quenching, there are four types of media: air, brine (salt water), oil, and water. Where water or brine is used, water is lost directly through evaporation. Oil quench tanks are often cooled with water that circulates through coils of a heat exchanger.

- Once-through cooling water should be eliminated and replaced with a properly operated cooling tower or chilled water loop that recirculates the cooling water.
- Where feasible, air cooling should be used.

Aircraft Parts Stripping and Cleaning

This process is a necessary step before hydraulic systems, engine parts, and other components can be refurbished and repaired.

- Dry paint removal methods, including the use of walnut shells, plastic pellets, sodium bicarbonate, and even carbon dioxide pellets, should be used where feasible. Intense light and heat sources are applicable for certain types of surfaces and offer water savings, but can use energy.
- Where caustic strippers or softening agents are used that require water to remove the residue, the resulting water should be filtered and recirculated. This recirculation reduces water and chemical use and concentrates waste materials for disposal.
- Very high pressure water systems should also be equipped with water filtration and recirculation devices.

Air Scrubbing

- Air scrubbers that use a water solution should be of the reticulating type and equipped with conductivity controllers or other devices to control the amount of makeup water.
- Scrubbers are excellent candidates for the use of alternate sources of water.
- Where feasible, a dry absorptive media should be used.

Painting

- Dry electrostatic paint systems should be used where feasible, but for large surfaces, spray painting is still the most commonly applied method.

- Systems that filter and recirculate cleaning water are available and should be used where feasible. Where water curtains are used to capture paint particles in spray booths, the water should be filtered and recirculated.

7.2.2.2 Plating, Printed Circuit Boards, and Metal Finishing

Overview – *Plating, Printed Circuit Boards, and Metal Finishing*

Cleaning metal, metal plating and surface finishing, coating plastic parts with metal, and the processing of circuit and wire boards all use similar techniques to clean and plate surfaces. Metal finishing includes all industrial operations that change the properties of metals to improve:

- Corrosion resistance
- Wear resistance
- Electrical conductivity
- Electrical resistance
- Reflectivity and appearance (e.g., brightness or color)
- Torque tolerance
- Solder-ability
- Tarnish resistance
- Chemical resistance
- Ability to bond to rubber (e.g., vulcanizing)
- Hardness

In these operations, the parts to be processed are either drawn through the tanks, as is the case with rolls of metal to be cleaned and painted, or they are suspended on racks or placed in plastic barrels that are dipped in the tanks. All processes begin with the preparation of the parts, by cleaning, followed by the process.

Processes include but are not limited to:

- Metal cleaning for painting
- Wire and circuit board processing
- Anodizing
- Electrolytic plating
- Electroless plating
- Galvanizing

Major water uses in these processes and this industry include:

- Process water
- Chemical solutions makeup
- Air scrubbers
- Water treatment
- Parts and plant cleaning
- Cooling towers
- Boilers
- Domestic use
- Irrigation

BMP Options – *Plating, Printed Circuit Boards, and Metal Finishing*

Water saving methods for equipment and plant cleaning, cooling towers, boilers, domestic use, and irrigation are discussed in their respective sections (7.3.3 Thermodynamic Processes, 7.3.4 Cleaning Industrial Vessels, Pipes and Equipment, 7.3.5 Commercial Landscapes, 7.3.6 General Building Sanitary and Safety Applications, and 7.1.1.4 Washing and Sanitation). The following section presents twelve ways to reduce water use in plating, printed circuit boards (Printed CBs), and metal finishing operations.

- Dragout control. Dragout occurs when processed parts are removed from one tank and transferred to another. Liquid adhering to the part contains the chemicals from that tank. Allowing this material to be carried to the next tank will contaminate that tank's contents and require that that rinse water or solution be dumped or reconstituted at some point to save water, minimize carry over through dragout control by:
    - Designing racks, barrels and processes, so that liquids captured in bends and curves of the pieces being processed are minimized, allowing time for parts to drain (dwell) over tank.
    - Using sprays in place of dipping parts.
    - Using air knives, fogs or misting to remove solution.
    - Vibrating or “bumping” parts to knock liquid off.
    - Ensuring parts are pointed down so that they drain most efficiently.
    - Using wetting agents.
    - Hanging bars above tanks to allow parts to drain
    - Installing drip guards between tanks

  - Using drain boards.

- Chemical concentration control. Use conductivity meters, chemical analysis equipment, optical sensors and similar methods to control the timing of draining, rinse baths, or adding chemicals to ensure it is necessary.

- Use multiple tank and countercurrent rinsing. Countercurrent rinsing[125] and the use of multiple tanks for rinsing allows the part to be placed in the most contaminated water first. The next rinse tank contains the cleaner water and so on. With countercurrent flow, the water from the cleanest tank is used to replace the more contaminated water in the next tank. Reactive rinsing, where the rinse water from the final tank is used for the pickle-rinse[126] tank, can also be used in some applications. Dual purpose rinsing is an option where the same rinse tanks or spray rinses can be used for multiple purposes when water quality is not critical.

- Use mechanical mixing, agitation, and air blowing in plating and rinsing processes. Agitation of plating liquids and rinsing solution maximizes contact of the liquid with the parts being processed, thus reducing time in each bath, extending the usefulness of plating liquids, allowing for lower concentrations of the chemicals in a bath, and helping to improve uniformity of the product.

- Select cleaning method that reduce the need for rinsing. Techniques for cleaning metals before painting have changed over the years. The classic zinc and iron phosphate cleaning processes require several rinses. New zirconium compounds and methods, such as the patented Piclex process, exemplify new strategies that eliminate one or more rinses.

- Pretreat makeup water. The treatment of the water used to make up the solutions in the tanks can be an important measure in achieving the maximum use of chemicals. Many plants soften their water and most major platers use reverse osmosis (RO) to produce high quality water for plating solutions. By using RO water, unwanted constituents that would concentrate with evaporation are no longer

[125] Countercurrent rinsing uses sequential rinse tanks in which the water flows in the opposite direction of the work flow (dirtiest to cleanest). Fresh water is added only to the final rinse station and is conveyed, normally by gravity overflow, to the previous rinse tank. Wastewater exits the system from the first rinse tank. From: Northeast Waste Management Officials' Association and Illinois Waste Management & Research Center. n.d. *Pollution Prevention for the Metal Finishing Industry: A Manual for Technical Assistance Providers*.

[126] "Reactive rinsing uses less water and saves chemicals. Most cleaning lines use an alkaline cleaner followed by an acidic pickle. Taking advantage of the chemical nature of the pickle liquors and alkaline cleaner, reactive rinsing feeds the water from the acid pickle to the alkaline rinse. This step neutralizes the cleaner and also prevents alkaline material from being dragged into the acid, prolonging the life of the pickle solution. Reactive rinsing cuts water use in half, and, in some cases, enables the plater to plumb more than two rinses in a series." From: Northeast Waste Management Officials' Association and Illinois Waste Management & Research Center. n.d.

present, reducing the need to dump tanks and replace water and solutions.

- Evaporation control. Many processes are operated at elevated temperatures or they actually produce heat during the plating process. Foams or floating balls specially designed to retard evaporation can cut evaporative losses by as much as 50 percent.
- Maximize air scrubber water recirculation and reuse. Air pollution is a concern in many plating operations. Air scrubbers draw the contaminated air through a scrubbing system.
    - Installing recirculation systems with conductivity controllers, temperature probes, and fill and dump controls similar to conductivity blowdown controls on cooling towers helps reduce makeup water to the scrubbers.
    - In plating operations, the reuse of spent rinse water and other sources of water is often an excellent alternate source of makeup water for air scrubbers.
    - Section 7.1.4 Medical and Laboratory Equipment and Processes describes the scrubbing process and BMPs in more detail.
- Rinse and process water recovery and reuse. Rinse water can often be used as makeup water for the process tank containing the chemicals being rinsed. This practice recovers chemicals and reduces fresh water use. Some platers have used filtration and reverse osmosis to recover chemicals and produce a very clean stream of water for reuse. Zero liquid discharge (ZLD) is becoming a goal of many platers as levels of allowable chrome and other metals in effluent become more stringent.
- Plating Tank Cooling. Input of electric energy into plating operations generates heat in the plating solutions. In the past, if the tank was air agitated or mixed, this heat was dissipated into the plating building. With the need to reduce air pollution and reduce evaporation, other cooling methods have been successfully employed.
    - Recover plating tank heat for use in other operations within the facility. This practice recovers waste energy, does not require cooling equipment, and does not consume water.
    - Where cooling is needed, use air cooling where bath temperatures can operate at 140^{o}F or above.
    - The use of a cooling tower or chilled water system represent other options, but they involve water and energy use. Refer to Section 7.3.3 Thermodynamic Processes for cooling system BMPs.

  - If cooling coils are used in the tank, some form of agitation will help ensure good heat exchange. Some platers circulate tank fluids through heat exchangers with pumps, thus providing for good heat transfer and helping to agitate the tank fluids.

- Rectifier selection and cooling. Rectifiers that convert alternating current (AC) to direct current (DC) for use in plating are found in all electroplating operations. Rectifiers may be either air cooled or water cooled. Many older facilities use once-through cooling to cool the rectifiers.
  - Air cooled rectifiers have to be placed where corrosive fumes from plating operations are not present, which usually means they are outside the plating line building. They also have to be correctly sized so as not to overheat.
  - Use a cooling tower or chilled water loop instead of once through cooling for water cooled rectifiers.
  - Waste heat produced by the rectifiers should be recovered where possible.
  - Many plating operations operate boilers, and the waste heat from rectifiers and tank cooling operations can be used to pre-heat boiler makeup water. Preheating water for the RO system improves the productivity and efficiency of these systems.
- Metering, flow control, and data acquisition. The old adage of "if you don't measure it, you can't manage it" applies to plating and metal finishing operations. Metering of makeup water to the RO system, tank filling, cooling towers, and other major water using areas will help manage the system and reduce costs. Good metering will also alert managers to potential problems.

7.2.2.3 Food Processing and Beverage Manufacturing

Overview – *Food Processing and Beverage Manufacturing*

The Food and Beverage Industry contributes $85 billion a year to California’s economy and employs more than 180,000 people representing 15 percent of the state's manufacturing work force. Table 7.23 summarizes the economic benefits of the Food and Beverage Industry in California.

Table 7.23 - California Food and Beverage Information from the U.S. Department of Commerce for 2009

Meaning of NAICS-based code	NAICS -based code	Year	Number of paid employees for pay period including March 12	Annual payroll ($1,000)	Total cost of materials ($1,000)	Total value of shipments ($1,000)	Value added ($1,000)
Animal food mfg	3111	2009	4,393	211,809	2,199,835	3,510,288	1,308,768
Grain & oilseed milling	3112	2009	3,394	198,634	3,072,253	4,683,906	1,612,932
Sugar & confectionery product mfg	3113	2009	6,742	337,798	1,321,768	2,549,318	1,242,968
Fruit & vegetable preserving & specialty food mfg	3114	2009	32,143	1,231,723	6,885,212	12,834,029	6,120,784
Dairy product mfg	3115	2009	17,022	871,511	8,021,191	11,847,995	3,833,542
Animal slaughtering & processing	3116	2009	20,868	696,639	4,291,901	7,339,875	3,028,075
Seafood product preparation & packaging	3117	2009	2,239	67,701	666,274	937,203	271,348
Bakeries & tortilla mfg	3118	2009	33,744	1,145,688	2,742,711	6,707,244	3,961,891
Other food mfg	3119	2009	29,539	1,135,650	6,487,987	13,081,103	6,655,519

Food processing and beverage manufacturing are often associated with California because of the volume and popularity of California products. California produces 89 percent of the United States' wine and is the leading producer of most of the nation's fruits and vegetables, accounting for about 21 percent of the fruits and vegetable products grown in the United States. California food processors produce over $13 billion of processed fruits and vegetables a year; $1 billion more than the next two states combined. California is also a leader in dairy, beef, poultry, and aquaculture production. Most of these products are partially processed in California before going to market.

Water is vital to the food processing and beverage manufacturing sector, both to grow the crops that provide the input for the sector and to process its products. This chapter focuses on water used in the commercial and industrial processing of food and beverages; it does not address water used in agricultural production or water used in the commercial food and beverage industries, such as commercial food preparation and restaurants (refer to Section 7.1.1 Commercial Food Service for details on water used in commercial food and beverage industries).

Food and beverage processing covers a wide range of products. The amount of water used per product varies depending on the product being produced, and not all are addressed in this section. This section includes a description of the water uses in these industries, particularly those uses involved in the product preparation, such as cleaning of equipment, boiler feed and cooling tower makeup, and inclusion in the product; factors influencing the ability to conserve; types of BMPs; use of alternative supplies; and, several case studies.

Because of the size and scope, the industries used as representative examples in this section include: fruit and vegetable processing, chicken processing, and wine making.

Regulatory Factors Effecting Water Use Efficiency – *Food Processing and Beverage Manufacturing*

Regulations governing the food processing industry are an integral part of the operation of food processing facilities. Food processors must follow a number of state, federal, and local regulations that control every aspect of their industry in order to ensure protection of public health and the environment. These regulations cover food safety, water quality, and waste disposal regulations. These regulations affect the food processors' ability to use water more efficiently by limiting the use of recirculated and reused water.

Water that comes in contact with food products must generally be of potable water quality or higher in order to protect public health. Although, there are many regulations related to non-water using aspects of food and beverage processing, this document summarizes only the ones related to water use.

The Hazard Analysis and Critical Control Point (HACCP) of 1997 is a regulation that establishes stringent controls on food processing sanitation, especially meat processing, juice and raw fruit, and the vegetable industries. Due to the implementation of these controls, water use per chicken processed has increased.

At the federal level, three agencies – The U.S. Department of Agriculture, the Food and Drug Administration, and the U.S. Environmental Protection Agency – are the main federal agencies governing food safety and processing.

- US Food and Drug Administration Title 21 provisions cover both processing and labeling regulations. The Current Good Manufacturing Practices guide (21 CFR Part 110) covers sanitary practices.
- US Department of Agriculture Food Safety and Inspection Service is responsible for inspection of most types of meat and poultry.

- US Environmental Protection Agency regulates water supply, wastewater treatment, and disposal and related factors.

Water quality represents another major concern for food processors. The State Water Resources Control Board (SWRCB) and Regional Water Quality Control Boards (RWQCB) enforce strict water quality objectives for effluent whether it is land applied for irrigation or sent to publicly-owned treatment facilities. There are also limits on the number of times water can be reused in a facility as constituent concentrations increase with every reuse. In some cases, dilution may be necessary to meet water quality objectives.

Water Use Information – *Food Processing and Beverage Manufacturing*

Food processing involves energy and water use. A 2004 study conducted by the California Energy Commission (CEC) found that total food processing water use accounts for approximately 37 billion gallons of water per year (113,550 af/yr) (Table 7.24). This includes total water use by the major food processing sectors, but does not include the water used to grow the products. Because of the enormity of the fruit and vegetable processing sector in California, it accounts for a large percent of water and energy use.

Table 7.24 - Utility Use by Major Food Processing Industry in California

Food Processing sector	Water Use (million gal/Yr.)	Natural Gas (Million Therms/Yr.)	Electricity (Million kWh/yr.)
Fruits & Vegetables	30,000	300-400	600-800
Cheese	600	43	583
Milk powder/Butter	360	33	130
Beef	1200	5	88
Poultry	2000	40	360
Wine	2900	41	316
Source: CEC. 2004. California Food Processing Technology Road Map.			

Based on 2003-2004 Information

The amount of water used and the way it is used varies by the food product being processed (see Table 7.25). Water uses that are common to multiple industry sectors are discussed in other sections of this report:

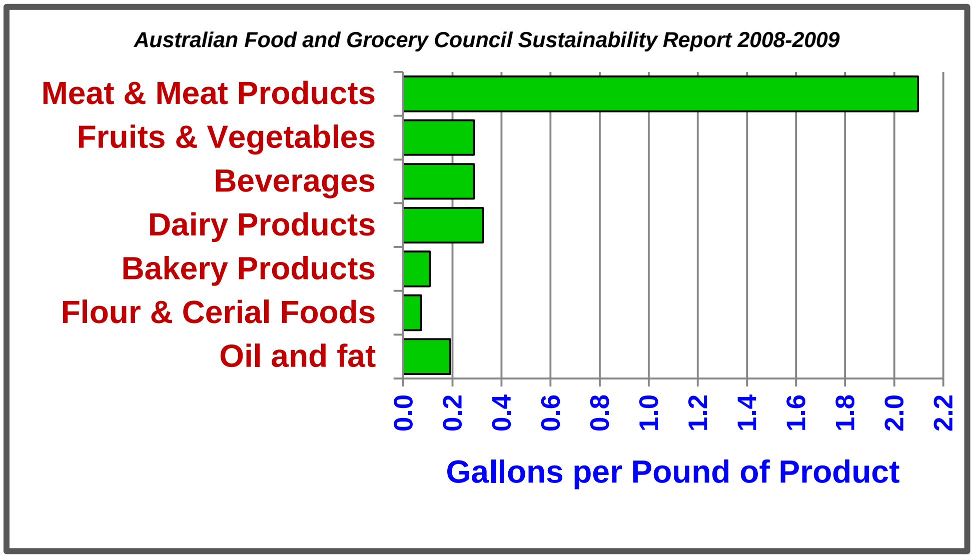
- Domestic uses (multiple sections)
- Thermodynamic processes (cooling towers, refrigeration and air conditioning, energy recovery, and cogeneration) (Section 7.3.3)
- Laboratory uses (Section 7.1.4)
- Water treatment (Section 7.3.8)
- Equipment cleaning (Section 7.3.4)

Table 7.25 - Water Use in Food & Beverage Processing

Water Using Processes	Food Processing Industry									
	Animal Processing	Animal Food	Bakeries & Tortillas	Beverages	Dairy Products	Fruits & Vegetables	Grains & Oil Seeds	*Miscellaneous	Seafood	Sugars & Confectionaries
1. Potential Water Reuse	x	x	x	x	x	x	x	x	x	x
2. Environmental Control	x	x	x	x	x	x	x	x	x	x
Air Pollution	x	x	x	x	x	x	x	x	x	x
Area Cleaning/Dust Cont.	x	x	x	x	x	x	x	x	x	x
Wastewater Treatment/Reuse	x	x	x	x	x	x	x	x	x	x
3. Process Water Use	x	x	x	x	x	x	x	x	x	x
Inclusion in product	x	x	x	x	x	x	x	x	x	x
Fluming/transport	x	x				x		x	x	
Product washing	x	x	x	x	x	x	x	x	x	x
Cooking/Autoclaving	x	x	x	x	x	x	x	x	x	x
Blanching/Pre-cook	x					x		x	x	
Peeling & Prep.						x			x	
Processing animal parts	x	x	x	x	x	x	x	x	x	
Canning & bottling	x	x		x	x	x	x	x	x	
Can/bottle cooling/warming	x	x		x	x	x	x	x	x	
Conveyor lubrication	x	x	x	x	x	x	x	x	x	
Pump seal water & other uses	x	x	x	x	x	x	x	x	x	x
4. Cleaning	x	x	x	x	x	x	x	x	x	x
Clean in/out-or place systems	x	x	x	x	x	x	x	x	x	x
Can/bottle/package cleaning	x	x	x	x	x	x	x	x	x	x
Transport vehicle cleaning	x	x	x	x	x	x	x	x	x	x
Crate & pallet washing	x	x	x	x	x	x	x	x	x	x
Other cleaning	x	x	x	x	x	x	x	x	x	x
5. Domestic Uses	x	x	x	x	x	x	x	x	x	x
Sanitation	x	x	x	x	x	x	x	x	x	x
Irrigation	x	x	x	x	x	x	x	x	x	x
6. Thermodynamic Processes	x	x	x	x	x	x	x	x	x	x
Cooling towers	x	x	x	x	x	x	x	x	x	x
Boilers	x	x	x	x	x	x	x	x	x	x
Refrigeration	x	x	x	x	x	x	x	x	x	x
Cogeneration & thermal recovery	x	x	x	x	x	x	x	x	x	x
Air Conditioning	x	x	x	x	x	x	x	x	x	x
Humidification	x	x	x	x	x	x	x	x	x	x
7. Laboratory Operations	x	x	x	x	x	x	x	x	x	x
8. Water Treatment	x	x	x	x	x	x	x	x	x	x

* Miscellaneous - Snacks, Seasonings, Coffee, Dressings, etc.

Figure 7.38 shows the water use efficiency for producing food products as identified in the *Australian Food and Grocery Council Sustainability Report 2008-2009*. With the exception of meat and meat products, water use for most food products produced in Australia falls within 0.07 and 0.32 gallons per pound of product produced. Meat and meat products use considerably more water than other food processing industries.



Fruit and Vegetable Processes Water Use and Efficiency (NAICS Code 311 and 312)

Figure 7.38 - Australian Water Use for Food Processing

Types of Equipment and Processes – *Food Processing and Beverage Manufacturing*

This section describes the basic equipment and processes used in fruit and vegetable processing, meat and poultry processing, and beverage manufacturing. General flow charts for these processes can be found in Appendix E.1.

Fruit and Vegetable Processing

Many fruits and vegetables are shipped directly to market from the field after an initial wash. Since they are perishable, however, many are processed to extend their life, as is the case with frozen products, juices, canned and packaged items, and pickled items.

Five major process areas that are common to all fruit and vegetable processing include:

- Cleaning and sanitation
- Product washing and sorting
- Preparation for processing (peeling, blanching, etc.)
- Food processing and cooking
- Final canning and packaging for shipment

Cleaning and Sanitation

Cleaning and sanitizing provide the most significant opportunities for water savings in many food and beverage processing facilities. Cleaning of vessels, pipes, and equipment is covered in detail in Section 7.3.4, Cleaning Industrial Vessels, Pipes, and Equipment.

Water use for cleaning is common to many industries, but clean–in-place and clean-out-of-place systems are unique to industries that must clean pipes and tanks from the inside for good sanitation, such as food and beverage processing.

Product Washing and Sorting

Product washing and sorting uses a process called fluming to transport the product. It is often the first washing process as well. Health and safety regulations determine the degree to which this water can be treated and reused. Systems designed to meet all regulatory requirements have been used to reduce water use. Water used in washing and sorting of fruits and vegetables must be treated to remove solids, color, biochemical oxygen demand (BOD), and other wastes.

Preparation for Processing

Preparation for processing involves blanching, peeling, coring, pitting, and washing of prepared items. The processes vary depending on the item being processed. In coring, pitting, and dicing operations, juices and waste are typically removed with water. Since peeling, blanching, dicing, and cutting release juices and sugars, the water used to wash produce after this operation may contain high BOD loads, thus limiting reuse options. Systems that do not use water to transport peels, cores, pits, and other waste increase water reuse options.

Food Processing and Cooking

Food processing and cooking extends the shelf life of the food product and produces a variety of desirable products. Produce can be preserved for market in a number of ways including:

- Refrigeration and freezing
- Canning
- Irradiation
- Dehydration
- Freeze drying
- Salting
- Pickling
- Pasteurizing
- Fermenting

- Chemical Preservation

With the exception of irradiation and chemical preservation, these activities all involve thermodynamic processes. The section on thermodynamic processes for cooling towers, boilers, and similar equipment provides more information on how these thermodynamic processes work (see Section 7.3.3 Thermodynamic Processes).

In cases where food or juices are concentrated, thermal methods have historically dominated the industry, but they consume large amounts of energy, largely for steam. A number of newer food processing technologies are now available to separate solids from liquids. More recently developed technologies include membrane treatment processes.

Pumps

Pump seals in food processing can use significant amounts of water. In all pipe systems, pumps move the product to its destination. Food service pumps must be made of food grade materials and may not use lubricants or materials that could contaminate the food being processed. The seals on the pump must also keep out contaminants. As a result, water seals are commonly used. With water seals, if the seal leaks only clean potable water will enter the food. However, water seals on pumps continuously discharge water. With multiple pumps in a typical food processing plants, pump seal water use can be significant.

Final Canning and Packaging for Shipment

In canning and packing, cans must be cooled once they exit the retort or autoclave. Conversely, cold products such as bottled fruit juices, beer, and sodas must be warmed so that the cans or bottles do not collect condensation. Washing of bottles, jugs, and containers after filling has historically taken place by immersion of large volume sprays that run as long as the process line operates. However, electronic sensors on the line can actuate a spray system that only washes full cans and bottles when they are passing by.

Water is also commonly used to lubricate conveyor belts that move cans and bottles through the process. This water is softened and mixed with biocides and soaps before it is sprayed onto the conveyors. Dry lubrication systems are rapidly gaining acceptance in the industry.

Beverage Manufacturing

Beverage manufacturing includes the production of bottled and packaged fluids such as distilled spirits, beer and wine, soft drinks, bottled water, and related products. With a few exceptions, all of these beverage products have the same basic water uses and opportunities for water savings; they all use water for cleaning, bottling, and the common uses of boilers, cooling towers, domestic use, irrigation, and related uses.

Wine Making As An Example

Making wine is one of the oldest food processing activities on earth. While modern wineries use many of the same techniques as ancient wine makers, they also use automation, newer materials, and more advanced sanitation techniques. California produces between 85 and 90 percent of the wine made in the U.S. It is a nearly $20 billion dollar industry and is a major employer.

The wine making process is water intensive since water is needed at every step of the process. Uses include the normal domestic and landscape uses found in all workplaces, as well as cooling towers and steam boilers in some facilities. The California winemaking industry consumes over 400 gigawatt-hours of electricity annually for cooling, making it the second largest electricity-consuming food industry in California after fruit and vegetable processing (CEC, 2004). A large portion of this electricity is used to operate refrigeration equipment that requires cooling towers, a water intensive operation. The 2010 publication, *Comprehensive Guide to Sustainable Management of Winery Water and Associated Energy*, provides an overview of the sources of wastewater in the wine making industry. This information provides a reasonable approximation of how water is used within this sector (Figure 7.39).

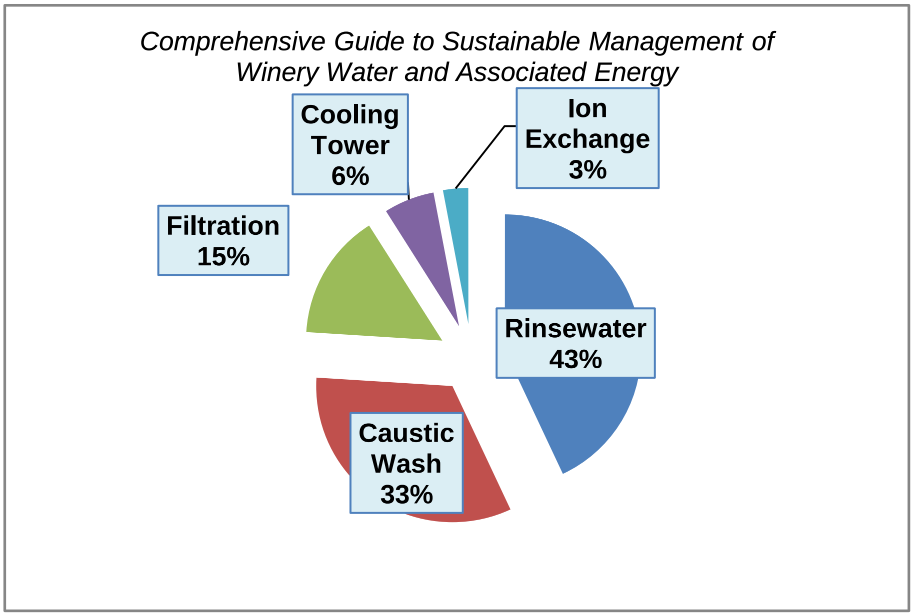


Figure 7.39 - Example of Winery Wastewater Distribution

The single largest use of water in wine making is for cleaning vessels and equipment, but there are many other uses, including:

- Crush operations
- Press operations
- Tank cleaning
- Transfer line cleaning

- Barrel cleaning and soaking
- Cellar operations
- Distillation
- Ion exchange
- Bottling
- Water softening
- Boiler feed
- Cooling

Subjects such as ion exchange, clean-in-place systems, cooling towers, boilers, and water used for employee sanitation are covered in their respective chapters of this report.

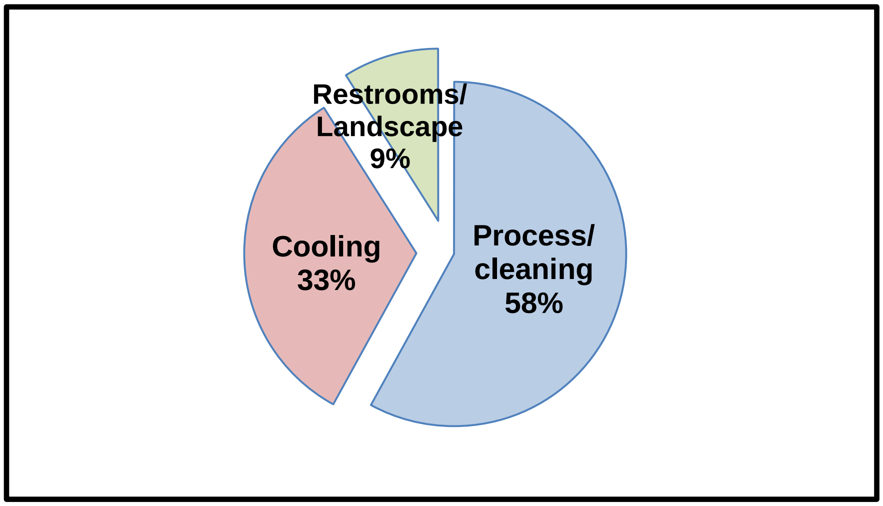
The Meat and Poultry Industry

The meat, pork, poultry, and seafood industries are undergoing a historical change driven in part by consolidation in the retail food market industry and the need for increased efficiencies due to rising energy and utility costs. This change is similar to trends seen in other food processing areas, such as fruit and vegetable processing. In 2009, according to the U.S. Department of Commerce (U.S. DOC) the industry employed nearly 23,000 Californians and produced $8.2 billion in the value of shipments (Table 7.26).

Table 7.26 - California Food and Beverage Information from the U.S. Department of Commerce for 2009

Meaning of NAICS-based code	NAICS -based code	Year	Number of paid employees for pay period including March 12	Annual payroll ($1,000)	Total cost of materials ($1,000)	Total value of shipments ($1,000)	Value added ($1,000)
Animal food mfg	3111	2009	4,393	211,809	2,199,835	3,510,288	1,308,768
Grain & oilseed milling	3112	2009	3,394	198,634	3,072,253	4,683,906	1,612,932
Sugar & confectionery product mfg	3113	2009	6,742	337,798	1,321,768	2,549,318	1,242,968
Fruit & vegetable preserving & specialty food mfg	3114	2009	32,143	1,231,723	6,885,212	12,834,029	6,120,784
Dairy product mfg	3115	2009	17,022	871,511	8,021,191	11,847,995	3,833,542
Animal slaughtering & processing	3116	2009	20,868	696,639	4,291,901	7,339,875	3,028,075
Seafood product preparation & packaging	3117	2009	2,239	67,701	666,274	937,203	271,348
Bakeries & tortilla mfg	3118	2009	33,744	1,145,688	2,742,711	6,707,244	3,961,891
Other food mfg	3119	2009	29,539	1,135,650	6,487,987	13,081,103	6,655,519

While each of these sectors has differences, they all involve bringing animals to a central location; processing them to remove skin, hair, scales or feathers, removing internal organs; taking the animals apart; processing the parts; and, packing them for shipment. Water use for the cleaning and processing of the carcasses, cleaning and sanitizing equipment, boiler operations and cooling and refrigeration are the major water uses in these industries. Figure 7.40 shows the breakdown of water used on meat processing in California. (Pacific Institute, Waste Not - Want Not). This document used the Poultry industry as a representative example of meat-related water use.



Source: Pacific Institute, Waste Not - Want Not [Calculated from MWD audit data of two meat-processing plants (MWD 2002)]

Figure 7.40 - Water Use in Meat Processing Industry in California

Poultry Processing – Representative Example

Poultry processing is a major component of the animal slaughter industry in California. According to the California Poultry Federation, 250 million chickens and almost 16 million turkeys are processed each year in the State. Figure 7.40 shows typical water uses in poultry processing. There may be additional water uses if the poultry is cooked or breaded.

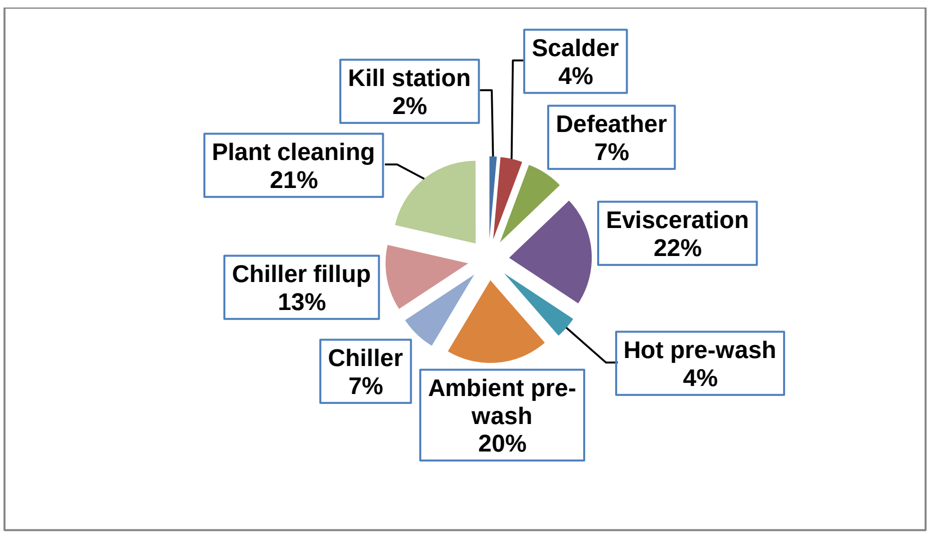


Figure 7.41 - Typical Water Use in Poultry Processing

Equipment found in poultry processing is unique to the industry. The major difference between the meat processing industry and other food processing industries is that most of the cleaning is done on the outside surfaces of equipment rather than in pipes and the inside of vessels, tanks, or casks.

BMP Options – *Food Processing and Beverage Manufacturing*

The BMPs identified below were included based on input and expertise from representatives within the industry, experts working in the area of water conservation, and recognized studies and documents on water conservation. These BMPs are generally used and proven in industry, but they may not be applicable to every site. A specific site assessment would be needed to determine whether a particular BMP is applicable and appropriate.

General BMPs that apply commonly to the food industry can also be found in Section 7.3.4 Cleaning Industrial Vessels, Pipes, and Equipment, and Section 7.3.3 Thermodynamic Processes. Therefore, these are not described as BMPs in this section. BMPs specific to Food Processing and Beverage Manufacturing Industries are presented below:

Fruit and Vegetable Processing

Washing Operations

- Use vibration and air to help clear fruit and vegetables of debris and dirt before fluming or washing
- Use brushes to clean produce
- Spray wash instead of submerging fruits and vegetables to wash them
- Use countercurrent washing
- Reduce overflow
- Use can cooling water for first flush water

Fluming for Transport of Raw, Peeled, or Blanched Products:

- Where the fruit or vegetable will not be damaged by mechanical handling, use conveyor belts, use pneumatic systems and totes to move product instead of water.
- Use flumes with a minimum cross section to reduce water volume.
- Recirculate flume water where allowed by code.
- Use flumes with parabolic cross-sections rather than flat-bottom troughs.
- Eliminate fluming water and use dry removal of dirt.
- Sorting, culling, and grading should occur before fluming or washing. This will also reduce wastewater and save energy.

Processing Preparation, Use:

- Dry peeling and blanching
- Mechanical peeling
- Chemical peeling
- Steam blanching

Equipment and Facility Cleaning

- Reuse pump seal waste water for washing crates and pallets.
- For rinsing and cleaning cans and beverage bottles (including wine bottles):
    - Use self-closing valves and/or automatic shutoffs or sensors that only allow timed sprays run to rinse bottles and cans when they are passing the spray nozzle.
    - Clean bottles with air.
- For cleaning sweep-and-use squeegees to remove solid waste, in place of using a hose.
- For clean-in-place processes, the list below articulates methods for reducing water use:
    - Dry recovery of refuse.
    - Eliminate wet transport of wastes where possible.
    - Installing drip and catch equipment to keep floor clean.
    - Use squeegees to remove bulk waste from floor before cleaning.
    - Use floor scrubbing and vacuum systems.
    - Hand clean larger parts from equipment.
    - Place level indicators on tanks and overflow alarms on vessels.

Concentrating

When concentrating food and juices, use filtration and membrane processes as an alternative to thermal/steam operations. The following summarizes some applications of membrane processes:

- Micro-filtration for:
    - Cold sterilization of beverages
    - Clarification of fruit juices, beers, and wines
    - Continuous fermentation
    - Separation of oil-water emulsions
    - Wastewater treatment

- Use Ultra-filtration for:
  - Concentration of milk
  - Recovery of whey proteins
  - Recovery of potato starch and proteins
  - Concentration of eggs
  - Clarification of fruit juices and alcoholic beverages
- Use Nano-filtration for:
  - Removal of micro-pollutants
  - Water softening
  - Wastewater treatment
- Reverse osmosis for:
  - Desalination
  - Concentration of food juice and sugars
  - Concentration of milk[127]

General

- When coring, pitting, and dicing, use dry transport and conveyor belts as an alternative to transporting product by water.
- For conveyor belt operations, investigate use of dry lubrication systems. Early attempts at dry lubrication systems were not always successful, but dry lubrication is now becoming commonplace.

Meat and Poultry Operations

The principal opportunities for reducing water use in meat and poultry processing by moving from wet to dry cleaning include:

- Dry recovery of manure, drippings, intestines, and other product waste.
- Eliminate wet transport of waste where possible.
- Install drip and catch equipment to keep floor clean.
- Use squeegees to remove bulk waste from floor before cleaning.
- Use floor scrubbing and vacuum systems.
- Hand clean larger parts of equipment.

If the meat or poultry is breaded or cooked, the following water efficiency measures can be employed:

[127] Nóra P, Pongrácz E, , Myllykoski L, Keiski R. 2004. “Waste minimization and utilization in the food industry: Processing of arctic berries, and extraction of valuable compounds from juice-processing by-products.”

- Use drip pans and splash guards to catch breading or parts.
- Practice manual cleaning procedures before washing.
- Only wash equipment once dry waste has been removed.
- Many of the cooking, autoclaving, drying, and similar operations require steam. Thus, capturing and returning steam condensate represents a water saving measure.

General - Alternate Sources of Water and Recirculated Water Use

Use of alternative sources and recirculated water is a best management practice for all industries. Issues and uses specific to Food Processing and Beverage Manufacturing are discussed in this section. These BMPs may include:

- Recycling water within the plant
- Use of alternate sources for non-food processing areas
- Reuse of plant effluent for irrigation

Limitations on Water Reuse

The U.S. Federal Food and Drug Administration and the U.S. Department of Agriculture’s strict guidelines for food safety often means that much of the water used in meat and poultry processing, as well as other food processing operations, may only be used once. The use of ozone and membrane treatment of wastewaters are techniques now being tested within the poultry industry, and the use of recovered water for non-contact uses such as cage cleaning, dust control, and others are now common.

Wastewater Reuse for Irrigation

One of the most important considerations is that most food processing wastewaters can be used for irrigation. Nutrients in the wastewater can help fertilize the crops, and irrigation removes pollution from receiving streams or wastewater treatment plants. When examining food processing water use, this reuse is often left out of the analysis.

Where water is to be used for crop irrigation, water quality (e.g., salts, especially sodium salts) becomes a major concern. Organic loading, irrigation rates, nutrient levels and other factors are important to consider. Many companies are using potassium salts for recharging softeners and pH adjustment, isolating waste streams with very high concentration of salts, and providing "end-of-the-pipe" treatment technologies to make their effluent usable for irrigation. (See the *Manual of Good Practice for Land Application of Food Processing/Rinse Water*. Prepared for the California League of Food Processors 2007 by Brown and Caldwell)

Examples of water reuse practices may be found in the canning, dairy, beer and wine, and frozen foods industries. Many canneries follow this practice as long as sodium levels and total salinity remains within bounds.

Land Application Reuse Regulations

Regulations specific to land application of wastewater from food processors include:

- Porter Cologne Act - Reuse cannot impact beneficial uses of groundwater
- Basin plans - Defines the beneficial use of water for each region
- Anti-degradation policy
  - Protects groundwater
  - Requires the use of Best Practicable Treatment and Control

7.2.2.4 The High-Tech Industry in California

Overview – *High Tech*

Starting in the 1950s, high technology (or high-tech) companies began a rise in California that has continued through the present day. Silicon Valley and other centers of high-tech in Southern California saw the development of the silicon-based integrated circuit, the microprocessor, the microcomputer, and other key technologies. Products produced by high-tech include microprocessors, personal computers and peripherals, video games, and a wide array of mobile devices such as MP3 music players, cell phones, smart phones, and tablets, resulting in an increase in networking systems and datacenters.

In the 1980s and 1990s, California led the nation in the number of facilities built to fabricate semiconductors and other microelectronic components. Towards the end of the 1990s the trend began to reverse. High-tech companies began building new facilities elsewhere, and the state's older facilities began to shut down. Some of the reasons for this shift include the high cost of doing business in the state, an increasingly skilled global workforce, and large incentives offered by other states and countries. As a result, a significant fraction of high-tech manufacturing has moved out of the United States to East Asian countries, especially Japan, China, and Taiwan. By 2009, the United States semiconductor production capacity had slipped to just 17 percent of global capacity, down from 25 percent only two years earlier.[128] This net migration of high-tech microelectronic manufacturing has been pronounced in California, and it is true not just with semiconductors, but also with networking equipment, servers, computers, peripherals, and mobile devices.

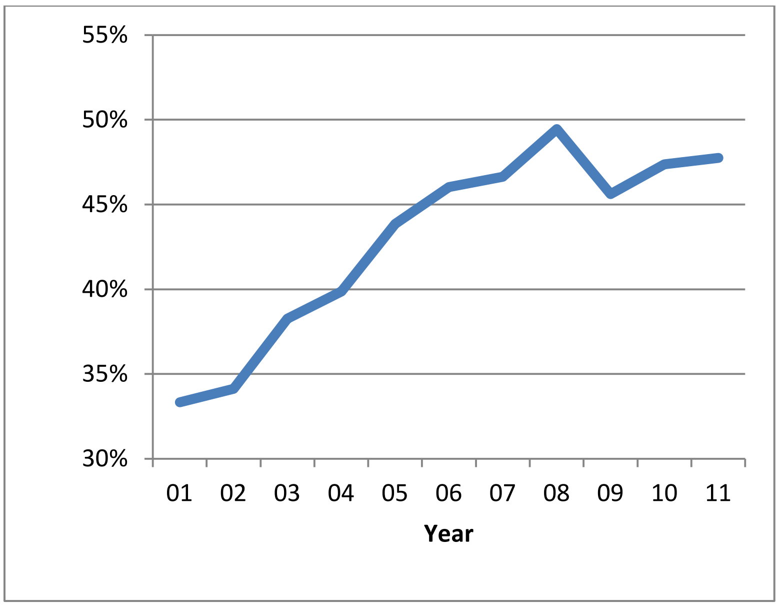
According to U.S.DOC information, overall employment in the high-tech industry in California has declined by 100,000, from 298,000 employees in 2002

[128] http://www.manuacturingnews.com/news/10/0212/semiconductors.html

to 198,000 in 2009. This trend is further explored in a recent Milken Institute report, which states that California is losing a larger share of manufacturing employment overall, and in high-tech in particular, at a faster rate than that of other states.[129]

Current Trends

Within high-tech, California has seen a growth in services, in contrast to product manufacturing. The recent Milken Institute Report shows this transition in terms of the numbers of jobs generated by high-tech services versus high-tech manufacturing in the State (Figure 7.42).[130] Product manufacturing is the most water intensive fraction of high-tech.



Source: Moody's Analytics, Milken Institute

Figure 7.42 - Percent Increase in High-Tech Service versus Manufacturing Jobs in California, 2001-2011

Most data on the composition and size of this industry draws from the NAICS, but these numbers are misleading due to the fact that the NAICS code does not reflect true manufacturing numbers. Intel Corporation provides a good example. The global leader in semiconductor chip making, Intel is headquartered in California where it concentrates a large amount of its research activity. All the corporation's manufacturing sites are located in other states, including Arizona, New Mexico, Oregon, and Massachusetts, and other countries, including China, Ireland, and Israel. Intel is listed with a NAICS code of 334413 - "Semiconductor Manufacturer," but while the company has a considerable number of employees in California working in design, validation, finance, legal, etc., none work in semiconductor manufacturing. Similarly, Global Foundries, the world's third

[129] DeVol RC, et al. 2009. *Manufacturing 2.0, A More Prosperous California, Milken Institute Report*. www.milkeninstitute.org/pdf/CAManufacturing.pdf
[130] The Milken Institute. 2011. *Blueprint for California*. State of the State Conference 2011. http://www.milkeninstitute.org/pdf/SOS2011BriefingBook.pdf

largest independent semiconductor foundry is headquartered in Milpitas, California, but has its fabrication plants in Singapore and Germany, with one new plant within the United States being built in New York.

Clearly, the high-tech sector in California is evolving, shifting from the manufacture of products to the delivery of services such as software, databases, and cloud computing. When considering its water footprint, it is important to consider the industry as it stands in California today. Therefore, the discussion of water conservation BMPs in this report focuses on the smaller scale semiconductor and other electronic component manufacturing remaining in the state, and the research and development laboratories that support these industries.[131]

In addition, solar energy is included, which is a sector closely related to high-tech where manufacturing is growing, thanks to abundant natural resources, strong state mandates like the 33 percent renewable portfolio standard, and incentives like Senate Bill 71, the clean-tech manufacturing equipment tax credit.

The solar energy industry has seen an almost seven percent growth nationwide since 2010, and solar job growth over the next 12 months is expected to be about 24 percent for the U.S.[132] Aggregate data on water used for solar power generation is not currently available at this nascent stage for the industry.

Water Use Information – *High-Tech*

Much of the water use in high-tech is for human use and cooling, neither of which falls into the focus of this sector analysis. For high-tech, the most water-intensive activities are: (i) fabrication processes in semiconductor manufacturing, and (ii) the cooling of enterprise-scale data centers that provide access to the free flow of large amounts of data. Estimates suggest that a typical fabrication plant uses between 1.22 to 122 af (322 to 32,229 gals) of water per day, using approximately 16 gallons per chip fabricated. Much of the water is ultrapure water (UPW) produced from local feed water (refer to Section 7.2.2.5 for a discussion on the UPW production process). From 1.25 to 2 gallons of city water is needed to produce one gallon of UPW.[133] On the other hand, a 15-megawatt data center may use up to 360,000 gallons of water per day.[134]

Table 7.27 summarizes water use activities and level of water use in California High-Tech industries.

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[131] It should be noted that the R&D and design work that goes into electronics manufacturing is also moving elsewhere.
[132] The Solar Foundation. 2011. *National Solar Jobs Census 2011*.
[133] Based on information from Intel Corporation. [2012]. *2011 Corporate Responsibility Report.* pages 43-46. annual sustainability reporting on water use (pg 43 – 46),
[134] Miller R. 2010. "Water Usage: The Next Disclosure Challenge?"

Table 7.27 - Water Use in High-Tech Industries

Life-cycle stages	Design	Raw Materials	Fabri-cation	Assembly	Packaging	Shipping	Operational Life	End of Life Retirement
Activities	Proto-types R&D	Silicon, gold, aluminum, lithium	Chips, board proces-sors, drives, casing, etc.	Contract manufact-uring	Cardboard Electrostatic Shrink wrap Wood Foam	Multi-modal	Data centers/lab climate control (i.e. HVAC, CRAH)	Disassembly, smelting
In California?	Yes	No	No	No	Yes	Yes	Yes	Yes
Level of Water Use	***Low***	***High***	***High***	***Medium***	***Medium***	***Low***	***Medium***	***Low***

Types of Equipment and Processes – *High-Tech*

Ultra Pure Water

Ultra pure water (UPW) is used widely in the high-tech sector. Water from a utility is not nearly pure enough for high-tech uses.[135] Strict requirements for microchip fabrication and for use in the manufacturing of many stages of printed circuit boards (PCB) require that the water contain less than 27.7 parts per billion (ppb) of total dissolves solids (salts and minerals), less than 10 ppb of total organic carbon, and that the water be sterile. To achieve this level of purity, water is passed through particle filtration, activated carbon, softening, micron size filtration, reverse osmosis, strong cation and anion ion exchange, and post micro filtration and disinfection with ultraviolet light. Special materials, such as polyvinylidene fluoride (PVDF), are used for pipes and storage tanks that carry UPW. The production of UPW and the reuse of reverse osmosis (RO) reject water offer many opportunities for water conservation in the semiconductor and printed circuit board computer chip insertion processes.

Semiconductor Processing

Semiconductor processing consists of a number of water-using steps including:

- Wet cleans
- Photolithography removal
- Dry etching
- Wet etching
- Chemical-mechanical planarization (CMP)
- Wafer backgrinding to reduce the thickness of the wafer so the resulting chip can be put into a thin device like a smartcard or

[135] Even the wastewater produced by the high-tech sector is significantly cleaner than drinking water for most constituents.

Personal Computer Memory Card International Association (PCMCIA) card.

PCBs, also called wire boards, are made from non-conducting materials, such as a base made from a dielectric core impregnated with resin. A completed board with electronic components, such as microchips, inserted and soldered in is called a PCB assembly.

To make a PCB, the copper coated board is manipulated through a number of steps to add layers, etch away layers, and drill and plate holes to form the needed circuits on the board. The processes involved include:

- Patterning (etching)
- Chemical etching
- Lamination
- Drilling
- Exposed conductor plating and coating
- Solder resist
- Screen printing
- Testing
- Printed circuit assembly and packaging

Manufacturing PCBs is somewhat similar to metal plating and finishing. A typical circuit board process involves electrolytic and non-electrolytic plating, acid etching, silk screening to add material or "masking," and similar processes. Between each step, multiple rinses are needed. Although water is used in the actual processing (e.g., during etching and plating), rinsing requires the most water.

Populating circuit boards with microchips, resistors, and other electrical components is the last step before the product is shipped. In this process, semiconductors and other electronic components such as resistors and capacitors are inserted into the printed circuit boards. The connections are soldered to make good electrical connections, usually by passing the back of the board over a molten solder bath. The boards are then washed for a final time to remove residue.

Research and Development

Research and development occurs at both the academic and corporate level. Virtually all of the nanotechnology processes and equipment used by manufacturers to create semiconductor circuitry are developed and tested by these research facilities. Relatively few of these processes involve water use; instead, they use gasses to create the structures. Water is used in chemical mechanical planarization and wafer cleaning, but because of the smaller scale of these facilities, BMPs for fabricators and foundries are generally not cost effective and would not result in any significant water savings. Nonetheless, elimination of once-through cooling by using chilled water circuits and using RO reject water for other purposes, such as vacuum pump seal water or makeup for scrubbers, all still apply.

Solar Panels

The use of water to wash solar panels is less intense than other power generating industries. Water is used in the production of Photovoltaic (PV) cells and associated manufacturing for all wet processing steps such as removing chemical residues from equipment and rinsing substrate wafers and panels. In the PV manufacturing process, both standard industrial water and purified deionized water are required to manufacture wafers and cells. Up until recently, no industry standards on water quality for Photovoltaic manufacturing existed. In March 2010, Semiconductor Equipment and Materials International (SEMI) released a PV standard called SEMI PV3-0310, Guide for High Purity Water Used in Photovoltaic Cell Processing.[136]

There are four steps to make a crystalline solar panel.[137] Step one involves using molten polysilicon to grow crystals or cast blocks of polycrystalline silicon. Step two involves cutting and polishing the material into thin, smooth wafers. Step three involves chemically treating the wafer and adding electrical contacts to turn it into a solar cell. The final step involves connecting many solar cells together, covering them with glass, enclosing them in an aluminium frame and adding an electrical junction box.

There are many opportunities for the solar industry to reduce water use. To increase the effectiveness of these strategies it is important to understand the critical relationships between facility, process technology, and manufacturing equipment requirements related to water reuse strategies. Finally, characterization of water quality requirements for every step in the manufacturing process helps in identifying ways to minimize water usage.

Water Use Information

It is hard to normalize water use for different sections of the high-tech sector due to the diversity of product types. Some possible metrics are gallons per dollar in revenue and gallons per chip manufactured. Please also refer to Chapter 5.0 – Water Use Metrics and Data Collection, for overall industrial sector metrics.

[136] For more information on the standard, refer to SEMI. 2010. "SEMI PV3-0310 - Guide for High Purity Water Used in Photovoltaic Cell Processing".
[137] Of course, different manufacturers have their own methods of producing solar modules and thin-film PV manufacturing is different. This is merely a high-level illustrative explanation.

General BMP Options - *High-Tech*

The BMPs described in this section are applicable to both manufacturing facilities and research laboratories for the high tech industry. All are currently being successfully employed at various facilities. Their economic viability depends on specific facility design, cost of utilities, and other related factors. What works at one facility may not necessarily work or be economically practical at another, similar facility.

The following information presents some of the most common methods employed by this industry to successfully accomplish reductions in water use. Opportunities for reducing water use in the plating areas are discussed in Section 7.2.2.1 Plating, Printed Circuit Board, and Metal Finishing.

Reduction of Water Use for Wafer Processing

Over the years, a number of water reduction practices have been implemented. These include:

- Using programmable tool features
- Installing control equipment to only use the exact amount of water needed throughout the specific operation.
- Using spray rinsing in place of emersion rinsing
- Using process timers instead of dump rinser cycles
- Countercurrent rinsing
- Optimizing ion-exchange regeneration cycles

Ultra Pure Water (UPW) Production Water Recirculation and Reuse

In a typical reverse osmosis operation used in semiconductor operations, the RO unit recovers 75 percent of the water fed to it. Many plants have employed treatment systems such as nanofiltration to recover water from the reject stream. Because it is expensive to create UPW, there is a natural economic incentive to reduce water use for wafer processing. Savings are possible by:

- Recovering part of the fresh water processed through the ultrapure water system.
- Using RO reject water for cooling tower water and other uses that do not require UPW.

Maximize Use of Alternative Water Sources for Non-Potable Uses

Much of the water used at high tech facilities does not have to be treated to UPW quality. As a result, water from the UPW waste streams, reject water from the RO unit, and other alternate onsite sources can be used in places that do not require UPW. Some of these uses include:

- Cooling tower makeup, though it is often necessary to supplement with water with dissolved solids content.
- Scrubber water, though it is often necessary to supplement with water with dissolved solids content.
- Toilet and urinal flushing.
- Ornamental fountains and features.

Sources of non-potable water can range from RO reject water and selected UPW waste streams to stormwater runoff, air conditioning condensate, foundation drain water, rainwater, and other sources.

Heat and Energy Recovery to Reduce Water Use

If process and air conditioning waste heat can be recovered, it can be used to pre-heat incoming water making RO units operate more efficiently. This use also reduces heat load on the cooling tower, thus saving water in this operation while reducing energy bills.

Substitution of Non-Water Using Processes

As the complexity increases and the size of semiconductors shrinks, even UPW creates problems with traditional cleaning methods. For this reason, the industry has investigated a number of closed-loop and "dry cleaning" methods. Some of these methods include:

- Pinpoint cleaning
- Supercritical fluid cleaning
- Cryogenic aerosol cleaning
- HF vapor cleaning
- Closed-loop
- Dry manufacturing

Alternative Manufacturing Methods

Future water use may decrease for technical reasons other than water efficiency. Application of alternative methods as they develop would help further reduce water use.

Populating Circuit Boards BMPs

The main use of water in these operations is to clean circuit boards after all of the components have been soldered, an operation generally known as “Deflux.” The recovery and reuse of up to 90 percent of this water is possible. Clean water is necessary, but does not have to be UPW quality. The water is heated to near boiling and sprayed precisely on the circuits being defluxed. Water savings opportunities include:

- Counter cleaning operations (freshest water last).
- Precise aim and pressure of hot water spray.
- Addition of cleaning compounds that will better remove the flux while reducing the total amount of fresh water required.

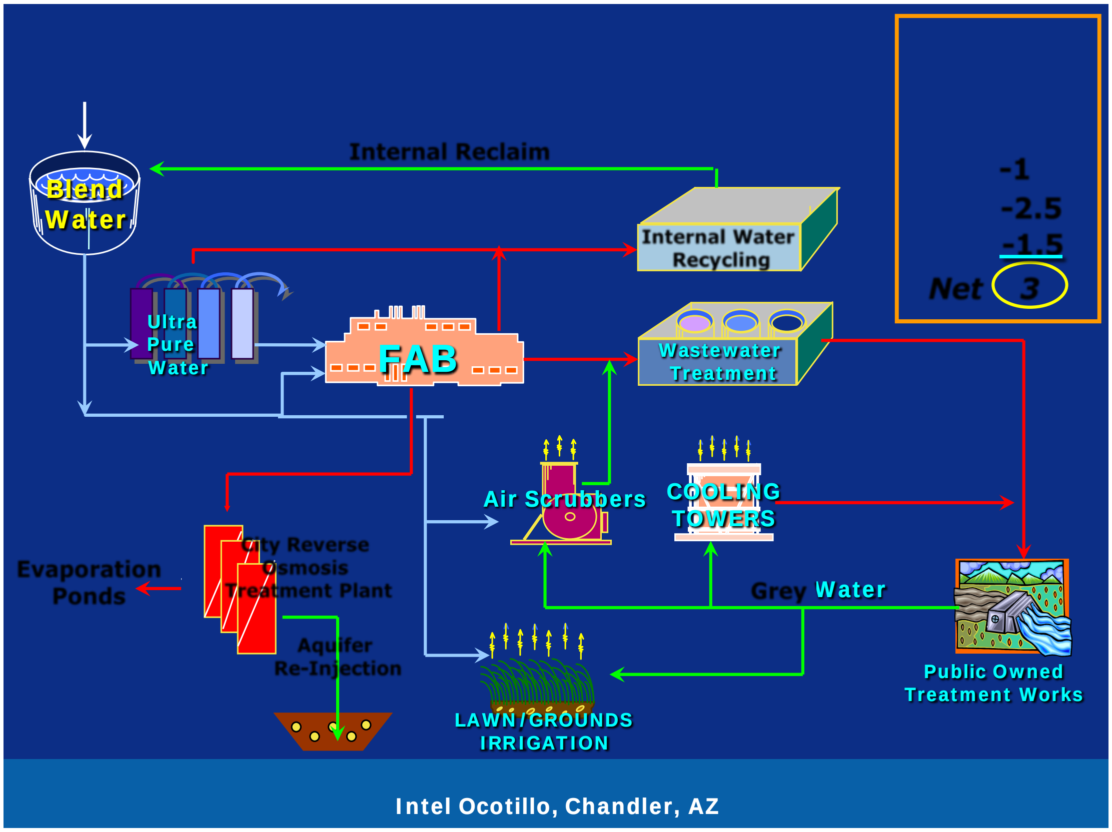
Solar Energy System Manufacturing

- Use filters to produce pure water – Optimize pre-treatment for RO, to minimize the amount of reject water, through the use of activated carbon filtration to produce high-quality DI water and increased water recovery.
- Employ more efficient manufacturing systems – By using faster cutting systems, solar manufacturers can use less water for lubrication as process time is decreased.
- Segregate and treat to facilitate water recovery – It is difficult to reclaim and recycle water if it is disposed through a central drain. However, if wastewater is segregated, it is possible to reuse waste streams in other process areas.
- Employ re-use paths for process chemicals and water – Use re-use paths for chemical wet baths and rinse water. Employing chemical spiking or dosing can minimize bath dump, which includes water. Whenever possible, manufacturers should eliminate single-pass rinse steps.
- Employ water reduction strategies for wet scrubbers and chemical abatement systems.
    - Implement point-of-use abatement systems using an “on demand” water flow: system scrubbing only occurs when process gas is being abated rather than maintaining a constant flow of water through the system. This mode of operation needs to be verified on an individual basis, taking into account other potential issues related to safety, environmental emission considerations (i.e. ensure this does not decrease the efficiency of the abatement system), biological growth, fouling, and others.
    - Use potable city supply water for point-of-use abatement systems rather than RO/DI, minimizing the use of RO and associated generation and disposal of the reject stream.
    - Use alternate methods for packed bed wet scrubbers to regulate the delivery of makeup water, such as conductivity or pH, rather than using a constant makeup flow. This needs to be verified on an individual basis accounting for potential issues related to safety, environmental emission considerations (i.e. ensure this does not decrease the efficiency of the scrubber), concentration of prohibited

materials (i.e. metals/fluorides) that could cause violation of discharge limits, biological growth, fouling, and others.

Water Savings Example – *High-Tech*

The following example illustrates High-Tech water savings achieved by Intel Corporation through implementation of a number of BMPs.



Example: Intel's Water Conservations Efforts

Intel purchases potable water from the City of Chandler, AZ. A majority of this water goes to production of ultra pure water for manufacturing processes. Cleaning silicon wafers during fabrication is one of the largest uses of water in Intel factories. Once used, the water's quality is still suitable for a number of onsite and offsite reuse and recycling programs. Intel and Chandler's strong partnership has made it possible to implement, over the past decade, a progressive water management system which maximizes water conservation and reduces use of potable water by millions of gallons each day.

Chandler Reverse Osmosis Water Treatment Facility – Aquifer Recharge

Our Arizona site has a unique partnership with the City of Chandler which operates an Intel funded treatment process. Using reverse osmosis (RO) technologies, the wastewater from FAB 12, 22, and 32 are treated to drinking water standards and re-charged to the underground aquifer to replenish the groundwater supply in Chandler. Since 1996, this water conservation strategy alone has resulted in over 4.5 billion gallons of water put back into the aquifer by Intel. This water conservation strategy supports a key City of Chandler effort to store water in the underground aquifer to assure the city has enough water to meet the future needs of all citizens and businesses for many more years even if the drought continues.

Reuse of Wastewater – Reclaim

Additionally, Intel utilizes treated wastewater from Chandler's Ocotillo Water Reclamation Facility, avoiding the use of the potable water supply. Every day of the year, the Arizona site takes back millions of gallons of processed wastewater from the City of Chandler sewage treatment plant to supply water to our cooling towers, operate our air abatement equipment, support the site landscaping, and irrigate the farm fields around the Ocotillo site.

Figure 7.43 - Ocotillo Water Conservation Strategy

7.2.2.5 The Petroleum Refining and Chemical Industries in California

This section explores the potential for water efficiency in the petroleum refining and chemical industries in California. Both industries have much in common, although the chemical industry is more diverse. While the U.S. DOC includes the pharmaceutical industry in the chemical sector, for the purposes of this report, the pharmaceutical industry is discussed in its own subsection.

Overview – *Petroleum Refining and Chemical Industries*

Petroleum Refining

California has approximately 11.3 percent of the refining capacity in the United States, currently refining 2.1 million barrels of crude oil a day. It ranks third behind Texas and Louisiana in refining capacity. According to the USDOC, in 2009, the petroleum refining sector employed 12,426 Californians, had a value add of $11.9 billion, and total shipments valued at $65.9 billion.

Figure 7.44 shows that oil refineries in California are primarily located in three areas, the San Francisco Bay area, the Los Angeles area, and the Bakersfield area.

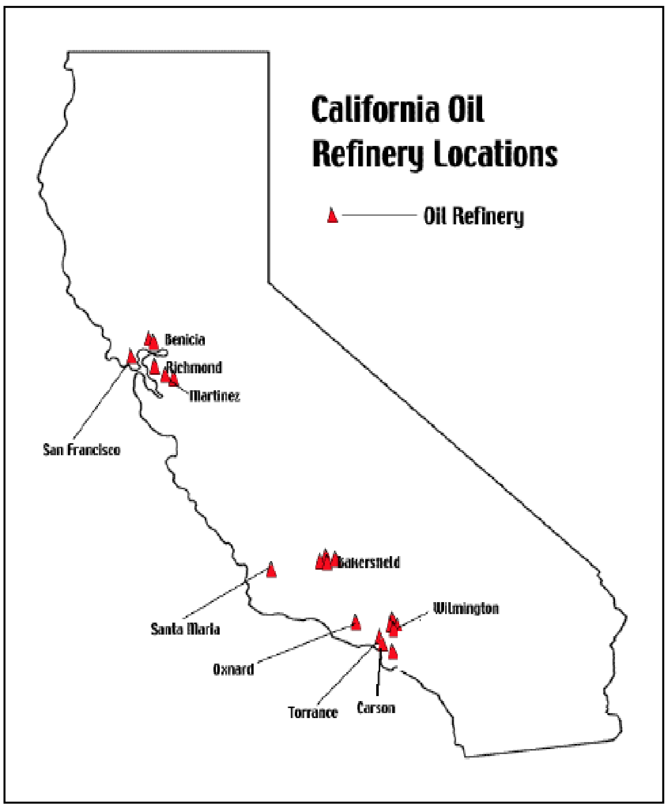


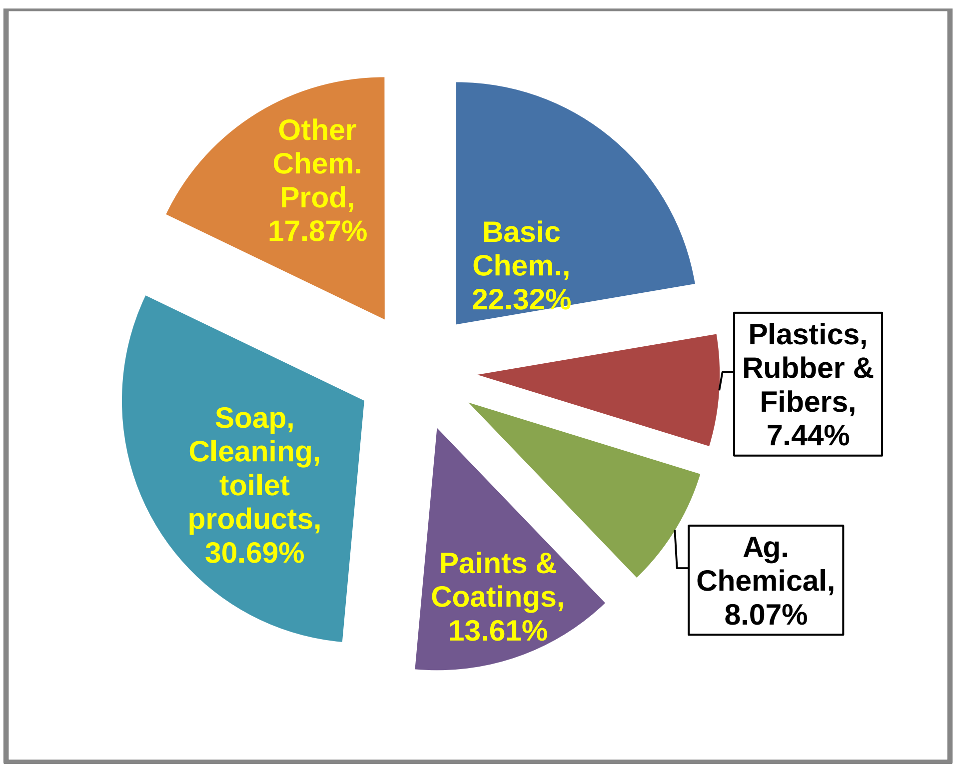
Figure 7.44 - California Oil Refinery Locations

The petroleum refining industry separates crude oil, a mixture of many organic molecules, into useful products, or it rearranges molecules into useful products. Water is used within the refinery to cool and condense oil fractions, provide steam to heat fluids, for use in reactions such as hydrogen synthesis and catalytic cracker operations, for air pollution control, washing of crude to remove salts, for fire and safety, and for equipment testing and maintenance.

Chemical Industry

The California chemical industry sells and consumes significant amounts of chemicals in the State, but actual production of these chemicals often occurs elsewhere. According to the definitions of the NAICS, basic chemicals include petrochemicals, synthetic dyes, inorganic chemicals, industrial gases, and other organic compounds that often serve as the building blocks for other products. Most basic petrochemicals, such as ethylene, are produced in other states.

Figure 7.45 shows that only 22 percent of the value of shipments in California is for basic chemicals. The rest are "downstream" products that use the basic chemicals. In addition, California produces many inorganic minerals and chemicals. These chemicals are often used in industries such as aerospace, textiles, computers, and retail products. In fact, the largest non-pharmaceutical segment of the industry is the production of soaps, cleaners, polishes, and toiletries.



Source: US Dept. of Commerce, Census of Mfg.

Figure 7.45 - Value of Shipments for California Chemical Industry in 2009 Exclusive of Pharmaceuticals

Employment in the chemical sector (excluding pharmaceuticals) has followed the national declining trend. In 2000, California had 32,312 workers in the chemical sector (excluding pharmaceuticals). By 2009, this number had declined to 28,396 according to the U.S. DOC. Table 7.28 summarizes the non-pharmaceutical chemical industry in California in 2009. As the table shows, only 15 percent of employment in the sector is in basic chemicals while the largest sector of employment is for the soaps - toilet preparations areas and "other chemical products and preparations." The largest dollar and employment sectors are primarily using chemicals produced elsewhere to make consumer products sold in bottles, tubes, vials, and jars in retail and commercial establishments.

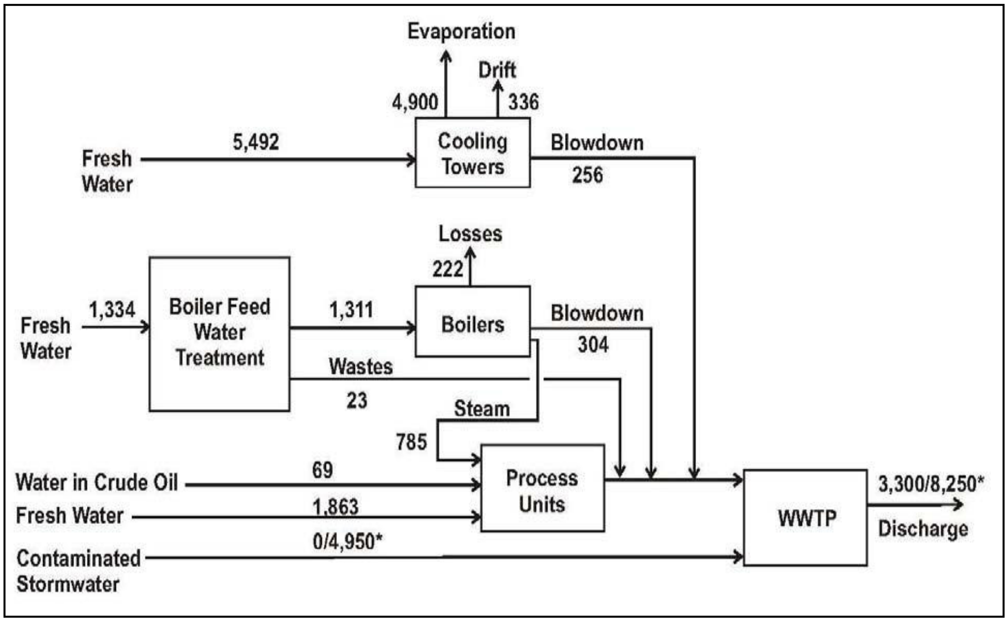
Table 7.28 - California Chemical Industry Statistics in 2009* Excluding the Pharmaceutical Sector

NAICS Code	Category of Chemicals	Number of Paid Employees	Total value of shipments ($1,000)	Value added ($1,000)
3251	Basic chemicals	4,149	$2,831,095	$1,332,074
3252	Resin, synthetic & artificial rubber, fibers & filaments	3,542	$943,571	$463,760
3253	Pesticide, fertilizer, & other agricultural chemicals	1,699	$1,023,483	$479,630
3255	Paint, coating, & adhesives	3,712	$1,726,426	$854,818
3256	Soap, cleaning compound, & toilet preparation	9,111	$3,893,498	$2,346,906
3259	Other chemical product & preparation	6,183	$2,266,708	$1,030,322
TOTAL FOR CALIFORNIA		**28,396**	**$12,684,781**	**$6,507,510**
Source: U.S. DOC - Census of Manufacturers				
* Pharmaceuticals is part of the NAICS Chemical Sector, but will be covered in its own chapter.				

Water Use Information – *Petroleum Refining and Chemical Industries*

<u>Petroleum Refining</u>

Water use in the petroleum refining industry is dominated by cooling and boiler feed water requirements. In fact, according to information from the American Petroleum Institute, 75 to 90 percent of all water used in a refinery is for these two purposes. Figure 7.46 illustrates water use in a typical refinery.



Source: Council of Great Lakes Industries - Water Footprinting - www.cgli.org/waterfootprint/.../SlideDeck5-PetroleumRefining1.pdf

Figure 7.46 - Typical Water Balance for a 160,000 Barrel a Day Refinery
Flow rates in gallons per minute

According to the Pacific Institute study entitled *"Waste-not, Want-not,"* 57 percent of the water use in petroleum and coal processing is for cooling, 34 percent is boiler feed, six percent is process use, and three percent goes toward other uses. Energy conservation and reusing water for cooling tower and boiler makeup are major ways to reduce water use. Cooling towers, boilers, and cogeneration are covered in Section 7.3.3, Thermodynamic Processes, which covers the BMPs for the operation of these processes. Energy efficiency and the choice of energy efficient processes will minimize water requirements for cooling towers, boilers and energy systems. Table 7.29 summarizes energy efficiency measures for refineries.

Table 7.29 - Technologies for Energy Efficiency in Refineries in California

Technology Area	Technology Examples
Process Control	Neural networks, knowledge based systems
Process Optimization and Integration	Analytical tools, site integration
Energy Recovery	Hydrogen recovery and integration, flare gas recovery
Catalysts	Higher selectivity, increased lifetime
Reactor Design	Process intensification, membranes, reactive distillation, dividing-wall column
Biotechnology	Biodesulfurization, bio-feedstocks
Combustion Technology	Low NOx burners, high-efficiency burners
Utilities	Membranes, low-maintenance pumps
Power Generation	Advanced cogeneration, Gasification (IGCC), power recovery

Source: Worrel E and Galitsky C. 2004. *Profile of Petroleum Refining Industry in California.*

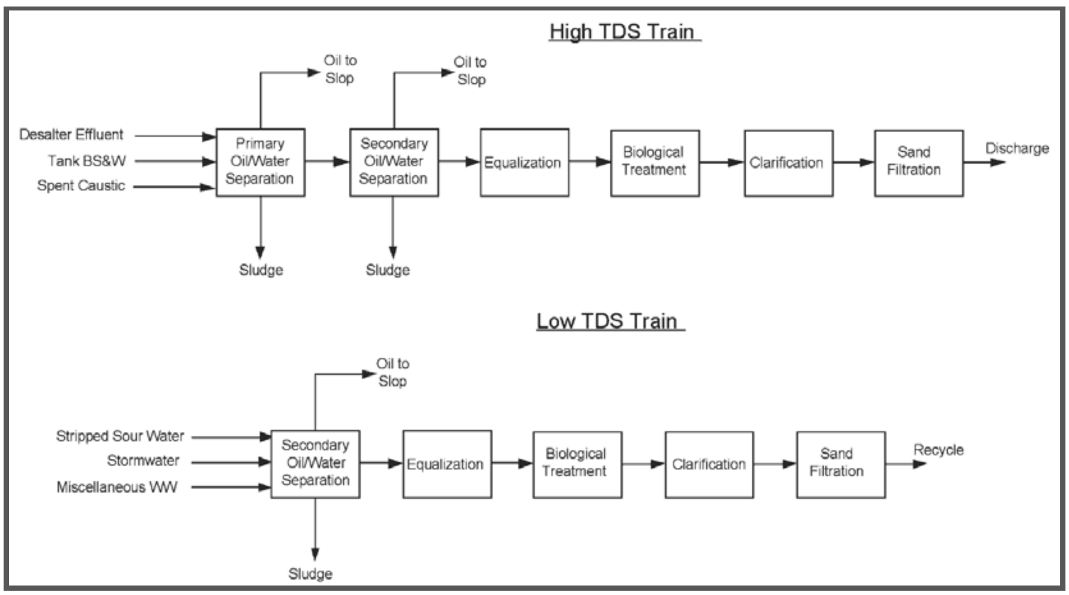
Chemical Industry

Many industries in this sector use a lot of water, for the manufacturing of pesticides, cosmetics, soaps, toiletries and other products, as well as for cleaning of vessels, pipes, and equipment. Water use in the chemical sector varies by type of product produced. For basic petrochemicals, cooling water and boiler feed uses dominate, but for end-use products such as cosmetics, cleaning of vessels and equipment, inclusion in the product, and sanitary water use by employees can represent large uses in a facility along with cooling water and boiler feed.

BMP Options - *Petroleum Refining and Chemical Industries*

Water Reuse

Segregating and reusing water within the refinery is a major way to reduce water use. Segregating wastewater streams by TDS content is one way to make sure that salty streams are not mixed with fresher water that can be reclaimed (Figure 7.47).



Source: IPIECA, Petroleum Refining Water/Wastewater Use and Management, 2010, www.ipieca.org

Figure 7.47 - Segregating High TDS Streams from Other Water

Table 7.30 provides a summary of the major water reusing opportunities within the refinery itself.

Table 7.30 - Water Reuse Options for Oil Refineries

Water Category	**Contaminant Specification**	**Potential Source of re-use Water**
Desalter makeup	• Sulphide: <10 mg/l • Ammonia: <50 mg/l • Total dissolved solids: <200mg/l	• Stripped sour water • Vacuum tower overhead • Crude tower overhead
Coker quench water	• Total dissolved solids: <100mg/l • Biological solids: none • H_2S and odorous compounds: none	• Stripped sour water
Coke cutting water	• Total suspended solids: <100 mg/l • Biological solids: none • H_2S and odorous compounds: none	• Stripped sour water
Boiler feedwater makeup (quality required is highly dependent on the pressure of the steam produced)	• Conductivity: <1 µS/cm • Hardness: :0.3 mg/l • Chlorides: <0.05 mb/l • Sulphates: <0.05 mg/l • Total silica: <0.05 mg/l • Dissolved oxygen: <0.007 mg/l	• Treated and upgraded refinery wastewater
Cooling tower makeup	• Conductivity: <6,000 µS/cm • Alkalinity: <3,000 mg/l • Chlorides: <1,500 mg/l • Suspended solids: <150 mg/l	• Treated and upgraded refinery wastewater

Source: IPIECA. 2010. Petroleum Refining Water/Wastewater Use and Management. www.ipieca.org

Alternative Water Sources

Use alternative water sources to reduce potable water use. Refineries and chemical industries on the East and Gulf Coasts have successfully used storm water and other onsite sources for a number of uses, including fire protection, water for boilers and utilities after proper treatment, pump seals, and cooling tower makeup. Consider use of the following:

- Stormwater and Other Onsite Sources. In areas with low rainfall, like California, the feasibility of capturing, treating, and reusing storm water is unlikely to be practical and will need to be examined for cost effectiveness. Treated wastewater from restrooms and showers, and similar sources may provide inexpensive but small quantities of water for the operations.

- Condensate. Refineries and chemical plants produce various types of condensate in their operations that can be reused.
  - Clean steam condensate from sources such as steam heaters and reboilers can be recirculated back to the boiler feedwater treatment plant deaerator to reduce the need for fresh water makeup. Recovering hot condensate also provides an ancillary benefit of energy savings at the deaerator. Steam condensate from chemical reactions and heating processes involving water can also be evaluated for reuse within the process.
  - Refrigeration and air conditioning processes can also produce very clean condensate, which can be reused.
- Municipal Recycled Water. Municipal recycled water is another source of freshwater supplies that could substitute for potable water. Substituting recycled water can significantly reduce potable use and is being successfully used by California refineries and chemical industries. It is also being considered by other refineries, chemical industries, and recycled wastewater providers.
  - Recycled water can be used for cooling tower makeup, boiler feed, and all other uses except potable use.
  - Additional treatment may be needed and its availability may be limited due to lack of infrastructure to produce and deliver recycled water to industrial users.
  - Recycled water is a freshwater source and should be used efficiently.
  - Section 9.0 Public Infrastructure Needs for Recycled Water contains additional information.

Other General BMPs

- Implement metering, sub metering, and installation of automated data recording systems to follow water use at all major use points (refer to Section 7.3.2, Building Meters, Submeters and Management Systems for details).
- Convert pumps to mechanical seals, where feasible.
- Where packing glands are required, using alternate water sources for seal water.
- Using dry vacuum pumps, where feasible.
- Where liquid ring pumps are required, either install a water recirculation system or use wastewater for the seal.

- Install automatic cutoffs and solenoids on all water using equipment to ensure that water flow is stopped when the equipment is not working.
- Institute training programs for employees.
- Install water efficient plumbing fixtures and appliances.
- Follow vessel washing and pipe cleaning procedures. (See Section 7.3.4, Cleaning Industrial Vessels, Pipes and Equipment.)

Chemical Industry-Specific BMPs

BMPs specific to the chemical industry are covered in Table 7.31. (This information was gathered from publications of the British Government for use in its industries.)

Table 7.31 - Vessel-Washing Equipment for Chemical Manufacturing

1. Communication - Make sure your staff understands the most effective washing methods.
2. Batch formulation - Processing the same types of chemical in batches can reduce the frequency of vessel washing.
3. Mixing outside the vessel - This practice may reduce the need for vessel washing.
4. Dedicated equipment - Using specific vessels for specific products can reduce cleaning requirements.
5. Production scheduling - Batching compatible products together will minimize the washing needed between them.
6. High-pressure cleaning - Systems that direct dense sprays and jets of wash liquor can help reduce the amount of water used, while improving wash efficiency by 90 percent.
7. Automated vessel washing - You can use this process to control water use more precisely and reduce emissions, especially in enclosed vessels.
8. Optimizing cleaning levels - Ensure that you use only the required level of cleaning for particular products. You may not need to wash at all, or you might be able to reuse wash liquor.
9. Optimizing cleaning agents and solvents - Using different cleaning agents and solvents may reduce washing.
10. Using wash liquor in product - Look into using wash liquor to dilute subsequent product batches where required.
11. Material recovery – In areas where you cannot reuse wash liquors, look at ways of recovering materials from the effluent.

Source: British Government Web Site - Business Link http://www.businesslink.gov.uk/bdotg/action/detail?itemId=1083098743&r.i=1083098500&r.l1=1079068363&r.l2=1082900032&r.l3=1083098121&r.t=RESOURCES&type=RESOURCES

Potential Savings – *Petroleum Refining and Chemical Industries*

Petroleum Refining

Simple generic metrics, such as gallons of water used per unit of production, are unsuitable for petroleum refineries, especially if refineries are being compared. Although most refineries may produce gasoline, diesel, or jet fuel, different processes may be used to achieve a certain product array, for a certain product specification, and volume from different input crudes. As the International Petroleum Industry Environmental Conservation Association (IPIECA) Operations Best Practice Series 2010 for Petroleum Refining Water/Wastewater Use and Management states:

> *"Petroleum refineries are complex systems of multiple operations that depend on the type of crude refined and the products desired. For these reasons, no two refineries are alike. Depending on the size, crude, products, and complexity of operations, a petroleum refinery can be a large consumer of water, relative to other industries and users in a given region. Within the refinery, the water network is as unique to the refinery as its process."*

A simple generic metric designed as a benchmark for all refineries is neither practical nor appropriate.

Individual refineries should measure and monitor water use for different processes and operations and assess trends in water use. With an assessment of water use, refineries can develop and evaluate BMPs to achieve cost-effective water use management within the context of operational, equipment, and production needs for the individual refinery. The IPIECA Operations Best Practice Series 2010 for Petroleum Refining Water/Wastewater Use and Management is a good starting point for refineries to evaluate potential options to measure and evaluate water use. At this time however, the CII Task Force cannot recommend simple, generic metrics for the refining sector.

7.2.2.6 The Pharmaceutical and Biotech Industries

Overview – *Pharmaceutical and Biotech*

The Pharmaceutical/Biotech industry produces a wide variety of products. It is one of the largest industries in California, and California's Pharmaceutical/Biotech industry is the largest in the nation. The industry includes research, chemical diagnostics, Pharmaceutical/Biotech substances produced by the conversion of organic and natural substances, products produced by fermentation or synthesis, and the formulation and production of final products. In great part, the biotechnology revolution began in California. A 2005 report by Junfu Zhang and Nikesh Patel, titled "*The Dynamics of California's Biotechnology Industry*," points out that although the biotechnology industry is still small compared to the rest of the Pharmaceutical/Biotech industry, it is the fastest growing sector in the industry.

Based on 2009 data from the USDOC, the pharmaceutical/biotech sector employs 40,989 Californians, and has a total value of shipments of $30,840,359 and a value added of $25,335,967. The last year the USDOC published information at the six digit NAICS level for California is 2007; Table 7.32 presents this information. Approximately 75 percent of value of shipments and 61 percent of employees in the California Pharmaceutical/Biotech industry work in the area of the preparation and manufacturing of products for the industry. Overall, California represents 11 percent of the United States industry. Historically, this sector has spent fifteen to twenty percent of its revenues on research, according to Congressional Budget Office estimates.

Table 7.32 - U.S. Census of Manufacturers Information for Pharmaceutical/Biotech Industry in California in 2007

Pharmaceutical/ Biotech Product	NAICS Code	Number of Establishments in California	Value of Shipments in California ($1,000's)	Number of Employees in California	Number of Establishments in USA	Value of Shipments in USA ($1,000's)	Number of Employees in USA
Medicinal and botanical manufacturing	325411	64	$945,161	3,346	410	$11,316,752	24,626
Pharmaceutical/Biotech preparation manufacturing	325412	170	$20,082,378	26,762	991	$142,876,257	158,531
In-vitro diagnostic substance manufacturing	325413	71	$3,131,798	8,960	259	$12,407,704	29,080
Biological product (except diagnostic) manufacturing	325414	50	$2,740,830	4,767	350	$21,798,314	36,163
	TOTAL	355	$26,900,167	43,835	2010	$188,399,027	248,400

Formulation processes convert bulk chemicals into refined products that include tablets, capsules, liquids, patches, and ointments. Typical formulation operations include mixing, blending, granulating, drying, coating, polishing, tablet pressing, capsule filling, sorting, and packaging. The basic mechanism of the Pharmaceutical/Biotech/biotech industry used to provide necessary ingredients include: chemical synthesis, natural product extraction, and fermentation.

- Chemical synthesis, including reaction, separation, purification, and drying, is used to produce many of the pills and other products found on pharmacy shelves
- Extraction of natural products from organisms ranging from plants and roots to fungus and animal parts as well as blood fractionation.
- Fermentation is a fundamental process used in producing many of today's medical products.

Water Use Information – *Pharmaceutical and Biotech*

Major water uses in the pharmaceutical/biotech/biotech industry are:

- Cooling
- Boilers
- Clean steam boilers (fed with ultrapure water)
- Ultrapure water treatment systems
- Inclusion in product
- Fermenters
- Cleaning of equipment and containers
- Autoclaves and sterilizers
- Air pollution - scrubbers
- Vacuum pump seal water
- Pump seal water
- Humidification
- Used in reaction
- Sanitation
- Irrigation

US Federal Food and Drug Administration Classification of Water for use in the Pharmaceutical/Biotech Industry

- Potable (drinkable) water
- USP purified water
- USP water for injection (WFI)
- USP sterile water for injection
- USP sterile water for inhalation
- USP bacteriostatic water for injection
- USP sterile water for irrigation

Source: USFDA. 1986. http://www.fda.gov/ICECI/Inspections/InspectionGuides/InspectionTechnicalGuides/ucm072925.htm

For water uses common to many CII businesses such as employee sanitation, cooling towers, and irrigation, the reader is referred to those sections elsewhere in this document. (Section 7.3.6 General Building Sanitary and Safety Applications, Section 7.3.3 Thermodynamic Processes, Section 7.3.5 Commercial Landscape, and others.)

Regulatory Limitations on Water Use

All aspects of production are covered under the Federal Food, Drug, and Cosmetic Act (FD&C Act), Food and Drug Administration Amendments Act (FDAAA) of 2007, and other legislation, rules and regulations. Water used for pharmaceutical/biotech production must meet Food and Drug Administration (FDA) standards. The FDA has established eight categories of water, ranging from non-potable water for outdoor uses, potable water, and six USP (United States Pharmacopeia) categories of purified water.

Non-potable water can be used for irrigation of landscapes, cooling tower makeup, and similar uses. Potable water can be used for much of the in-plant general cleaning. However, USP category water must be used in the production of medicines and for much of the cleaning of equipment.

Ultra-Pure Water Process

The production of ultra-pure water offers some unique opportunities for water efficiency in the pharmaceutical/biotech, nanotechnology, and microelectronics industries. In this process, potable water is passed through a series of water treatment operations to produce water that is almost completely pure, purer, in fact, than distilled water. Depending on the quality needed, water is passed through a sediment filter and activated carbon, softened, filtered with a micro filter, disinfected with ultraviolet light, and then passed through a RO system. In some cases these processes still do not produce pure enough water. In those cases, the water is then passed through strong acid - strong base ion exchange resins that remove all but about 20 ppb of TDS. The wastewater produced by the use of this water for washing and similar operations is often "cleaner" than the tap water supplying the plant, and can be reused in other areas.

Reverse Osmosis Water

The operation of the RO system offers many opportunities for both water use reduction and reuse. Modern RO units recover more than 75 percent of the water fed to the system. The remaining 25 percent, called reject water, is soft, particle free, and of good enough quality to use in cooling towers and similar applications. In some facilities, the reject water is again passed through either a saltwater RO membrane or a nanofiltration system, and the product water is recycled to the front of the RO system.

Ion Exchange Water

If ion exchange is used, the facility can choose to regenerate the resins on- or off-site, which will shift water use from one site to another, but water will still be used.

Cleaning

Cross contamination is a major industry concern; to prevent it, cleaning involves thorough washing, rinsing, and sterilizing. In addition, steam and strong oxidizing agents are often used in the sterilizing phase of the clean-in-place system. Much of the cleaning operation used in the pharmaceutical/biotech industry is similar to the processes used in food processing and chemical manufacturing cleaning.

Bioreactors

Most new biotechnology industries use biological fermentation bioreactors to produce antibiotics and similar products. For years, the general trend in the industry was toward larger reactors, but for some specialty biotechnology companies, the use of smaller reactors with disposable plastic liners has gained some acceptance. These smaller reactors lessen the need for the thorough cleaning now practiced; significantly reduce the potential for cross contamination; and reduce water use while producing a recyclable plastic waste. Refer to Appendix E.3 for a schematic of a typical bioreactor.

Cooling and Heating

Cooling tower makeup, boiler feed water, and water used for processing product are the main uses of water in a pharmaceutical/biotech manufacturing operation. Refer to Section 7.7.7 Thermodynamic Processing for a diagram on cooling and heating systems.

BMP Options – *Pharmaceutical and Biotech*

General

- Reuse RO reject water in production cycles, cooling tower makeup water, boiler feed water, and irrigation.
- Meter, sub-meter, and install automated data recording systems to follow water use at all major use points.
- Convert pumps to mechanical seals.
- Where packing glands are required, using alternate sources of water for seal water.
- Use dry vacuum pumps.
- Where liquid ring pumps are required, either install a water recirculation system or use wastewater for the seal.
- Follow vessel washing and pipe cleaning procedures (see Section 7.3.4, Cleaning Industrial Vessels, Pipes and Equipment.
- Install automatic cutoffs and solenoids on all water using equipment to ensure that water flow is stopped when the equipment is not working.
- Institute training programs for employees.
- Install water efficient plumbing fixtures and appliances.

Summary of Water Conservation Audits of Pharmaceutical/Biotech Manufacturing and Research Facilities

During 2009 and 2010, four biotechnology companies, including a research facility and three manufacturers in the San Diego, California area, received water efficiency audits. All four entities used half or more of their water for a combination of cooling tower makeup, landscape irrigation, and boiler makeup. Since the audits were targeted at process water uses, they did not address domestic plumbing fixtures and irrigation system efficiencies. The single largest non-irrigation use by far for all four facilities was for cooling tower makeup. The auditors examined all process water uses listed and identified five areas where the most water could be saved:

- Installing water tempering devices on autoclaves
- Increasing cycles of concentration in cooling towers
- Using recycled water for cooling
- Recovering and reusing high quality rinse water from cleaning of vessels, water from still reject, and clean steam discharge for boiler makeup

Alternative Water Sources

Consider using the following alternative water sources for all non-potable use, where feasible.

- Stormwater and other onsite sources. Stormwater and other onsite sources have been successfully used for firewater, and for boiler and utility water after proper treatment. Pump seal water is another possibility, as is cooling tower makeup. In areas of lower rainfall, such as California, the feasibility of capturing, treating, and reusing storm water will need to be examined to determine cost effectiveness. Condensate from refrigeration and air conditioning processes, treated wastewater from restrooms and showers, and similar sources may provide inexpensive but small quantities of water for the refinery operation.
- Municipal Recycled Water. The use of municipal recycled water is another way to reduce the use of freshwater supplies that could be used for potable purposes. Recycled water can be used for cooling tower makeup, boiler feed, and all other uses except potable use. However, it may need additional treatment. The Section 10 in this report concerning recycled water has additional information.
- Seawater. Seawater can be used for cooling purposes for plants located along the coast, entirely eliminating the use of fresh water for cooling. However, power plants using seawater for cooling are now being required to eliminate once-through or pass-through cooling, which will further require them to install recirculating systems to reduce the volumes of water they withdraw.

7.2.2.7 Power Plants

Overview – *Power Plants*

The electric power subsector (NAICS 2211) comprises power generation (NAICS 22111) as well as transmission and distribution (NAICS 22112). Within the electric power subsector, most of the water use is associated with power generation, which will be the focus of discussion in this section.

Electric power generation is further divided into four NAICS subsectors: hydroelectric power generation (NAICS 221111), fossil fuel electric power generation (NAICS 221112), nuclear electric power generation (NAICS 221113), and other electric power generation (NAICS 221119). Most of renewable energy plants, such as solar, wind, biomass, and geothermal energy plants are included in the last subsection. Table 7.33 shows the electricity sources generated in the State as well as those imported from outside of the State in the year 2010.

Table 7.33 - Total System Power in Gigawatt Hours, 2011

Fuel Type	California In-State Generation (GWh)	Percent of California In-State Generation	Northwest Imports (GWh)	Southwest Imports (GWh)	California Power Mix (GWh)	Percent California Power Mix
Coal	3,120	1.6%	692	20,158	23,969	8.4%
Large Hydro	36,596	18.3%	74	1,430	38,101	13.4%
Natural Gas	90,751	45.3%	215	13,072	104,037	36.5%
Nuclear	36,666	18.3%	-	8,031	44,697	15.7%
Oil	36	0.0%	-	-	36	0.0%
Other	0	0.0%	-	-	0	0.0%
Renewables	33,244	16.6%	5,398	2,751	41,393	14.5%
Biomass	*5,777*	*2.9%*	*419*	-	*6,195*	*2.2%*
Geothermal	*12,685*	*6.3%*	-	*574*	*13,259*	*4.7%*
Small Hydro	*6,130*	*3.1%*	*6*	-	*6,136*	*2.2%*
Solar	*1,058*	*0.5%*	*29*	*130*	*1,217*	*0.4%*
Wind	*7,594*	*3.8%*	*4,945*	*2,047*	*14,585*	*5.1%*
Unspecified Sources of Power	N/A	N/A	21,339	11,381	32,719	11.5%
Total	**200,414**	**100.0%**	**27,718**	**56,821**	**284,953**	**100.0%**

Source: QFER and SB 1305 Reporting Requirements. In-state generation is reported generation from units 1 MW and larger. http://www.energyalmanac.ca.gov/electricity/total_system_power.html. (Data as of August 1, 2012)

Electricity generation can use substantial amounts of water, depending on the fuel source, power generation technology, and cooling technology employed (Table 7.34). Water requirements for thermoelectric power plants, especially those that rely on steam generation, are particularly high. Water requirements for solar photovoltaic (PV) and wind, however, are negligible, as these systems require only small amounts of water for periodic cleaning. However, cumulative water demand for large utility scale installations could be relatively high (unit water demand per unit energy produced) because water may also need to be used for dust suppression, which can be a major consideration in desert environments where local water resources are scarce. Hydroelectricity also uses water, although the use requirements are a complex function of climate, reservoir design and operation, location, and other factors. Water requirements for geothermal power generation are highly variable, depending upon the cooling technology employed and, for wet cooling towers, whether geofluids or freshwater is used as the coolant. Solar thermal energy (or Concentrating Solar Power, CSP) uses considerable water.

Table 7.34 – Saline and Fresh Water Withdrawal and Consumption Factors (in gallons per kWh)

		Once-Through	Recirculating (Tower)	Recirculating (Pond)	Dry
Steam	Withdrawal	10 – 60	0.95 – 1.46	5.95	0 – 0.004
	Consumption	0.064 – 0.4	0.39 – 1.2	0.24	
Combined Cycle	Withdrawal	7.5 – 20	0.15 – 0.61	6	0 – 0.004
	Consumption	0.020 – 0.1	0.13 – 0.44	0.24	
Geothermal	Withdrawal	-	0.0067 – 6.8	-	0 – 1.8
	Consumption	-	0.005 – 5.1	-	
Solar PV	Withdrawal	0 -0.033			
	Consumption				
Wind	Withdrawal	0 – 0.001			

Source: Cooley, et al. 2011.

Note that water use in Table 7.34 is presented by the generation process rather than by fuel type. This is because of the similarities in water demands based upon these distinctions (e.g. steam compared to combined cycle[138] power plants). As such, solar thermal can be as water-intensive as some of the other steam-driven thermoelectric power plants, including coal and natural gas driven power plants.

Water Use Information – *Power Plants*

Electricity generated from fossil fuels and nuclear plants is typically produced through thermoelectric processes by which the heat or radioactive energy released through combustion or fission processes is converted to electric energy. Water is used in power plants mainly for two purposes – heating water to produce steam in the boiler and using water for cooling. The cooling system requires far more water than the steam cycle.[139]

In general, there are two types of wet cooling processes – once-through cooling (or open cycle in which water is used for a single pass through the heat exchanger system) or recirculation cooling (or closed cycle wet in which water is used for recirculated evaporative cooling in the heat exchanger system). The once-through cooling requires a lot of water, but nearly all of the water used is discharged back to the water system. In California, nearly all the water withdrawals for once-through cooling are saline from the ocean or coastal estuaries and do not involve withdrawals of fresh water. On the other hand, recirculation cooling needs less overall water supply, but it uses fresh water and

[138] In electric power generation, a combined cycle is an assembly of heat engines that work in tandem off the same source of heat, converting it into mechanical energy, which in turn usually drives electrical generators. The principle is that the exhaust of one heat engine is used as the heat source for another, thus extracting more useful energy from the heat, increasing the system's overall efficiency. From http://en.wikipedia.org/wiki/Combined_cycle. Accessed June 6, 2013

[139] USGS Report indicates: While large amounts of water are needed for once-through cooling, consumptive use is a small percentage of the total withdrawn. Smaller amounts of water are withdrawn for recirculation cooling than for once-through cooling, but the consumptive use is a larger percentage of the amount withdrawn.

consumes nearly all of this supply in the cooling process due to evaporation. There are several other cooling systems that use considerably less or almost no water at all, such as wet surface air cooler (WSAC), hybrid wet/dry system, and dry (air) cooling tower (Electric Power Research Institute, 2007). The highest water consumption factors result from the use of evaporative cooling towers.

In a report, "Estimated Use of Water in the United States in 2005"[140], the United States Geological Survey (USGS) reported that 49% of all fresh and saline water withdrawal, and 35% of all fresh water withdrawal, was used in the thermoelectric power sector nationwide. In California the thermoelectric power sector used 12,650 mgd, which consisted of 12,600 mgd of saline water for once-through cooling and 50 mgd of fresh water for other cooling technologies. These water withdrawals accounted for 28% of the total statewide water withdrawals (fresh water and saline water), but only $1/10^{th}$ of one percent of the total fresh water withdrawals in the year 2005 (data source; USGS 2009). This is considerably less than the national average because California thermoelectric power plants currently rely primarily on saline water for cooling and the state imports about 35% of its electricity from outside of the state.

Population growth, aging infrastructure, regulatory requirements, future uncertainty, and changing climate are pressing the energy sector to pursue greater levels of efficiency and the use of alternatives wherever possible, including the use of more efficient water practices and alternative sources or technologies. To meet the needs of increased energy demand by consumers, the energy sector continues to develop more resources. These new resources are an opportunity to replace aging inefficient power plants and employ superior efficiency practices. Climate change has the potential to also change where precipitation falls in California, posing risks to hydroelectric facilities generation potential and to increase demand for electricity where temperatures become more extreme (cold and heat). In addition, competition for fresh water resources is also going to increase as a result of these factors, requiring the power industry to use less water, use water more efficiently, and find advanced innovation technologies in cooling and other processes to save water or not use water at all.

Regulatory Effects on Power Plant Water Use

State Water Resources Control Board Policy Proposal (2008)

In May 2010, the SWRCB adopted Resolution No. 2010-0020 – "Water Quality Control Policy on the Use of Coastal and Estuarine Waters for Power Plant Cooling" – and an associated certified regulatory program environmental analysis. The Resolution states that there are 19 electrical power plants (including two nuclear-fueled plants) located in the state that use marine or estuarine waters as a source of cooling water in a single-pass system, known as once-through cooling system. These power plants have a combined capacity to withdraw over 15 billion gallons of water daily. The SWRCB adopted the Resolution to protect

[140] Kenny et al., 2009. *Estimated Use of Water in the United States in 2005.*

the marine environment from impacts caused by the impingement and entrainment of marine organisms, and the impacts of pressure, temperature and chemicals used in the cooling process on the marine organisms. This Resolution may have the effect of reducing the use of saline marine water as a source of single-pass cooling water, and an associated increased reliance on fresh surface or groundwater sources.

The Resolution establishes uniform requirements for the implementation of Clean Water Act (CWA) Section 316(b), using best professional judgment in determining best technology available (BTA) for cooling water intake structures at existing coastal and estuarine power plants that must be implemented in National Pollutant Discharge Elimination System (NPDES) permits. Resolution No. 2010-0020 intends to ensure that the beneficial use of the state's coastal and estuarine waters are protected, while the electrical power needs essential for the welfare of the citizens of the State are also met. To conserve the state's scarce water resources, the SWRCB encourages the use of recycled water for cooling water in lieu of marine, estuarine, or fresh water. In recent years, most new and upgraded power generation facilities use recirculation cooling systems, while some are using dry or hybrid cooling technologies to reduce environmental impacts and to save fresh water.

Power Plant Cooling Water- Recycled Water Offset Program

The CEC promotes the use of recycled water for cooling water as part of the permitting process. In any application for certification (AFC), the CEC actively requires that cooling tower water preferably come from a municipal recycled water source before other water sources are considered, and where possible, power plants are to use zero liquid discharge systems that maximize onsite water recycling. To date, all power plants using recycled water for cooling water take delivery of their recycled water from an approved Title 22 wastewater treatment plant. This delivery is accomplished either by pipeline or tanker truck. One problem that arises throughout the state is that power plant locations are not always in close proximity to recycled water sources.

To address this issue, some utility agencies have proposed that power plants be allowed to use recycled water offsets. Under an "offset" approach, the power plant operator would team up with a recycled water producer to help fund recycled water projects that might not otherwise be feasible. Through this arrangement the power plant operator would replace the use of potable water with recycled water (e.g., golf course irrigation). The power plant operator would then receive an offset equal to 90% of the amount of the recycled water that has now replaced what was a demand for potable or raw water. The CEC would allow the power plant operator to use a potable water or raw water source for cooling water in an amount equal to the offset received. This approach would increase the amount of potable water available for other uses throughout the state, and increase the amount of recycled water used throughout the state, but would not physically deliver recycled water to the power plant. CEC and the SWRCB should consider this as a viable approach rather than the direct delivery of recycled water. The ability to invest in the infrastructure could be affected by market conditions, especially for intermittent facilities.

BMP Options – *Power Plants*

The U.S. Environmental Protection Agency and other federal and California State agencies recommended many water saving methods or the BMPs of water use in industries in general and in electricity power generation in particular. Those methods include:

- Use of municipal recycled water for power plant cooling.
- Adaptation of innovative water use and water recovery, water reuse, and water recycling measures.
- Implementation of advanced cooling technologies; adoption of energy efficiency measures and less water-intensive renewable energy sources, such as solar PV and wind, etc.

> The SWRCB encourages the use of recycled water for cooling water in lieu of marine, estuarine, or fresh water and SWRCB Resolution No. 2010-0020 "Water Quality Control Policy on the Use of Coastal and Estuarine Waters for Power Plant Cooling" and the California Energy Commission (CEC) promotes the use of recycled water for cooling water as part of the permitting process.

Electric Power Research Institute (2007) and Cooley et al. (2011) recommend the following strategies to increase fresh water use efficiency in the electricity power generation.

- Increase electricity generation efficiency.
- Install solar PV and wind power generation facilities.
- Use dry and hybrid cooling systems.
- Recirculate or reuse water within plants:
    - Increase closed cooling cycles.
    - Use blowdown.[141]
    - Capture vapor produced in wet cooling tower.
- Use alternative water sources:
    - Waste water treatment plant discharge.
    - Water produced in oil/gas extraction.
    - Storm water flow.
    - Mine drainage.
    - Agricultural runoff.
    - Saline aquifers.
- Section 7.3.3 Thermodynamic Process BMPs

Minimizing withdrawal and consumptive use of fresh water in thermoelectric power sector is important to the State's water use efficiency goals. Integrated energy and water policy is needed to ensure citing of future power plants do not adversely impact water resources.

[141] 'Blowdown' refers to water drawn-off/discharged out of the cooling tower to prevent buildup of dissolved minerals and salts.

7.3 Common Devices, Processes, and Practices Applicable to the CII Sectors

This section summarizes water saving BMP"s with Common Practices across various types of CII entities so that businesses have one place to go for information on water use BMPs, as well as other commonly used techniques in the CII sector, such as heating and cooling (thermodynamic processes), water treatment, and use of alternative water sources.

Common Practices are those practices or BMP's that are common to a variety of CII entities. Some common practices or BMP's applicable to CII entities would be; landscaping, metering, using potable water, and the thermodynamic processes of cooling and heating.

7.3.1 Alternate Onsite Sources of Non-Potable Water

Overview

In the past, the use of alternate onsite sources of water has been hindered by the absence of a regulatory framework and the lack of readily available technologies to help facilitate their use. These obstacles are rapidly disappearing as a result of a number of changes including the two major plumbing code bodies; (International Association of Plumbing and Mechanical Officials and the International Code Council) developing "green codes,"; the National Sanitation Federation developing water quality criteria for gray water reuse; organizations forming to promote the use of alternate water sources; and, California beginning the development of state-level guidance and regulations. California stands at a threshold of opportunity to be a national leader in promoting alternate onsite sources of water, such as gray water, rainwater, stormwater, and many other sources that are often being discharged as waste.

To provide clear direction to local jurisdictions for the oversight of these types of system, ensure protection of public health, and advance the ability to reuse water, the CII ask Force is recommending that the CBSC should adopt updates to the plumbing code based on the The International Association of Plumbing and Mechanical Officials (IAPMO) 2010 Green Plumbing Code supplement and the NSF 350 standard. Volume II describes regulatory conditions and standards in more detail.

Alternate onsite sources are different from recycled water. As the word onsite implies, these are water sources that are generated on the premise where they will be used. By contrast, under Title 22, recycled water is treated municipal wastewater effluent provided by a municipal wastewater authority for reuse for non-potable purposes. Recycled water is discussed extensively in Section 9.0.

Underlying Concepts

- The use of an alternate onsite source of water is a best management practice.
- Alternate onsite sources of non-potable water are freshwater resources and should be used efficiently.
- Any water source can be treated to meet the needs and conditions of a desired end use.
- Economics and volume of water available should be carefully evaluated to determine the economic viability of capturing onsite sources. Each situation is case-specific.

- These sources of water are perfect candidates to use in conjunction with potable water, municipal recycled water, and self-supplied fresh water.
- The potential of this resource is only limited by the supply available, ensuring a safe water quality for the intended use, and the ingenuity of the user.

7.3.1.1 Codes, Standards, Regulations, Organizations, and Rating Systems

Many factors have converged to encourage the use of the alternate onsite non-potable sources of water. Commercial and institutional facilities also have significant opportunities to capture and reuse a variety of alternate onsite sources for non-potable applications. Industrial operations already reuse onsite sources of water, but older regulations and codes have hindered the easy development of these systems in the commercial and institutional sectors. In addition, there is a lack of clarity on the requirements for using these types of systems.

The most important approaches to standardizing requirements are summarized below:

<u>Codes</u>

Codes provide officials with building standards to follow. In California, state building standards are administered by the California Building Standards Commission. Local jurisdictions may adopt more restrictive standards under certain conditions. The two state standards of most relevance for water use and associated plumbing and fixtures are the California Plumbing Code and the California Green Building Standards Code (also known as the CALGreen Code) (California Code of Regulations, Title 24, Parts 5 and 11). The California Plumbing Code is a modification of a model code published by the International Association of Plumbing and Mechanical Officials. The California Plumbing Code recognizes four non-potable sources of water. They are:

- Municipal recycled water - water from municipal wastewater treatment facilities.
- Graywater - untreated water from showers, bathtubs, clothes washers, and hand washing sinks that is used for subsurface irrigation.
- Rainwater – water that is collected from roofs and elevated surfaces.
- Onsite Treated Non-Potable Water - all other onsite sources that are treated to the level required for their intended use.

<u>Standards</u>

Standards set criteria that must be followed. The National Sanitation Federation (NSF) has established NSF Standards 350 and 350-1 for graywater reuse. They provide water quality parameters for graywater use above ground for irrigation and toilet flushing (350) and subsurface irrigation (350-1).

Regulations

Regulations by the State of California for onsite use of alternative water are adopted by the California Building Standards Commission (CBSC) and incorporated into the California Plumbing Code. The plumbing code is enforced by local jurisdictions that adopt it through local ordinances, which can vary from the state's criteria.

Graywater Reuse

Chapter 16A of the plumbing code was developed by Department of Housing and Community Development (HCD) and adopted by the CBSC. As a result, legal graywater reuse is now more feasible in the residential sector. In 2010, the legislature adopted SB 518, which required the CBSC to adopt graywater standards that extend to nonresidential customers. Those standards are currently under development.

Green Plumbing Codes

New national codes and standards are now available for the first time. These include the 2010 IAPMO new Green Plumbing Codes and the new NSF Standard 350 for water quality considerations for the reuse of onsite sources. California currently uses older versions of the IAPMO plumbing codes and uses NSF standards in establishing state codes and standards. The CBSC and others have a real opportunity to advance onsite reuse by considering and adopting appropriate provisions of the IAPMO Green Plumbing Code Supplement and the NSF 350 Standard.

Regional Water Quality Control Boards

In addition to regulation through the plumbing code, the RWQCBs also issue permits for wastewater treatment facilities. This includes permits for use of recycled water from those facilities. The SWRCB and RWQCB also play a significant role in regulating storm water. The use of alternative supplies in certain sectors may also require approval by other state and federal regulatory agencies.

Organizations

Organizations such as the American Rainwater Catchment Systems Association, American Water Works Association, and others promote the use of alternate water sources. Environmental organizations such as the Sierra Club also promote alternate sources use.

Rating Systems

Rating Systems such as the U.S. Green Building Council's LEED (leadership in energy and environmental design) and the Green Globes' Green Build Initiative (GBI) provide points toward certification for use of alternate onsite, non-potable sources of water.

7.3.1.2 Potential Sources of Onsite Non-Potable Water

Many diverse sources of water are produced on every type of property. This water is usually discharged to sewers or stormwater drains. The capture and use of these resources is growing as costs for conventional potable freshwater rises. There are many potential sources not covered in this document. Each site should assess its possible alternate sources to determine if there is an opportunity to capture and use it. The following section provides a brief description of some of the most commonly used sources.

Rainwater Harvesting

Rainwater harvesting is the catching of water from roofs and other elevated structures and stored in cisterns for future use. In contrast, stormwater is collected off of other surfaces such as parking lots and lawns (see next discussion for stormwater harvesting). There is, however, the potential for rainwater contamination from any surface.

Rainwater harvesting is one of the oldest forms of alternate onsite sources of water. Although rainwater has been use for drinking purposes in some homes in the past, this document only discusses the non-potable uses in commercial, institutional, and industrial settings.

Approximately 0.62 gallons of water can be collected per square foot of collection surface per inch of rainfall. In practice, most installers assume a capture efficiency of 80 percent. Some rainwater is lost to first flush, evaporation from the roof surface, or splash-out from the gutters. Rough collection surfaces are less efficient at conveying water, and water captured in pore spaces is lost to evaporation.

The inability of the system to capture all water during heavy storms also affects practicable efficiency. For instance, spillage may occur if the flow-through capacity of a filter-type roof washer is exceeded, and overflow rainwater will also be lost when storage tanks are full. The use of rainwater collection systems is most practical in regions with periodic precipitation throughout the growing season.

In California, since most regions don’t receive precipitation during the summer, early fall, or late spring, cisterns are far less practical than in other parts of the country; very large storage capacities are needed to capture enough water to use at any length into the irrigation season. With more frequent precipitation events, smaller cisterns are needed and fewer capital costs incurred.

Stormwater Harvesting

Stormwater harvesting includes catching runoff from parking lots, roofs, and landscape. This water can either be captured in storage structures, such as holding ponds or storage tanks for future use after proper treatment, or it can be slowed and allowed to infiltrate to the local aquifer. If storage structures are used, economics and design considerations are similar to that for rainwater, except that stormwater generally contains higher levels of contaminants than rainwater.

Allowing infiltration to aquifers for stormwater management and runoff management dates back to the oldest known form of rainwater harvesting for agricultural practices by Native American tribes in the Southwest. Storing water in the soil profile is usually the least expensive form of storage. It slows stormwater runoff and allows percolation into local aquifers. An example of this practice may be found in the County of San Diego's handbook on stormwater management (see adjacent text box).

> County of San Diego
> Low Impact Development Handbook
> Stormwater Management Strategies
>
> Integrated Management Practices (IMPs) help developers mimic the site’s natural hydrological function. IMPs may include directing runoff to natural and landscaped areas, man-made filtration devices such as small vegetated swales, rain gardens, and permeable pavements and pavers. Other basic principals include dividing and sectioning impervious surfaces (no large continuously paved areas), eliminating runoff pathways and re-dispersing runoff (no downspouts connected to storm drains), and, where feasible, harvesting of rain water in rain barrels or cisterns and using runoff as an irrigation source. These Low Impact Development (LID) techniques can be applied to areas of residential, commercial, industrial, and municipal development.

Air Conditioner Condensate

Air conditioner condensate is the water formed inside air conditioning coils from dehumidification. Since the condensate is from the atmosphere, it lacks minerals and salts, but it does collect bacteria and particulates from the air passed through it.

Estimating the amount of condensate produced requires a psychrometric evaluation of makeup air, climatic data, and operation of the air conditioning systems. This evaluation will determine the amount of condensate that may be available. The best time to incorporate condensate collection systems is in the design phase of a facility.

Swimming Pool Filter Backwash Water

Swimming pool filter backwash water from the backwash of sand filters can be used for landscape irrigation and other uses if properly treated. Backwash water can contain high levels of suspended solids and bacteria. Sedimentation, filtration, and disinfection may be needed before use. Swimming pool water may also contain fairly high dissolved solids levels. Chlorine may be a factor if it is too high for the plants being irrigated. Algaecides can also damage plants, but in most cases, it can be used for irrigation with minimal treatment.

Cooling Tower Blowdown

Cooling tower blowdown is the water discharged to keep minerals from building up in cooling towers. It is usually high in TDS, but can be used to irrigate salt tolerant plants. Blowdown can also be used for other purposes such as toilet flushing, but special attention would need to be given to TDS levels and the type of treatment needed to bring it to the level needed for those uses.

Reverse Osmosis and Nanofiltration

Reverse osmosis (RO) and Nanofiltration (NF) reject water is purge water rejected from this type of treatment equipment. This water has typically been treated and disinfected. In the case of RO reject water, the water has almost always been softened. One constituent of concern with RO or NF reject water is TDS. Where nanofiltration is used for softening, the reject water can also be very hard.

Graywater

Graywater is water from laundries, bathing, and hand washing fixtures. See the NSF 350 and NSF 350-1 standards for this type of water. If the IAPMO Green Plumbing and Mechanical Code is followed, graywater refers to untreated water from graywater sources that are only used for subsurface irrigation.

Onsite Treated Wastewater

Onsite treated wastewater systems are sewage treatment plants located on the premise where the wastewater is generated. When treated properly, this effluent can be a viable source of fresh water.

Foundation Drain Water

Foundation drain water is water pumped from under foundations, French drain systems, basement sumps, and from under slabs to prevent flooding of basements or buildings below the land surface. This water can vary significantly depending on the soil type and ground it comes in contact with. This water should have a major cation and anion analysis performed on it prior to use in order to determine its makeup. Normally, this type of water is an excellent candidate for landscape irrigation and cooling tower makeup.

Boiler Blowdown

The quality of blowdown from boilers varies considerably depending on the quality of steam needed. Most commercial low-pressure boilers produce a blowdown that is high in TDS, but high pressure boiler blowdown is often low in TDS and can be used for non-potable purposes.

7.3.1.3 Potential Uses of Alternate Onsite Sources for Non-Potable Purposes

Many potential uses exist for these alternate non-potable sources. The most important factor when evaluating the possible uses is what minimum water quality is needed to meet the needs of the user and to ensure safety of the water for the intended use.

Some potential uses include:

- Irrigation
- Green roofs
- Cooling tower makeup water
- Toilet and urinal flushing
- Makeup for an ornamental pond/fountain
- Swimming pools
- Laundry
- Industrial process use
- Any other use not requiring potable water

These onsite sources can even be used for non-industry practices such as aquifer recharge and meeting environmental needs for in-stream flow and wetlands maintenance.

Water Quality Considerations

Making these sources usable often requires treatment; however, these sources do not need to be treated to more than the quality required for the intended use. Table 7.35 illustrates some of the water quality considerations that must be taken into account when using alternate sources.

Table 7.35 - Water Quality Consideration for Alternate Onsite Sources of Water

Possible Sources	Water Quality Considerations					
	Sediment	(TDS)	Hardness	Organic (BOD)	Pathogens	Other considerations
Rainwater	**1-2**	**1**	**1**	**1**	**1**	*None*
Storm water	**3**	**2**	**1**	**2**	**2**	*Pesticides & fertilizers*
Air conditioner condensate	**1**	**1**	**1**	**1**	**2**	*May contain copper when coil cleaned*
Pool filter backwash	**3**	**2**	**2**	**1**	**2**	*Pool treatment chemicals*
Cooling tower blowdown	**2**	**3+**	**3**	**2**	**2**	*Cooling tower 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					*Detergents and bleach*
Onsite wastewater treatment	**3**	**2**	**2**	**3+**	**3+**	*Human waste*
Foundation Drain Water	**1**	**2**	**2?**	**2**	**2**	*Similar to stormwater*
Other Sources	**?**	**?**	**?**	**?**	**?**	*Depends on source*
The use of pass-through (once-through) cooling water is also a possible source of onsite water, but it should be discouraged because of its huge potential to waste water. While it does provide a very clean source of water, it is not included in this list.						
1. Low level of concern 2. Medium level and may need additional treatment depending on end use or local quality 3. High concentrations are possible and additional treatment likely ? Dependent on local conditions (May vary greatly)						

Types of Treatment

Treatment technologies can be used to treat any onsite source to the quality specified in the tables above. Table 7.36 illustrates possible treatment technologies that may be needed to treat various sources to meet the NSF Standard 350 criteria for above ground irrigation. These treatment levels are only to be used as guides since the end use will determine the treatment needed.

Table 7.36 - Types of Treatment That May Be Employed Depending on Intended End Use Quality Needs

Source	Filtration	Sedimentation	Disinfection	Biological Treatment	Softening & Other	Other Considerations
Rainwater	?		?			Depends on end use
Storm water	X	?	X	?	?	Oils and heavy metals
Air conditioner condensate	?		X		?	Copper and bacteria
Pool filter backwash	X	?	X		?	Sediment, bacteria, & pool chemicals, salts
Cooling tower blowdown	X		X		X	High dissolved solids, bacteria, sediment
RO & NF reject water			?		?	High dissolved solids
Treated Gray water	X	X	X	?		Bacteria, BOD, sediment
Untreated Gray Water	For subsurface application only. May need lint screening					*Detergents and bleach*
Onsite wastewater treatment	X	X	X	X	?	Bacteria, BOD, sediment
Foundation Drain Water	X		X		?	Hardness, bacteria, sediment

Treatment Levels

The type of treatment will depend on the ultimate use of the alternate water source. For example, if the water is to be sprayed into the air for irrigation in areas where human contact is possible, disinfection is required if the water may contain pathogens. However, if the water is to be used for subsurface irrigation or cooling tower makeup where there is biological control already, disinfection may not be needed. Each situation must be evaluated separately. NSF’s recently released Standard 350 addresses end use quality for graywater for aboveground irrigation and toilet and urinal flushing, and Standard 350-1 addresses subsurface irrigation. These standards may be used as a guide for end-use water quality from any onsite source. Table 7.37 summarizes the more stringent above ground use parameters and Table 7.38 summarizes parameters for subsurface irrigation. Again, these are treatment levels for the use of water for irrigation and toilet and urinal flushing. Treatment levels for cooling tower use, boiler feed, and others should be determined on a case-by-case basis.

Table 7.37 - NSF Standard 350 Effluent Criteria for Commercial Reuse Above Ground

Parameter	Overall Test Average	Single Sample Maximum*	Description
$CBOD_5$ (mg/l)	10	25	Carbonaceous biochemical oxygen demand
TSS (mg/l)	10	30	Total suspended solids
Turbidity (NTU)	2	5	Nephelometric turbidity units
E. Coli[2] (MPN/100 ml)	2.2	200	Most probable number of colonies
pH (SU)	6-9	NA	7.0 in neutral: >7 - basic, < 7 - acetic
Storage Vessel Chlorine Concentration (mg/l of Cl)	>0.5 & <2.5	NA	Other disinfectants can be used
Color	MR	NA	Measured and reported
Odor	Non-O	NA	Non-offensive
Oily film and foam	ND	ND	None detectable
Energy Consumption	MR	NA	Measured and reported
* NA - Not applicable			

Table 7.38 - NSF Standard 350-1 Effluent Criteria for Commercial Reuse for Subsurface Irrigation

Parameter	Standard	Description
$CBOD_5$ (mg/l)	25	Carbonaceous biochemical oxygen demand
TSS (mg/l)	30	Total suspended solids
pH (SU)	6-9	7.0 in neutral: >7 - basic, < 7 - acetic
Color	Non-O	Measured and reported
Odor	ND	Non-offensive
Oily film and foam	MR	None detectable
Energy Consumption	Non-O	Measured and reported

7.3.1.4 Other Considerations

Multiple Sources

Plumbing of rainwater, gray water, drain water, and blowdown from various sources to common end uses, like landscape irrigation or non-potable indoor uses such as toilet flushing, is not common, but it is recommended. The cost effectiveness of such “hybrid” systems is improved by diversifying the sources of water and improving the consistency of water availability. Water treatment should be designed to treat the poorest water quality collected from the multiple sources.

Connections to Municipal or Recycled Water Sources

An effective way to use an alternate source of onsite water is to "backup" that alternate water source with a connection to a potable or recycled water source. This will allow the facility using the alternate onsite source of water to maximize its use of the alternate water source while having a backup water source when onsite sources are low due to operational or climatic conditions. In all cases, proper backflow prevention is necessary, which would typically be an air gap separation between the potable and non-potable supply.

Conclusions

With the significant opportunities to reuse water in the CII sector, the CBSC should adopt updates to the plumbing code based on the IAPMO 2010 Green Plumbing Code supplement and the NSF 350 standard. This will provide clear direction to local jurisdictions for the oversight of these types of system, ensure protection of public health, and advance the ability to reuse water.

7.3.2 Building Meters, Submeters, and Management Systems

Overview – *Meters, Submeters, and Management Systems*

An important axiom in building and property water management is that you cannot manage what you don't measure. The absence of water meters is one of the biggest obstacles faced by facility managers to assess water use. While most properties contain one or more main source meters that are provided and serviced by the water service provider, additional meters (submeters) for tracking water use *within* the property and at specialized end-uses often do not exist. However, such meters are generally easy to install, easy to monitor, and easy to maintain.

Tracking total property water use as well as specific uses within the building(s) is a key component of facility management efforts and essential to managing water costs and maintaining systems and processes on the property. In addition, meters are used extensively in industrial and other process operations within the facility to track and manage water consumption, and to act as an alarm when processes fail.

Locating Submeters

Where submeters should be installed is unique to each application; however, there are some locations that are typically recommended for submeter installation at most CII properties and for most CII operations. In some cases, the selection of these locations will be based entirely upon those building elements with high water use, while other submetered operations may be selected because of their vulnerability to failure, leakage, or other maintenance issues.

For example, submeters are commonly employed to measure usage for specific activities, such as cooling towers, processes of all types, and landscape irrigation, where the water consumption at these activities is sufficient to warrant a meter.

In the case of the latter two, a failure in these systems could quickly lead to substantial water waste. As such, measuring water use in real time can help facility managers identify water consumption anomalies that demand immediate attention by maintenance staff. Measuring also helps to identify areas for targeted reductions, track progress achieved with water-efficiency upgrades, and manage water and sewer costs.

Centralized Building Management Systems

Meters and submeters can be integrated into a centralized building management system, making it easy to track usage. Managers can use the information provided by the system for leak detection and to develop strategies for the more efficient use of water in order to reduce water, energy, and wastewater costs in their facility. These management systems are capable of electronically storing data from meters and submeters, reporting hourly, daily, monthly, and annual water use. They also trigger alerts upon detecting leaks or other operational anomalies. Real time monitoring and management systems are essential where there are multiple water using activities that consume large amounts of water, such as in certain industrial processes and large campus operations with diverse activities and building types.

Meter Selection

Installing the correct meter and ensuring that it continues to function properly is critical to accurate water measurement. There are many meter types and sizes intended for different uses, so it is important to choose correctly. Improper sizing or type can cause problems for the system. For example, an undersized water meter can cause excessive pressure loss, reduced flow, and noise, among other problems. Oversized meters are not economical and do not accurately measure minimal flow rates.[142] All source meters provided by the water service provider for domestic water service are considered utility grade water meters, and they must comply with AWWA standards. However, submeters used for the purposes described above and not used for revenue purposes are not subject to such standards.

Technical Feasibility – *Meters, Submeters, and Management Systems*

All of the practices, products, and technologies described within this report section have been in existence for an extended period of time and found to be technically feasible. In each case, however, economic feasibility must be evaluated within the context of the physical condition and demands of the specific process, property, or building being considered for metering and management.

[142] Smith T A. 2003. *Plumbing Systems and Design. Water-Meter Selection and Sizing*. www.ctaspe.com/docs/techarticles/Water%20meter%20selection%20and%20sizing.pdf.

BMP Options – *Meters, Submeters, and Management Systems*

Consider the following best practices for metering water use:

Determine What to Meter and Submeter

The following recommendations are based on the U.S. Green Building Council's proposed 2012 Leadership in Energy and Environmental Design (LEED) rating system:

Source Meters

- Meter all water conveyed to the facility, regardless of source. For example, even if a building's water is solely supplied by an alternative source (e.g., municipally supplied reclaimed water), a source meter should be installed.[143]
- If multiple sources of water are provided to a facility, each source should be metered and tracked separately.

Submeters

- Consider installing separate submeters to measure the following uses if they are permanently plumbed:[144]
    - o Freestanding building with projected annual water use of 100,000 gallons or more.
    - o Tenant space with projected annual water use of 100,000 gallons or more.
- Cooling tower with projected annual makeup water use of 100,000 gallons or more. Makeup water added to the system and blowdown water discarded from the system should be separately metered. A single makeup meter and a single blowdown meter may record flows for multiple cooling towers if they are controlled with the same system. Separately controlled cooling towers should have separate makeup and blowdown water meters.
- HVAC systems with aggregate annual water use of 100,000 gallons or more. If the facility has 50,000 square feet or more of climate controlled space, the following systems should be submetered individually or collectively: (1) evaporative coolers, humidifiers, and mist cooling devices; and (2) recirculating water systems with a fill water connection, such as chilled water, hot water, and dual temperature systems.
- Any boiler with aggregate projected annual water use of 100,000 gallons or more, or a boiler of more than 500,000 British thermal

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[143] U.S. Green Building Council. 2010. *Draft Rating System for Building Design & Construction.* www.usgbc.org/ShowFile.aspx?DocumentID=8182.
[144] U.S. Green Building Council. 2010.

units per hour (BtuH). A single makeup meter may record flows for multiple boilers.

- Landscape irrigation that is automated and permanent.
- Water use from alternative water sources such as rainwater, air handler or boiler condensate, or other sources.
- Makeup water used to supplement rainwater, graywater, and other onsite water collection and treatment systems plumbed to receive supplemental water (reclaimed, raw, or potable) from municipal supply, onsite treatment systems, or a groundwater well.
- Manmade ornamental and recreational bodies of water including pools, spas, and ornamental water features. Makeup water provided to such water bodies with a combined surface area of 500 square feet or more should be metered, regardless of the projected amount of water use. Do not meter individual features of less than 50 square feet that cannot be reasonably metered collectively.
- Any other process with a projected annual water use of 100,000 gallons or more.

In addition, also recommended for submetering consideration are the following:[145]

- Other nonpotable water uses (process water) from sterilizers, air compressors, water filtration systems, laundry, and vehicle wash systems.
- Commercial food service water heaters with another meter for all food service water.

Meter Selection

1. First, determine the meter's use and select the appropriate meter from the meter types listed below:[146]
    - Positive **Displacement Meters.** Positive displacement meters are best suited for small commercial or institutional applications because they have higher accuracy at low flows and can precisely measure peak flows. Depending on size, costs range from under $50 to over $1,000, not including installation cost, meter box and piping, and related costs.
    - **Compound Meters.** Compound meters are good for large commercial or institutional facilities because they accurately measure low flows and high flows with their multiple-measuring chamber design.

145 Huff W. 2009. "Water Meters: A Facility's Cash Register, Plumbing Systems & Design Magazine."
146 Smith T A. 2003.

- **Turbine and Propeller Meters.** Turbine and propeller meters are most appropriate for continuous, high flow applications and are inaccurate at low flows. These types of meters are not usually recommended for commercial, institutional, or residential buildings because water flows are in constant fluctuation with very low minimum flow rates. Their costs are similar to positive displacement meters.
- **Electromagnetic Flow Meters.** Electromagnetic flow meters have no moving parts and do not obstruct flow. They have electronic outputs that are easy to connect to automated systems and data management systems. Meters between 2" and 10" cost from $1,000 to $2,500 depending on size.
- **Ultrasonic and Time-Flight Meters.** Ultrasonic and time-flight meters can be attached to the outside of the pipe and are excellent for temporary flow measurement such as a water conservation audit. These meters cost from $3,000 to $7,000 depending on the system.

2. Next, select the appropriate meter size.
    - It is important to understand the building's size, function, fixture types, usage occupancy, and peak population in order to select the appropriately sized meter. These statistics determine the minimum and maximum flow rates and should result in the selection of a properly sized water meter.[147]
    - AWWA Standard M22, *Sizing Water Service Lines and Meters,* provides additional guidelines for selecting and sizing utility-owned and installed water meters.[148]

Meter Installation and Maintenance

- When installing a meter, follow the manufacturer's instructions. Improper installation can lead to metering inaccuracies.
- Meters should be installed in an accessible location to allow for repair and calibration. In addition, the meter location should be protected from potential damage from surrounding equipment.
- To ensure uniform flow entering the meter, do not install the meter near pipe bends. In general, place the meter with at least 10 pipe diameters of straight pipe downstream and five pipe diameters of straight pipe upstream.[149]
- Create a map indicating the location of all source meters and submeters.

[147] Smith T A. 2003.
[148] American Water Works Association. 2004. *Sizing Water Service Lines and Meters.*
[149] American Water Works Association. 1999. *Manual for Water Meters—Selection, Installation, Testing, and Maintenance,* Fourth Edition.

- Include a strainer on all meters and submeters. It is possible that debris and sediment will enter a meter with the flow of water that can have an adverse effect on accurate measurement. An in-line strainer on the meter's inlet will collect debris and sediment and prevent these from entering the meter body.[150]
- Meters deteriorate with age and should be tested for accuracy and calibrated on a regular basis. Sub-meters, however, may be subjected to more frequent inspection and calibration, depending upon the type and size of the meter and its application.

Water Use Tracking and Integration into a Water Management Plan

Meters, alone, do not yield efficiencies. Meters are a tool used to provide the data that can be monitored to aid in the efficient operation of a facility. This value includes discovering and correcting water use anomalies and helping the organization allocate the cost of water to the appropriate tasks or processes. In addition to staffing the facility with motivated, aware, and trained monitoring personnel, several best practices to consider are:

- Consider installing a "real time" centralized building management system with remote communication capabilities to the meters and submeters.
- If not integrating metering data into a centralized system, consider the following:[151]
    - Assign responsibility to track water use on a monthly or more frequent basis.
    - Train staff on meter reading and data recording.
    - Plot total water use and submetered data monthly, and examine data for unexplained fluctuations.
    - Evaluate trends and investigate and resolve any unexpected deviations in water use.

[150] Smith, T A. 2003.
[151] FEMP. 2013b. "Best Management Practice: Water Management Planning." www1.eere.energy.gov/femp/program/waterefficiency_bmp1.html#mmp

7.3.3 Thermodynamic Processes

Overview

Thermodynamics is the term physicists use to describe energy transfers that can be strictly related to heat and work.[152] Single-pass (once-through) cooling, cooling towers, evaporative coolers, and boilers are examples of water dependent thermodynamic processes technologies found throughout the CII sectors. Water is the key substance used by these technologies to affect heat and energy transfer and transformation. This section covers both heating and cooling systems that use water; non-water-dependant processes are not covered in this discussion.

The heating, ventilation and air conditioning (HVAC) industry is directly involved in providing heating, hot water, and cooling to the commercial and institutional sectors. The NAICS code for that industry is 238220. For industrial operations, cooling tower construction and installation can be classified under NAICS 333415 or 332313, while boilers can be classified under NAICS 238290 or 332400.

7.3.3.1 Cooling Systems

Overview – *Cooling Systems*

Cooling systems remove "unwanted" energy in the form of heat and dissipate that heat to the environment. Examples of cooling systems include air conditioning, process cooling, dehumidification, and refrigeration. Cooling is either achieved by evaporating water, by the direct use of water, or by the use of a mechanical refrigeration system. To begin this discussion, two terms are defined below.

Heat Pump

A heat pump is a machine or device that "moves" thermal energy from one location to another. In the case of refrigeration or air conditioning, heat pumps are used to cool a space; heat is moved from the "source," which is at a lower temperature, to location of higher heat, called the "heat sink." Mechanical air conditioners and refrigeration systems are heat pumps. If reversed, the heat pump moves heat from the outside to the inside to warm a space.

Heat Sink

A heat sink in this context is the environment – air, water, or earth – that holds the unwanted heat.

- **Air As a Heat Sink.** An example of air as a heat sink is the typical home air conditioner. The outside unit contains the compressor, cooling coils, and fan. The compressor pump compresses the working fluid, such as Freon™ gas, which becomes very hot from

[152] "Work" is thermodynamically defined as the energy transferred from one system to another.

the energy put into it though the compression. A fan then cools the gas by drawing in outside air and forcing it over the coils, thus returning the working fluid to a liquid phase. The heat from the motor and the heat from liquefying the Freon™ is rejected to the atmosphere. The liquid then flows back inside air conditioning coils where it expands as it passes through a small valve. As it turns back into a gas, it becomes very cold, able to absorb the heat from the room being cooled as the inside air handler (fan) blows over the coils. The gas returns to the compressor, and the process repeats over and over again. The heat in the room is therefore pumped to the outside environment and discharged to the outside air (heat sink).

Air coolers for removing process heat provide another example. They work like car radiators: a fan draws outside air over coils as the warm fluid is pumped through the coils. The air acts as the "heat sink" to remove heat from (cool) the liquid in the tubes.

- **Earth as a Heat Sink.** Some air conditioning units use the ground as a heat sink. These "geothermal" units run coils into the earth and the earth absorbs the heat rejected[153] by the unit.
- **Water as a Heat Sink**. Water is passed over the coils or through a "heat exchanger" where the working fluid or material being cooled transfers that heat to the water. The water can also be used in direct contact with the air to cool it through evaporation; such as the case with an evaporative cooler, which is sometimes called a swamp cooler.

A variation of this system is the chilled water loop. Water is cooled mechanically and circulated through a building to cool air (air conditioning) or equipment, and then returned to the chiller unit.

- **Combined Heat Sinks.** Cooling towers represent a combined case where water is used to remove heat from a compressor or from a manufacturing process. The warmed water is then sent to a cooling tower where the waste heat is "rejected" to the atmosphere by evaporating that water.

Types of Processes – *Cooling Systems*

There are five basic types of cooling systems that rely on water:

- Single-pass cooling
- Once-through cooling on natural bodies of water
- Cooling reservoirs
- Evaporative cooling
- Cooling towers

[153] ‘Heat rejection’ refers to the process of heat disposal/dissipation to the heat sink.

Single-Pass Cooling

Single-pass cooling uses water to remove heat, thus cooling equipment components. Water passes through a coil within or casing around a piece of equipment, and is then discharged to the sewer.

For the purposes of this report, single-pass cooling refers to the use of water to cool commercial and industrial type equipment. Types of equipment that often use single-pass cooling include:

- Chillers or other refrigeration systems
- Condensers
- Air compressors
- Hydraulic equipment
- CAT scanners
- Degreasers
- Welding machines
- Vacuum pumps
- X-ray equipment
- Ice machines
- Wok stoves

Vacuum pumps, X-ray equipment, ice machines, and wok stoves use water for processes, in addition to the water used for single-pass cooling. Such equipment and its associated water use, apart from single-pass cooling, are discussed in other sections (e.g., Section 7.1.4.2 Medical and Laboratory Equipment and Processes, Vacuum Systems; Section 7.1.4 Medical and Laboratory Equipment and Processes, Photographic and X-Ray Equipment; Section 7.1.1.10 Commercial Food Service, Ice Machines; and, Section 7.1.1.10 Commercial Food Service, Wok Stove, respectively).

Once-through Cooling With Natural Bodies of Water and Cooling Reservoirs

Large industrial operations, including manufacturing facilities and power plants, sometimes use "once-through" cooling with water from a natural body of water.

Natural Bodies of Water

Once-through cooling with natural bodies of water refers to the use of a river, natural lake, or saltwater body as a source of cooling water. Water is directly returned to the natural body of water from which it was withdrawn. Since enormous volumes of water are typically involved, these withdrawals can affect aquatic wildlife by both entrapping them in the flow of water and by creating thermal barriers with the warm water that is discharged. To put this into perspective, one 750-megawatt power plant can withdraw as much as 1.5 billion gallons of water per day. For these reasons, the State of California no longer allows power plants to employ once-through cooling using sea water and freshwater sources that are not sufficient to support this type of flow rate. Smaller industrial facilities and some air conditioning systems can use this type of cooling, but permitting requires careful consideration. Because of its limitations, no further consideration is given in this document: once-through cooling is not recommended as a best management practice.

Cooling Reservoirs

Cooling reservoirs, sometimes called cooling ponds, are manmade reservoirs used by industries and power plants for process cooling. Water is pumped through heat exchangers and recirculated through the reservoir where it cools through natural processes. The amount of water evaporated from a cooling reservoir is a combination of natural evaporation and evaporation from the added heat from the cooling process ("forced evaporation").

Evaporative Cooling

One of the oldest technologies used to cool an occupied space is an evaporative cooling system, sometimes called a ‘swamp cooler’. These coolers simply pump water over wet pads that have air drawn through them. The evaporation of the water cools the air passing through it. This air is then blown into the space to be cooled (refer to Figure 7.48 for an example evaporative cooler). These systems are inexpensive and use less energy than a refrigerated air system common to most residential and light commercial applications. However, they can consume significant volumes of water if not properly controlled.

Conventional Evaporative Cooling

Evaporative coolers can either be of the once-through–type or recirculating-type. In the once-through-type, water, usually from a potable water supply, is continuously run over the pads and allowed to drain either to the yard or to a storm or sanitary drain. These systems are very wasteful. Most modern evaporative coolers have recirculating pumps that continuously pump water from a basin over the pads when the system is on. They use a float valve similar to that in a toilet tank to maintain the water level in the basin. Water is "bled-off" to flush salts from the system either by a valve left partially open or with the use of a conductivity probe and solenoid valve system, as is the case in larger more sophisticated systems.

www.ose.state.nm.us/water.../conservation/evap-coolers-brochure.pdf

Figure 7.48 - Evaporative "Swamp" Cooler

Indirect Evaporative Cooling

Another technology uses a heat exchanger arrangement. Part of the air is humidified and thus cools. This cool air is then passed through a metal "heat exchanger." This device passes the humid cool air on one side of metal sheets and discharges the warmer, more humid air back to the atmosphere. On the other side, air from the occupied space is circulated where it contacts the cooler metal surfaces, where it absorbs heat from circulating air. The cooled air is returned to the living space and the humid, warmer air is exhausted to the outside. This system is called indirect evaporative cooling.

Pre-Cooling

In recent years, a new form of evaporative cooler has entered the market. It works by pre-cooling air that is being used to cool conventional air-cooled air conditioning coils. These systems are also used to pre-cool air for gas turbines and other industrial operations. These pre-cool systems use the same evaporative technology and have the same considerations as conventional evaporative coolers. The cool, humid air is then drawn through conventional air coils of an air conditioning system.

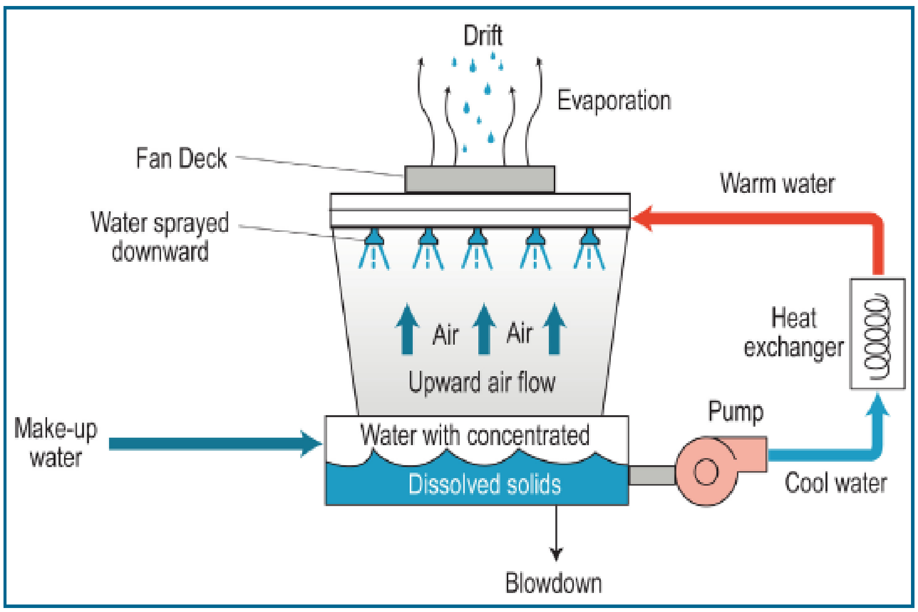
Cooling Towers

Common applications of cooling towers in the CII sectors are to remove heat (unwanted energy) generated by a manufacturing process and for air conditioning and refrigeration equipment. Warm water from process or cooling equipment is introduced at the top of a cooling tower and trickles over a packing material, such as plastic corrugated fill. The water breaks up into a film or droplets over the packing material to maximize surface area, which in turn maximizes evaporation. Water collected in the well at the bottom of the tower is recirculated through the process. Recirculating water undergoes a temperature change of about 5°F to 15°F through this process. The water is usually cooled to within 10°F of the wet-bulb temperature.[154] Water circulating through the cooling tower loop is called the mass flow, and can vary from 100 to 200 gallons per ton-hour[155] depending on the change in temperature. The flow is just less than 150 gallons per ton hour for a 10°F change in water temperature as it's pumped through the heat exchanger.

There are two basic cooling tower configurations:

- Counter-flow towers draw air from the bottom while water is continuously sprayed onto the top of fill material in the tower.
- With cross-flow towers, air is drawn in from the side and across the fill, while water is sprayed from the top in a manner identical to counter-flow configurations. Fans can be located at either the outside or the bottom of the towers (forced-draft) or on top of the tower to draw the air out the top (induced-draft).

Figure 7.49 shows the general operation diagram for cooling towers and Figure 7.50 shows an actual cooling tower in operation.



Source: US. Department of Energy, Federal Energy Management Program

Figure 7.49 - General Water Flow Diagram for a Cooling Tower

[154] The wet-bulb temperature measures how much water vapor the air can hold at current weather conditions.
[155] One ton-hour is equivalent to 12,000 BTUs by definition

Figure 7.50 - Marley Counter-Flow Towers

Cooling Tower Water Quality Considerations – *Cooling Systems*

Water quality is critical for cooling towers. The materials that the tower and heat exchanger equipment are made from, the quality of the makeup water, and the type of treatment provided determine the tower's safe cycles of concentration.[156] Factors to consider include:

- Scaling - the buildup of calcium, magnesium, or silica deposits on tower surfaces and more importantly, the heat exchanger surfaces. These deposits restrict flow and significantly reduce thermal efficiency. Calcium carbonate precipitates when concentrations are above 750 to 850 mg/l and silica can form a very hard scale on hot surfaces at concentrations as low as 120 mg/l.
- Corrosion - the oxidation of metals due to rusting and other forms of corrosion causes pitting, rusting, and deterioration of metal surfaces.
- Biological fouling - the growth of algae and bacteria causes fouling of heat exchanger surfaces and of cooling tower fill and basin material. It also promotes corrosion and deterioration of tower surfaces.

Towers also act as huge air scrubbers as they operate, capturing dirt, insects, and airborne debris.

As the conductivity increases (salt concentrations increase), metals are more susceptible to corrosion. The type of material that the tower and exchanger are made of determine this susceptibility. Many commercial operations operate towers at water conductivities of 3,500 microSiemens (µS) or less. The standards

[156] Cycles of concentration represents the accumulation of dissolved minerals in the recirculating cooling water; how many times the water can be reused before too much dissolved mineral build-up affects operations and efficiency. Draw-off (or blowdown) is used principally to control the buildup of these minerals.

for pretreatment established by various authorities represent other considerations, and include TDS limits and limits for metals, such as cooper and zinc in the blowdown from the tower.

Managing the water chemistry of cooling tower water is not simple. Corrosion and scaling can easily damage both the cooling tower and the condenser equipment if not properly managed. Properly managing a continuously changing water chemistry that allows calcium carbonate and other minerals to deposit on metal surfaces, while also preventing metal corrosion, is a delicate balance. Various indices have been developed to help predict the corrosion/scaling balance points. These include the:

- Langelier Saturation Index
- Ryznar Stability Index
- Puckorius Scaling Index
- Larson-Skold Index
- Stiff-Davis Index
- Oddo-Tomson Index

Types of Water Quality Treatment

Over the years, many treatment methods have been developed to control water quality factors affecting cooling tower operation and efficiency. The type of treatment depends on the quality of the makeup water supplied to the tower and the desired cycles of concentration. The water can be treated (1) before it is fed to the cooling tower, (2) while the water is in the tower or piping system, or (3) by "side stream" systems that treat a portion of the circulating water in the tower.

The treatment of makeup water depends on the water chemistry and biology of the makeup water. The most common methods of treating makeup water before it is fed to the tower include:

- Filtration where particulates are an issue.
- Biocides such as chlorine if biological growth is an issue.
- Softening if hardness is an issue.
- Chemical treatment to remove precipitants and silica where applicable.
- Demineralization such as nanofiltration or reverse osmosis where TDS are an issue.

Treatment of makeup water before it enters the cooling tower can significantly simplify in-tower treatment and allow for the use of tower chemical and physical treatment devices that may not otherwise be effective. Treatment of recirculating cooling tower water depends on the type of problem.

Choosing the optimal treatment process or combination of processes requires an understanding of water chemistry and the process for which the water is being used. Entities with cooling towers are strongly encouraged to consult reputable cooling tower treatment experts.

Scale Control

For scale-forming substances, the following types of treatment to reduce or prevent deposition are common:

- Deposition inhibitors that prevent scale by solubilizing it, preventing precipitation or modifying precipitates to prevent adhesion.
- Dispersants that use polymers and large molecules to adsorb solids and keep them in suspension.

Examples of chemicals used for scale control include phosphonates to prevent scale formation, acids to increase solubility, chelates, and polymers. The use of acid should be carefully considered. Most commercial sites do not have properly trained staff to handle these dangerous chemicals. Where used, pH controllers are recommended to control the addition of acid. Special storage must also be provided.

Corrosion Control

Corrosion of metal components is a major concern. For concrete basins, many of the same conditions that cause metal corrosion can also cause the concrete to deteriorate. Phosphate-based compounds (ortho-phosphate, polyphosphate, and others) and similar chemicals are often used for steel surfaces. In the past, other metals ranging from chromates to zinc and molybdate compounds were used. Chromates were banned years ago, and zinc and molybdenum compounds are now phased out since these can cause environmental contamination and they can be toxic. For copper, azole compounds have been used.

Salinity and pH levels are also important. Some treatment techniques maintain pH levels in the range of 8.0 to 9.0 to help reduce corrosion. Conductivity controllers help by keeping salinity levels at acceptable levels for the tower's construction materials. Ceramic and plastic materials are often used because they are corrosion resistant.

Biological Control

Bacteria can cause slime growth on heat exchange and cooling tower surfaces, promote certain types of corrosion, and cause significant chemical imbalances. Algae grow wherever sunlight is present and can cause similar problems. Cooling towers are classic sources of pathogen growth, such as legionella. Common methods of biological control include chlorine and bromine compounds and ozone to control bacteria and algae in the water column. Even shading to keep sunlight from entering the tower can help limit algae growth. Many new methods of cooling tower water treatment, such as the use of ultraviolet light disinfection, are now on the market.

General

Side-stream treatment of cooling tower water has been used for years and is effective for control of sediment, hardness, silica and other constituents that may affect water quality. Filtration, softening, chemical precipitation, and other methods are also available on the market.

Water Use Information – *Cooling Systems*

Single-Pass Cooling

The flow rate needed to cool the equipment depends on the amount of heat rejected by the equipment. Manufacturer specifications generally provide a flow rate. If not, the measured energy rejected by the equipment can be used to calculate flow rates.

Example: Manufacturer's Recommended Flow Rate

A piece of equipment has a recommended flow rate of 2.5 gallons per minute. How much water does it use in a day?

Equation 7.27

Water use = flow rate (gpm) X 1,440 = 2.5 X 1,440 = 3,600 gallons per day

Evaporative Cooling

The effectiveness of this type of cooling depends on the relative humidity of the outside air and the outside temperature. Evaporative coolers only work well in relatively dry climates. Under perfect conditions, the amount of water that must be evaporated to provide one ton of air conditioning is 1.48 gallons/hour, based on the latent heat of water of 970 BTUs per pound or water evaporated. Water is also needed to flush out dissolved solids from the supply water so these salts do not build up and precipitate out on the pads and in the cooler basin. Current models can use between 3 to 15 gallons/hour of water per ton-hour according to the Alliance for Water Efficiency.

Cooling Tower

The amount of water a cooling tower uses depends on two main factors:

- The amount of heat discharged to the tower.
- The cycles of concentration.

The amount of water used by a cooling tower (makeup water) primarily depends on the amount of heat dissipated by evaporation, the amount that must be discharged to prevent the buildup of dissolved minerals and salts (blowdown). The amount of water lost through drift, leaks, overflows, and other losses can also affect the amount of makeup water required. This can be expressed in a simple equation (Equation 7.28).

Equation 7.28

$$M = E + B + D + L$$

Where M = Makeup, E = Evaporation, B = Blowdown,
D = Drift and wind loss and L = Leaks, overflows, and other losses

Evaporation and Blowdown

Heat drives evaporation. Table 7.39 estimates the evaporation that will occur per ton-hour of heat rejected. When the amount of heat rejected to the tower (BTUs) is known, the process row in Table 7.39 should be used to estimate evaporation.

When the chilled water system's efficiency is maximized, the total heat load to the tower will be lower and will successively lower the evaporation per ton-hour of actual heat removed in the refrigeration process. When a chilled-water cooling system (chiller) works, it pumps heat from the building, including the heat generated by the cooling system, to the cooling tower. It takes energy to pump the water in both the chilled water and cooling tower loops in order to operate the air handling units in the buildings and the compressor. A compressor may be rated at 0.5 kilowatt-hours per ton-hour, but when all of the other pump and air handling unit energy is added, an additional 0.1 to 0.15 kWh of energy is typically needed per ton-hour.

Table 7.39 shows the effect of this additional energy on the amount of water evaporated per ton-hour of actual cooling achieved for comfort inside a building. The higher the energy efficiency ratio of the system, the less water it needs. Compressor efficiency has improved significantly over the last few decades. Compressors with an efficiency rating of 0.5 kWh/ton-hour or less are available, but even with these very efficient systems, total loads per ton-hour of actual cooling will be in the 0.6 to 0.7 kWh/ton-hour range. Most total system energy efficiencies are currently under 1.0 kWh per-ton hour, even for less efficient systems. Nonetheless, the amount of water evaporated per ton-hour of actual cooling in a building can range from 1.67 gallons per ton hour to 1.86 gallons per ton-hour of total chiller system operation.

Table 7.39 - Impact of Air Conditioning System Efficiency on Water Evaporation

System Efficiency *(kWh / ton-hr.)**	**Energy Efficiency Ratio (EER)** *BTU's/ Watt-hr*	**Coefficient of Performance (COP)** *BTU's Removed/ BTU's Input*	**BTU's Rejected to Tower per hr**	**Gallons Evaporated per Ton Hour**
1.50	8	2.3	16,608	2.05
1.00	12	3.5	15,072	1.86
0.75	16	4.7	14,304	1.76
0.50	24	7.0	13,536	1.67
Process	N/A	N/A	12,000	1.48
One ton-hour = 12,000 BTU's per hour = 12.66 Million Joules per hour = 3.52 kWh of heat energy to the tower.				
* kWh / Ton-hr. is often abbreviated to kW/Ton				

The gallons evaporated per ton-hour of cooling multiplied by the hours of operation will equal the actual amount of water that will be evaporated. This will provide the "E" in Equation 7.36, [M = E + (M ÷ CC)].

When warm water from a process or an air conditioning compressor is returned to a cooling tower, its energy is dissipated to the atmosphere primarily by evaporation. The heat removed by evaporating one pound of water is approximately 970 BTUs and is known at the latent heat of evaporation. One gallon of water weighs 8.34 pounds, so the evaporation of one gallon removes 8,114.8 BTUs. One ton-hour of cooling is equal to 12,000 BTU's by definition. Therefore, 1.48 gallons of water is evaporated for every ton-hour rejected to the cooling tower.

As water evaporates, the dissolved minerals and salts in the makeup water remain. Additional water must be added (makeup) and some of the water in the basin periodically discharged (blowdown) to prevent minerals from building up and causing scaling and corrosion.

Drift and Wind Losses

Another type of water loss derives from drift and wind. It is caused by the entrainment of small droplets of water in the air stream as the fans force air through the tower or from wind blowing through the tower. If no drift eliminators are used, drift loss could be as high as 0.3 percent of circulation

Modern towers are equipped with very effective drift eliminators. Drift losses can be reduced to under 0.003 percent of the mass flow of the tower as reported by many manufactures. For a typical cooling tower, mass flow is in the range of 150 gallons per hour per ton-hour of cooling. With a modern drift elimination system, drift loss would be in the order of only 0.004 gallons per ton hour or under 0.3 percent of evaporation. This makes drift loss almost negligible. Drift eliminators also significantly reduce aerosols containing bacteria such as *Legionella* (causes Legionnaire’s Disease), as well as particulate deposition and salt deposits. The implication of this is that drift term (D) in Equation 7.29 can be dropped as part of the calculation.

Leaks and Other Losses

Leaks and other losses are primarily a maintenance issue. Well-maintained systems have little or no leak loss.

One common source of loss is an improperly set water level in the basin of the cooling tower. Water levels can be maintained with a float valve (see Figure 7.51) or ultrasonic level control valve (see Figure 7.52).

Figure 7.51 - Cooling Tower Float Valve and Overflow Pipe

Properly maintaining the float or level controller, eliminating leaks, and installing modern drift eliminators, simplifies Equation 7.28 to Equation 7.29:

Figure 7.52 - Ultrasonic Cooling Tower Level Control Valve

Equation 7.29

$$M = E + B$$

Cycles of Concentration

The next step in estimating water use for a cooling tower is to determine the cycles of concentration. The concentration of the minerals (salinity) in the blowdown divided by the concentration of the minerals in the makeup water is called the cycle of concentration (CC). This concentration of minerals is often called "total dissolved solids (TDS)" and is reported in milligrams per liter (mg/l) or parts per million (ppm).

Figure 7.53 shows the effect of increasing the CC on the total makeup water needed per ton-hour of actual heat removal based on system efficiency. Figure 7.53 makes two major points: first, energy efficiency saves water; second, after achieving six to ten CC, additional water savings are minimal. Figure 7.54 shows the diminishing water savings potential more dramatically. Going from 10 to 20 cycles of concentration only saves 0.10 gallons, while going two to five cycles of concentration saves 1.3 gallons of makeup water.

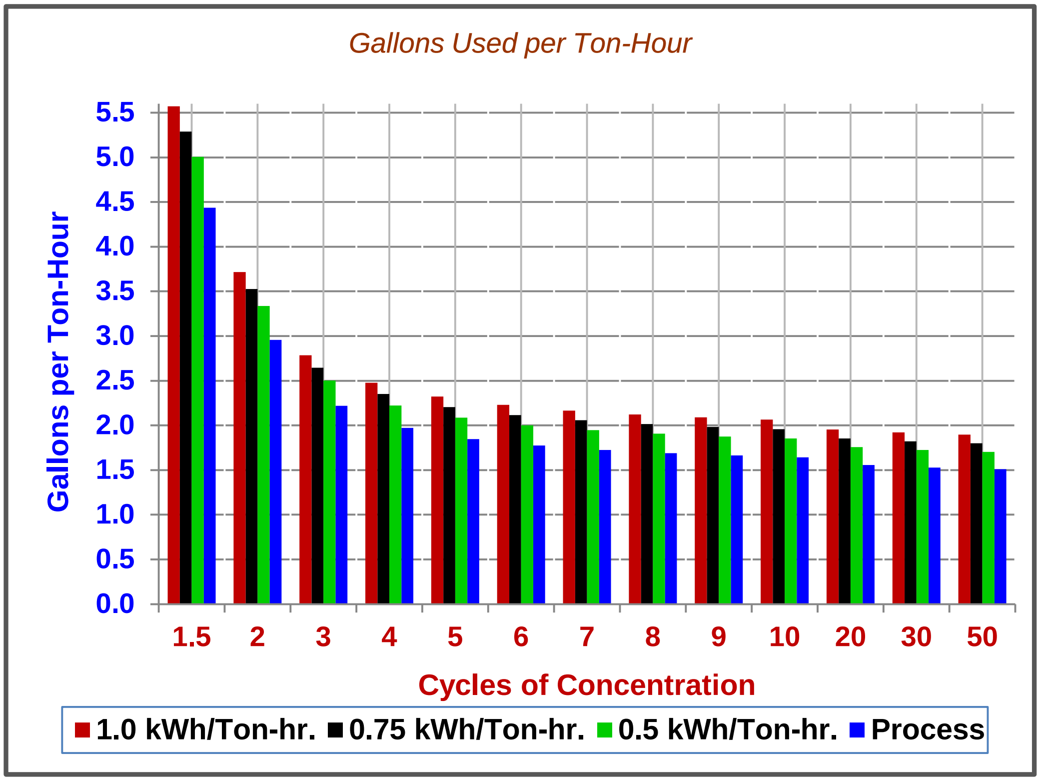


Figure 7.53 - Cooling Tower Makeup Requirements

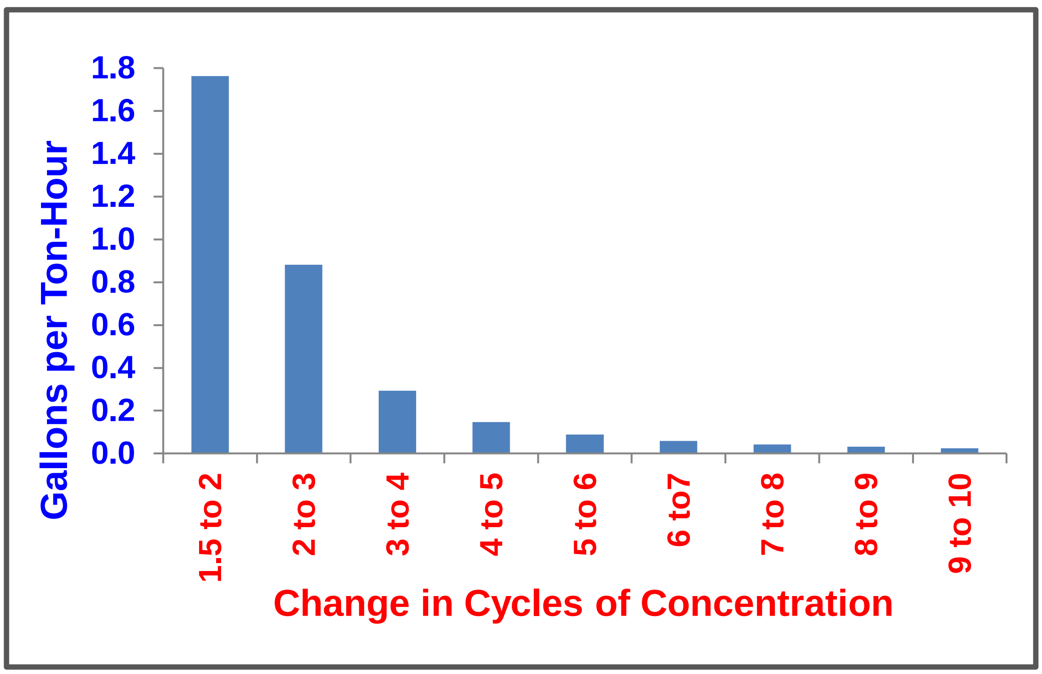


Figure 7.54 - Water Savings Potential

Since the electrical conductivity of the water is related to the TDS, conductivity can be used to estimate TDS. Conductivity is measured in microSiemens (µS). If the conductivity of the makeup water is 100 µS and the conductivity of the blowdown is 500 µS, the tower would be operating at five CC.[157]

Equations 7.30 and 7.31 show the calculation of CC.

Equation 7.30

Cycles of Concentration (CC) = Total Dissolved Solids (TDS) in Blowdown ÷ TDS in Makeup Water

$$CC = TDS\ (blowdown\ water) \div TDS\ (makeup\ water)$$

Where conductivity is used in place of TDS, as it is for all cooling tower controllers, the following equivalent equation should provide the same results.

Equation 7.31

$$CC = \mu S\ (blowdown\ water) \div \mu S\ (makeup\ water)$$

Conductivity can be used as an approximate substitute

If leaks, overflows, and drift are negligible, Equation 7.29 can be rearranged to provide an estimate of cycles of concentration:

Equation 7.32

$$CC = M/B$$

and therefore:

Equation 7.33

$$B = M \div CC$$

Equation 7.34

$$M = E + (M \div CC)$$

Equation 7.32 is an important check to determine tower efficiency. If the results of Equation 7.32 vary from the results of either Equations 7.30 or 7.31 by more than five percent, something is wrong. Either the conductivity probe or meter are not calibrated correctly, or there is a leak or failed drift eliminator. As cycles of concentration increase, the amount of makeup needed and thus the amount of water used by a cooling tower decreases, but only to a point.

[157] CC = 500 µS/100 µS = 5

General BMP Options – *Cooling Systems*

BMP for cooling systems occurs at several levels. Discussion of the technology and technical feasibility of energy efficiency measures and their cost is beyond the scope of this document.

Reducing Energy Input

The purpose of a cooling system is to get rid of unwanted energy. Any action that can reduce the amount of energy to be eliminated will reduce heat rejected to a cooling system. Where water is used as the cooling medium, these actions will reduce water use. Ways to reduce the load on a water-based cooling system, and therefore save water, include:

- **Energy Conservation.** Evaluate the processes in the plant for maximum energy efficiency and waste-heat recovery, since a more efficient building will reject less heat to the cooling tower.
- Energy conservation reduces the amount of waste heat generated and thus the cooling load regardless of the type of cooling system used. For example, for every ton-hour of energy savings for an air conditioning system using a cooling tower, 1.48 less gallons of water are evaporated, and at five cycles of concentration, about 2.25 gallons of makeup water are saved. Recovery of energy for water or space heating, operation of a desiccant drying operation as part of a desiccant cooling system, and preheating of material in an industrial operation are all examples of this strategy.
- **Use Non-Water Based Equipment/Processes.** Replacing processes or equipment with systems that do not require water cooling is the most obvious and one of the best ways to eliminate water use and save energy. Waste or unwanted energy can be discharged to the air, ground, or water. Where feasible, use cooling systems that reject waste heat (unwanted energy) directly to the atmosphere or to the ground.

Water Cooled System BMPs

If air-cooled or ground-cooled systems are not used, and cooling with water is the only option, it is important to choose the correct system.

Single-Pass Systems

- The BMP for single-pass systems should be elimination of this process. The only possible exceptions should be for medical emergencies.
- Where single-pass systems must be used, cool with non-potable water where feasible.
- Single-pass systems can also be connected to a chilled water or cooling tower loop, or a standalone reticulating refrigeration system

may be used. Recirculating refrigeration systems (Figure 7.55) are commonly found in laboratory and medical settings.

These systems typically use 0.5 to 1.0 kWh per hour of energy. Water use, based on actual audit data for such uses, averages 1.0 to 3.0 gallons per minute or 60 to 180 gallons per hour. Based on combined water and sewer rates for the six largest cities in California for 2010, water costs an average of $7.77 per thousand gallons. Thus, the value of the water saved by installing a chiller system ranges from $.47 to $1.40, while cost of the electricity to operate the system equals only $.05 to $.15.

Figure 7.55 - Recirculating Refrigeration System in a Chemistry Laboratory

Evaporative Coolers

The USEPA's 2009 WaterSense® Single-Family New Home Specification sets specific standards for evaporative coolers. WaterSense® recommendations are as follows:

Evaporative cooling systems – Evaporative cooling systems shall:

- Use up to 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 eight hours).
- Blowdown shall be mediated by conductivity or basin water temperature-based controllers.
- Once-through or single-pass cooling systems, systems with continuous blowdown/bleedoff, and systems with timer-only mediated blowdown management shall not be used.

In addition to the WaterSense® BMPs, for large systems of more than 50,000 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.

Automatic water and power shutoff systems for freezing.

Alternate Sources of Water

- The use of alternate sources of water, especially for cooling towers and cooling reservoirs, is one of the most effective ways to reduce the use of potable water in CII operations. Section 9 Municipal Recycled Water and Section 7.3.1 Alternate Onsite Sources of Water describe how these freshwater sources can be used in place of potable water. In all cases, it must be remembered that freshwater sources should also be used efficiently.

- Air conditioning condensate is of specific interest since it is produced as part of the air conditioning process.

Operation, Maintenance, and User Education BMPs
– Cooling Systems: Cooling Towers

Operational Considerations

Operational processes are the first consideration in the efficient operation of a tower.

- For towers larger than 500 tons, a continuous electrical record of operations should be available for downloading. If that record is not available, the operator should maintain a written shift log. A logbook also provides a written shift log. At a minimum, the shift log should contain:
    - Details of makeup 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, and appearance
    - A description of potential problems
- Above all, ensure that the employee responsible for the cooling tower operations is knowledgeable of what to look for when examining records and what to look for when visually examining the cooling tower.
- Operate towers at a minimum of five CCs using potable water, depending upon the chemistry of the makeup water used. In certain cases, where source water quality is high, CCs of as much as 15 may be achieved.
- Provide adequate training to cooling-tower operators and maintenance personnel.
- Perform a life cycle cost analysis, including all operating, capital, and maintenance costs, to determine the cost effectiveness of a cooling tower vs. air cooling.

Water Treatment Vendor Considerations

- Choose a water treatment vendor that will work with your facility.
    - Select a water treatment vendor that focuses on water efficiency. Request an estimate of the quantities and costs of treatment chemicals, volumes of makeup 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 in the contract. Increasing cycles from three to six reduces cooling tower makeup 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 BMP Options – *Cooling Systems: Cooling Towers*

- Install a conductivity controller that can continuously measure the conductivity of the cooling tower water and that 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 (µS/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 possible depend on the increase in cycles of concentration.
- Install flow meters on makeup 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 connected to an electronic data management system.
- Install automated chemical feed systems on large cooling tower systems of 100 tons or more. The automated feed will monitor conductivity, control blowdown, and add chemicals based on makeup

World's Largest GHP System

U.S. Department of Energy (DOE)

Office of Geothermal Technologies

Geothermal Heat Pumps (GHPs) for

Medium and Large Buildings

The Galt House East Hotel and Waterfront Office Buildings in Louisville, Kentucky, use a 4,700-ton GHP system to meet the heating and cooling needs of the complex. Completed in 1984, the 750,000-square-foot (70,000 m2) hotel uses a 1,700-ton GHP system that cost $1,500 per ton to install. In comparison, a conventional system would have cost between $2,000 and $3,000 per ton. As a bonus, the system saves about $25,000 per month in reduced energy costs and frees up about 25,000 square feet (2,323 m2) of additional commercial space that would have been needed to house conventional HVAC equipment. The Waterfront Office Buildings, built in 1994, add about 960,000 square feet (89,000 m2) of office space and almost 3,000 tons of GHP capacity to the project, making it the world's largest commercial GHP project. According to Marion Pinckley, Galt House designer and construction manager, water flow. These systems minimize water and chemical use while protecting against scale, corrosion, and biological growth.

- Install overflow alarms on cooling tower overflow lines, and connect the ~~o~~overflow alarm to the central location so that an operator can determine if overflows are occurring. This alarm can be as simple as a flashing light in the control area. More sophisticated systems may include a computer alert.
- Consider contacting the water service provider to determine if the facility can receive a sanitary sewer charge deduction from the potable water lost to evaporation. If the utility agrees to provide this deduction, calculate the difference between the city-supplied potable water makeup and the blowdown water that is discharged to the sanitary sewer.
- Use high-efficiency drift eliminators that reduce drift loss to less than 0.002 percent of circulating water volume for cross-flow towers and 0.001 percent for counter-flow towers.

Replacement BMP Options – *Cooling Systems: Cooling Towers*

Direct Expansion Air Conditioning

Cooling towers can be replaced with direct expansion (DX) air conditioning, which is technologically similar to home air conditioning, and is the most common type of system used worldwide. The DX systems cost less than chilled water-cooling tower systems per ton, but they are limited in size and have lower energy efficiency. A commercial example of the use of DX systems would be for a large department store. Multiple units would most likely be mounted on the roof. Because there are multiple units, only the units needed to achieve comfort in the building would be operated, so the units that are operating would be working at their optimal operational level. If one unit needs repair, the other units can continue to operate.

With large cooling tower systems, either expensive excess capacity must be installed or the facility must take the risk of being without adequate cooling if one chiller or tower must be taken out of service.

Geothermal Heat Exchange

Replace water heat sinks with ground source heat exchanges. Ground source heat exchange, often called geothermal heat exchange, is a rapidly growing segment of the air conditioning and heat pump market. According to the U.S. Energy Information Administration, sales tripled between 2004 and 2009. The ground can absorb significant amounts of thermal energy (hot or cold). In addition, summertime ground temperatures are always below daytime air temperatures. In California, average ground temperatures increase from below 60^{O}F in the north to the mid 70^{O}F range in the south. Ground source heat pumps are being used for a multitude of commercial operations ranging from schools to hospitals. These systems offer energy efficiencies similar to cooling towers in many cases, but they do not have the maintenance and liability issues associated with cooling towers. These systems can be operated in reverse in the winter for heating, thus eliminating the need for a dual cooling tower and boiler system. For office, school, and similar commercial operations, ground source heat exchange offers both convenience and energy savings with no evaporative water use.

Refrigerant Systems

Replace inefficient systems with refrigerant cooled systems. In recent years, variable refrigerant volume systems have come on the market. These systems use a working fluid such as Freon in place of the chilled water loop. They can be air cooled, ground cooled or water cooled, and they offer larger capacity and more application in commercial settings. The whole system is more efficient than older DX systems but less efficient than systems with cooling towers. These systems can also be used with ground source heat exchange systems making their energy efficiency levels similar to that of cooling tower systems without the use of water.

7.3.3.2 Heating Systems: Boilers

Overview – *Heating Systems: Boilers*

The term boiler can mean several things in the CII setting. Large water heating systems that do not "boil" water but simply heat it are often called boilers even though no steam is produced: these are not the focus of this discussion. The focus of this section is on steam-producing boilers.

Steam boilers are used in large building heating systems for cooking, operating steam turbines, or industrial heating operations. There are two main boiler configurations:

- The most common type is the fire-tube boiler, where the water tubes pass through the water being heated. Heat from the fuel's combustion passes through the tubes and turns the surrounding water to steam (see Figure 7.56).[158] Waste heat boilers are most often of the fire tube type in smaller operations.
- Another common type is the water-tube boiler. Water tube boilers are found in very large operations such as power plants. In these facilities, the water is contained in tubes that line a combustion chamber where gas, oil, or coal is burned.

The basic water conservation considerations for these two types of boilers are the same.

[158] New Mexico Office of the State Engineer. 1999. *A Water Conservation Guide for Commercial, Institutional and Industrial Users*. Page 68.

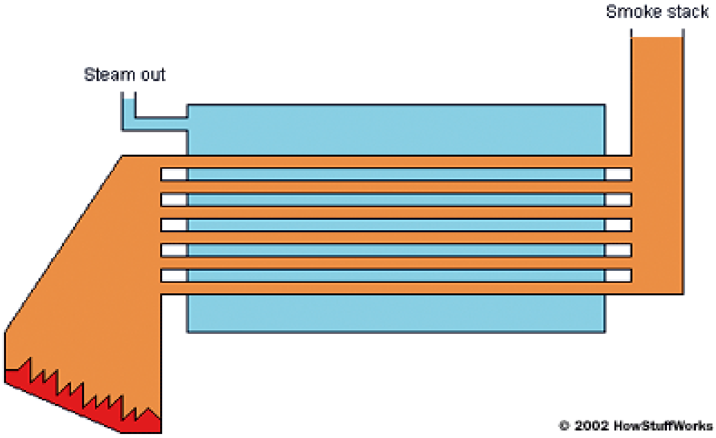


Figure 7.56 - Steam Boiler

Water Use Information – *Heating Systems*

To understand how to maximize water efficiency for a steam boiler, it is first necessary to understand how water is used in a typical boiler operation. Eight separate water uses and losses are typically associated with a steam boiler. These include:

- Makeup water to deaerator - Fresh water makeup to boilers is heated in a "deaerator" to remove air that can cause corrosion prior to feed into boiler.
- Condensate return to deaerator or boiler - Condensed steam that is returned to the boiler.
- Condensate loss - Condensed steam that is not returned to the boiler.
- Steam loss - Steam that is lost through leaks and other avoidable losses.
- Boiler water blowdown - Water from just below the top of the water level in the boiler that is discharged to control the buildup of dissolved minerals in the boiler.
- Flash-tank cooling water (tempering water) - When the boiler water is discharged, it must be cooled to under 140°F before it can be sent to a sanitary sewer. Once-through cooling is often used for this purpose.
- Sampler cooling water - The boiler blowdown must be cooled so it will not damage the conductivity controller probes. Single-pass cooling is often used for this.
- Mud blowdown - Sediments that collect at the bottom of the boiler need to be periodically purged by opening a valve at the bottom of the boiler. The frequency of this operation depends on the rate at which these sediments collect.

The water balance for the actual boiler can be written as a simple mass balance:

Equation 7.35

$$M = BD + CL + L$$

Where M = Freshwater Makeup, BD = Blowdown,
CL = Condensate Loss, and L = All other losses

Equation 7.35 does not address the water used to cool blowdown or to cool the sampler. These factors must be considered separately. As with cooling towers, the ratio of the minerals in the makeup water to the boiler water is used to determine the cycles of concentration (CC). It can be expressed as:

Equation 7.36

CC = Total Dissolved Solids (TDS) in Blowdown
÷ TDS in Makeup Water

Where conductivity is used in place of TDS, as it is for all cooling tower controllers, the following equivalent equation should provide the same results.

Equation 7.37

Conductivity can be used as an approximate substitute

CC=µS (blowdown water) ÷ µS (makeup water)

If leaks and other losses are negligible, Equation 7.35 can be rearranged to provide an estimate of CC:

Equation 7.38

$$M = BD + CL$$

In most cases, some condensate loss is inevitable. This loss is typically expressed as a percent of actual makeup to the boiler that is supplied by steam condensate. The calculation this effect requires that the pounds of steam produced be known. The facility may wish to consult an engineer to help with these calculations. In many cases, condensate loss is known. In those situations, the CC provides the percent of blowdown.

Operation, Maintenance, and User Education BMPs *– Heating Systems*

To improve water efficiency of boiler and steam systems, consider the following:

- Choose a water treatment vendor
    - Select a water treatment vendor that that focuses on water efficiency.
    - Request an estimate of the quantities and costs of treatment chemicals and the volumes of makeup and blowdown water

expected per year. Choose a vendor that can minimize water use, chemical use, and cost while maintaining appropriate water chemistry for efficient scale and corrosion control.

- Read water chemistry reports
    - Ensure the water treatment vendor produces a report every time he or she evaluates the water chemistry in the boiler. Upon receiving these reports, read them to ensure that monitoring characteristics such as conductivity and cycles of concentration are within the target range. Problems within the system can be identified quickly if proper attention is paid to the water chemistry reports.
- Maintain boilers, steam lines, and steam traps
    - Regularly check steam lines for leaks and make repairs promptly.
    - Regularly clean and inspect boiler water and fire tubes.
    - Develop and implement an annual boiler tune-up program.
    - Provide proper insulation on piping and the central storage tank to conserve heat.
    - Implement a steam trap inspection program for boiler systems with condensate recovery. When steam traps exceed condensate temperature, this program can indicate that the trap is leaking. Temperature can be monitored using an infrared temperature device.[159] Repair leaking traps as soon as possible.
    - Minimize blowdown
    - Calculate and understand the boiler's cycles of concentration. Check the ratio of conductivity of blowdown water and the makeup water. (Use a handheld conductivity meter if the boiler is not equipped with permanent meters.) This ratio should match the target cycles of concentration.
- Work with the water treatment vendor to prevent scaling and corrosion and to optimize cycles of concentration.
- Improve makeup water quality:
    - Consider pre-treating boiler makeup water to remove impurities, which can increase the cycles of concentration the boiler can achieve. Water softeners, reverse osmosis systems, or demineralization are potential pre-treatment technology options.

[159] North Carolina Department of Environment and Natural Resources. May 2009. *Water Efficiency Manual for Commercial, Industrial and Institutional Facilities*. Pages 49-52.

- Boiler water must be treated before use for all but the very low pressure-type boilers. Table 7.39 summarizes recommended boiler water concentrations from the ABMA.

Table 7.39 - ABMA Standard Boiler Water Concentrations for Minimizing Carryover

Drum Pressure (psig)	Boiler Water		
	Total Silica* (ppm SiO2)	Specific** Alkalinity (ppm CaCO3)	Conductance (micromhos/cm)
0-300	150	700	7000
301-450	90	600	6000
451-600	40	500	5000
601-750	30	400	4000
751-900	20	300	3000
901-1000	8	200	2000
1001-1500	2	0	150
1501-2000	1	0	100

Retrofit and Replacement BMP Options – *Heating Systems*

BMPs for boilers comprise of two main components. The first is reducing water through energy and water use efficiency, including: minimization of system water losses, controlling cycles of concentration, and using condensate return. The second involves water efficiency with blowdown and sampler tempering water.

Energy Efficiency

Energy efficiency is the first BMP for consideration. Since heat is used to provide energy, any reduction in energy use will reduce water use.

- For maximizing boiler water efficiency, energy and water conservation for equipment, appliances, and fixtures that use hot water is the first major component to reducing hot water use.
- Install recirculating hot-water systems for large buildings.

Minimizing System Losses

Fixing leaks and reducing other losses is the second most important factor. With the exception of hot water used for space heating and equipment heat transfer, most hot water is consumptively used and not returned to the boiler.

- Where a recirculating loop is used for space or equipment heating, it is also important to meter the makeup line to determine if that line is leaking.
- Install code-compliant steam-distribution lines and equipment with steam traps.
- Ensure that discharge pipes are easy to inspect for flow. Provide visible indicators that will show whether the valve has activated, thereby reducing plumbing leaks due to repeated openings of water-temperature- and pressure-relief valves (TPRVs).

Maximize Cycles of Concentration

Significant water savings can result from improving the boiler system management scheme. A key mechanism to reducing water use is to maximize the cycles of concentration.

- Installing an automatic blowdown control system is one way to minimize blowdown and maximize cycles of concentration.
- Proper control of boiler blowdown water is also critical to ensure efficient boiler operation and minimize makeup water use. Insufficient blowdown can lead to scaling and corrosion, while excessive blowdown wastes water, energy, and chemicals. The optimum blowdown rate is influenced by several factors, including boiler type, operating pressure, water treatment, and quality of makeup water. Generally, blowdown rates range from four to eight percent of the makeup water flow rate, although they can be as high as 10 percent if the makeup water is of poor quality with high concentrations of solids.[160]
- Operate closed-loop steam systems at twenty cycles of concentration or greater (5 percent or less of makeup water).

Maximize Condensate Return

From a water-efficiency standpoint, installing and maintaining a condensate recovery system to capture and return condensate to the boiler for reuse is the most effective way to reduce water use.

[160] U.S. Department of Energy. 2001. "Minimize Boiler Blowdown." www1.eere.energy.gov/industry/bestpractices/pdfs/steam9_blowdown.pdf, and U.S. Department Energy. 2001. "Return Condensate to the Boiler." www1.eere.energy.gov/industry/bestpractices/pdfs/steam8_boiler.pdf.

- Reduces the amount of makeup water required.
- Eliminates or significantly reduces the need to add tempering water to cool condensate before discharge.
- Reduces the frequency of blowdown, as the steam condensate is highly pure and adds little to no additional TDS to the boiler water.
- Since the steam condensate is relatively hot when it is added back to the boiler, less energy is needed to re-produce steam.

Metering, Measurement, and Control

Metering, measurement, and control are critical to good boiler operations and to minimizing water use. The following are BMPs recommended for boilers:

- Install an automatic blowdown control system, particularly on boilers greater than 200 horsepower, to control the amount and frequency of blowdown rather than relying on continuous blowdown.[161] Control systems with a conductivity controller will initiate blowdown only when the TDS concentrations in the boiler have built up to a certain concentration.
- Install a flow meter on makeup water line to monitor the amount of makeup water added to the boiler. Install makeup meters on feed-water lines (Refer to Section 7.3.2 Building Meters, Submeters, and Management Systems for recommendations on how to use the meter once it is installed.)
    - To steam boilers and water boilers of more than 100,000 BTUs per hour.
    - To closed-loop hot-water systems for heating.
- Install condensate return meters for all boilers of 200 horsepower or more in closed loop systems.
- Install automated chemical feed systems to monitor conductivity, control blowdown, and add chemicals based on makeup water flow. These systems minimize water and chemical use while protecting against scale and corrosion. Equip steam boilers of 200 boiler horsepower (hp) or greater with conductivity controllers to regulate top blowdown.

  Ensure that boiler-temperature and makeup meters are clearly visible to operators.

[161] East Bay Municipal Utility District. 2008. *WaterSmart Guidebook—A Water-Use Efficiency Plan Review Guide for New Businesses.* Pages PHOTO1-PHOTO8.

Tempering of Sampler and Blowdown Water

Conductivity Probe Cooling Water

To properly control blowdown, the conductivity of the water in the boiler should be measured with a conductivity probe, bearing in mind that the boiler water is very hot and can damage the probe. Use a sampler cooler to cool the water to a temperature that is suitable for the probe. These simple devices simply pass water through a heat exchanger that takes a small side stream of boiler water from the boiler either on a continuous or intermittent basis (Figure 7.57). Most samplers are simple single-pass cooling systems. Flow rates in the literature range from 1.0 to 2.5 gpm. This capture and reuse of sampler cooling water as boiler feed water may require constructing a collection tank to hold the cooling water until the system needs to send makeup water to the deaerator tank.

Figure 7.57 - Boiler Water Sampler Device

Blowdown Tempering Water

Blowdown tempering water is water used to cool the water discharged from the boiler to control dissolved solids buildup. For smaller boilers, it is the author's experience that large holding tanks that allow the blowdown to cool to below 140^{o}F may be used. For larger systems, heat recovery systems are commercially available that capture the heat and thus eliminate the single-pass cooling entirely.

Saving Potential – *Heating Systems*

Switching to an automatic control system can reduce a boiler's energy use by two to five percent and reduce blowdown by as much as 20 percent. A system can cost between $2,500 and $100,000. In some facilities, the water and energy savings can provide Payback within one to three years.

Both sampler and blowdown heat recovery systems save water and energy. The following example is from the U.S. Department of Energy's Energy Efficiency and Energy Renewable publication entitled Recovery Heat from Boiler Blowdown - www.eere.energy.gov:

Energy Savings Example: Heating Systems

In a plant where the fuel cost is $8.00 per million Btu ($8.00/MMBtu), a continuous blowdown rate of 3,200 pounds per hour (lb/hr) is maintained to avoid the buildup of high concentrations of dissolved solids. What are the annual savings if a makeup water heat exchanger is installed that recovers 90 percent of the blowdown energy losses? The 80 percent efficient boiler produces 50,000 pounds per hour (lb/hr) of 150-pounds per-square-inch-gauge (psig) steam. It operates for 8,000 hours per year. The blowdown ratio is:

Equation 7.39

$$\text{Blowdown Ratio} = 3{,}200 / (3{,}200 + 50{,}000) = 6.0\%$$

From the table, the heat recoverable corresponding to a six percent blowdown ratio with a 150-psig boiler operating pressure is 1.7 MMBtu/hr. Since the table is based on a steam production rate of 100,000 lb/hr, the annual savings for this plant are:

Equation 7.40

$$\text{Annual Energy Savings} = [1.7\ \text{MMBtu/hr}\ \times\ (50{,}000\ \text{lb/hr}/100{,}000\ \text{lb/hr})\ \times\ 8{,}000\ \text{hr/yr}]/0.80 = 8{,}500\ \text{MMBtu}$$

$$\text{Annual Cost Savings} = 8{,}500\ \text{MMBtu/yr} \times \$8.00/\text{MMBtu} = \$68{,}000$$

Table 7.40 - Recoverable Heat from Boiler Blowdown (MMBtu/hr)

Blowdown Rate % Boiler Feed Water	Steam Pressure, PSIG				
	50	**100**	**150**	**250**	**300**
2	0.45	0.5	0.55	0.65	0.65
4	0.90	1.0	1.1	1.3	1.3
6	1.3	1.5	1.7	1.9	2.0
8	1.7	2.0	2.2	2.6	2.7
10	2.2	2.5	2.8	3.2	3.3
20	4.4	5.0	5.6	6.4	6.6

Based on a steam production rate of 100,000 pounds per hour, 60^{o}F makeup water & 90% heat recovery.
Source: Recovery Heat from Boiler Blowdown - www.eere.energy.gov

7.3.4 Cleaning Industrial Vessels, Pipes and Equipment

Overview

Proper cleaning and sanitation represent a critical practice for such industries as food processing and pharmaceutical and cosmetics manufacturing. For food and pharmaceutical facilities, the U.S. Food and Drug Administration, U.S. Department of Agriculture, and state and local health agencies all have regulations overseeing these processes.

Cleaning and sanitizing is one of the more human-interactive operations within a facility. The use of hoses and spray equipment, physical removal of waste materials, timing of cleaning cycles, and the way in which cleaning equipment is used, are all controlled by the employees responsible for the operation. Any modification of these cleaning and sanitizing procedures requires that employees are part of the improvements. They must be trained, be aware of the need to reduce water use, and most importantly, be allowed to participate in the accomplishments. Some cleaning techniques, such as hand cleaning, the use of spray hoses, "manual scrub and wash down," and "fill and flush" are effective, but can use excessive amounts of water. This section examines ways to design facilities for ease of cleaning while reducing water use in the process.

Cleaning in these industries can be divided into several different areas discussed below:

- Clean in place (cleaning of pipes, tanks, processing vessels and transport tanks and trucks without taking them apart)
- Clean out of place (removing and cleaning and sanitizing parts)
- Can/bottle/package cleaning
- Crate and pallet washing
- Equipment and floor cleaning

7.3.4.1 Clean In Place

Overview – *CIP*

One of the most common cleaning and sanitizing operations is the cleaning of pipes, tanks, mixing vessels, cooking vessels, and other equipment that is permanently installed. Clean in place (CIP) systems use water, chemicals, and recirculation systems to clean the permanently installed pipes, vessels, and tanks. Factors that determine the cleaning effectiveness include circulation time, temperature, degree of agitation or spray action, and the formulation of cleaning solutions. Modern, efficient CIP systems typically use multiple tanks including chemical solutions tanks, and rinse water and water recirculation vessels. Multi-tank CIP systems (three or more tanks) are now considered the norm for most efficient facilities because of their water and chemical solution recovery versatility.

An example of a multi-tank CIP would be a five-tank system in a brewery that includes a caustic/surfactant tank, a phosphoric acid tank, caustic and acid wash recovery tanks, and a rinse water tank. Filtration, and even membrane processes, can also be used to clean washing fluids for reuse.

Three factors that promote water efficiency are:

- Good design
- Product recovery
- Efficient cleaning methods

Product Recovery

Maximizing the recovery of product from vessels, pipes, and tanks increases the amount of sellable product recovered and reduces the amount of material that must be cleaned. In food processing, options for product recovery include recovering edible product, recovering product for animal feed, and recovering product for other uses. All of these have the effect of reducing the amount of water needed to clean and sanitize, as well as reduce wastewater loading.

For pipe systems, recovering product includes:

- Using air to blow product out.
- Slug or pulse rinsing, where a small initial slug or pulse of water will carry a significant concentration of recoverable product.
- Pigging, which is the process of running a device (usually a soft rubber plug) through the piping to push and squeegee the product out. Pigging requires the installation of a "launch and recovery" system that allows the rubber device to be inserted at the front end and caught and recovered at the back end. The cost of these devices depends on the size of the pipe, the type of pig, and system design characteristics. The installed cost for such devices starts at under $20,000 but can go much higher for large diameter pipes. The product is pushed out of the pipe and can be recovered.

  Ice pigging is the process of using flake ice to push the material ahead of it through the piping system. It has gained favor in some situations since the ice only needs a launcher, can be incorporated in the product, and only small amounts of ice are needed. The pig is most often pushed with water, air, or the next product to be processed. An example of a pig pushed by a product is the switch from white to chocolate milk; the pig can help separate the products in the pipe without having to waste any product.

Cost considerations for CIP include cost of product lost, cost of water, solvent, chemicals, energy used, and waste disposal. In chemical and cosmetics plants, solvent use can also lead to air quality issues.

Cleaning Methods

For both vessel and pipe cleaning, the CIP system uses a combination of several steps to clean and sanitize pipes, tanks, and other vessels. The design of these systems and the sequence of cleaning determine their water, chemical, and energy use. Most CIP systems clean with a four step process: (1) first flush, (2) chemical cleaning, (3) sanitizing, and (4) intermediate and final rinses. In the parlance of the industry, CIP systems include wash and dump systems, which are the most wasteful kind, and single and multi-tank systems, which allow for better control, water recycling, and other advantages.

- **First Flush.** The first flush is designed to flush out remaining product from the pipe or tank. As the name implies, it is a way of "getting rid of" good product. The amount and intensity of this process is directly related to the amount of product left in the pipe or vessel and the characteristics of the product being flush out. That is why product recovery is important to water efficiency.

- **Chemical Cleaning.** Chemical cleaning formulations vary with the type of product being processed. Beer stone, milk stone (solid residues left behind in beer and milk processing), and food solids are examples of materials to be removed. Cleaning formulations include alkaline and acidic detergent washes.
- **Sanitizing.** Sanitizing involves either hot water or sanitizing chemicals. Peroxides, chlorine and bromine compounds, ozone, quaternary ammonia compounds, peroxyacetic acid, iodine compounds, and anionic acids have all been used.
- **Intermediate and Final Rinsing.** Intermediate and final rinses are used to remove chemical and sanitizing agents.

Operation, Maintenance, and User Education BMPs – *CIP*

- Train employees in proper CIP operations
- Maintain CIP equipment according to manufacturer's specifications and/or a regular inspection and maintenance program
- Allow adequate drain time for product recovery in vessels and tanks (including transport trucks).
- Use only a small amount of water or solvent to quickly spray the vessel to encourage better drainage of product adhering to the vessel. If the amount is small enough, the product recovered can often be incorporated into the final product.
- In pipe systems, optimize turbulence, time, temperature, and chemical cleaning agents to minimize water and energy use.
- Test water regularly and discharge only when its useful life is over.

Design BMP Options – *CIP*

Good design in the first step in water efficient CIP systems. Type of materials used and configuration of the system will make CIP operations more efficient.

Consider the following design factors to make CIP systems more efficient:

- Ensure that piping systems do not have sharp curves, joints, bolts and protrusions, or any areas where materials being processed can accumulate. Butt and flange welding, ball valves, and long radius elbows are examples of good piping systems.
- Tanks and vessels should be easy to clean.
- Eliminate "low places" in systems where material can accumulate.
- Using only easy-to-clean materials.
- Providing good access to all areas of equipment so it can be inspected and hand cleaned where necessary.

- Installing automated cleaning procedures to ensure constant operation.

Equipment BMP Options – *CIP*

Multi-Tank Systems

CIP equipment can have several configurations. Old wash and dump systems have given way to multi-tank systems that carefully control water use, capture and reuse water, and treat and filter water to be recirculated within the cycle. When replacing old wash and dump systems or installing new CIP systems, choose multi-tank CIP systems. Single- and two-tank systems are not considered to be as water efficient as multiple-tank systems, and are therefore not recommended as a BMP. Membranes and other treatments may be used to maximize recirculation of water. The reuse of filtered detergent water is common. Multi-tank operations also save energy and allow maximum recirculation.

Multi-tank CIP systems are available on the market. Costs depend on the size of the equipment needed, the nature of the substances to be cleaned, and the type of vessels and pipes to be cleaned. Costs range from $20,000 to over $1,000,000 depending on the application. Literature indicates that water use reductions of 30 to 50 percent are possible.

Automated Controls

With all of these systems, modern control technology and real-time analytical equipment help control temperature and determine optimal detergent and chemical concentrations, as well as the amount of waste products in rinse water, all of which contribute to both energy and water efficiency. Choose new or replacement equipment with automated controls to improve water efficiency.

Product Recovery

Large Vessels and Tanks

In the chemical industry and similar non-food industries, solvent used for washing can be recovered and product separated. Where the solvent is used to carry the product, the tank purge solvent can be used for the next batch of product.

Pipe Systems

Pigging systems – launcher, sensor, and retrieve and return systems – can be purchased for $20,000 and higher. Installation costs depend on the specific layout of the plant where installed. Water savings achieved by pigging system depend on the type of material being processed. Thick or semi-solid products, such as sour cream, are hard to rinse from pipes, so they can contaminate large volume of water. Pigging both recovers marketable material and reduces the amount of water needed to flush the product out.

Efficient Cleaning

While the overall process of efficient cleaning methods is similar for pipes, vessels, and tanks, there are some differences that need to be considered for tank and vessel systems compared to pipe systems.

Large Vessels and Tanks

- For vessels and tanks, the first step to efficient cleaning starts with good process control and, as mentioned above, good design. For process control, options to consider include optical devices to determine when rinse water is clear, level controls, and other methods ensure efficient operation.
- CIP systems for tanks and vessels typically employ spray ball technology. These devices range from simple balls with holes in them to high-pressure devices with multiple high-pressure nozzles that actuate turning devices that spray in multiple directions. The more pressure and directed force the ball has, the more efficiently it can clean. Some systems use booster pumps to increase pressure. Selection of the type of system to use depends on many factors, and many models are available. These systems are also useful for cleaning beer and wine casks, barrels, and vessels.
- CIP can also include use of manual spray hoses, including water jetting, or high-pressure sprays for hand cleaning of vessels such as tanks. These methods tend to be labor intensive, they often require entry into confined spaces, and they may consume large amounts of water, energy, and chemicals. Automated CIP systems offer many advantages.

Pipe Systems

- For pipe systems, cleaning and rinsing fluids are pumped through the pipes. Turbulence, time, temperature, and chemical cleaning agents are the factors that determine the optimum time required to clean pipe systems.

Example of a CIP Cycle Using Ozone

Typical 5-Step CIP Process

- Ambient temperature water rinse: removal of water-soluble residues
- Alkaline wash: removal of water-resistant residues
- Ambient-temperature or hot water and intermittent draining: removal of the bulk of the alkaline cleaning agent
- Peracetic Acid wash: neutralization of residual alkaline cleaning agent, de-mineralizes the surfaces of process equipment, and provides some corrosion control by neutralizing the caustic cleaning fluids.
- Final rinse and sanitization: hot water passed once through the circuit in bursts with intermittent drains, removing the acid cleaning agent and all other passivation residues. Final air blowing and draining.

Three-Step Ozone CIP Process

- Ambient temperature water rinses water-soluble residues from process equipment and interconnecting piping
- Alkaline wash: removal of water-resistant residues
- Ozone sanitization, rinse and flush. Final air blowing and draining

Source: Web: www.mksinst.com

Ozone Sanitation

In some systems, ozone can be used as a sanitizer. It is powerful, and it does not leave a residue, so rinse cycles may be eliminated, thus saving water and reducing wastewater strength. Since hot water use can often be reduced, hot water energy use may be reduced, but energy is also needed to produce ozone. Ozone applications require a benefit to cost analysis to determine their economic applicability on a case-by-case basis.

7.3.4.2 Clean Out of Place

Overview – *COP*

As the name implies, clean-out-of-place (COP) equipment is taken apart and washed. The simplest systems consist of vats that parts are placed in for hand cleaning. Modern equipment includes tunnel, cabinet, and emersion tank mechanical recirculation systems, as well as ultrasonic cleaning.

Operation, Maintenance, and User Education BMPs – *COP*

- As with CIP, It is important to test the water regularly so it is not discharged until its useful life is over. It is also important to minimize the vat size.
- Employee training and awareness helps workers' pay attention to small details.

Equipment BMP Options – *COP*

- The pharmaceutical industry commonly uses automated systems with verification-of-cleaning software. These systems may be applicable in other industries as well.
- Sanitizing baths (clean water with sanitizer) are often used to "soak" parts. Again, analyzing the water is important so sanitizer strength can be maintained instead of dumping. Sanitizer water can also be reused as first flush rinse water or even as wash water for the parts to be cleaned or for floor and area washing.
- The use of whitewater or ozone for cleaning and sanitizing offers opportunities to reduce the amount of rinse water needed in cleaning operations. Since hot water use can often be reduced, hot water energy use may be reduced, but energy is also needed to produce ozone. Ozone applications require a benefit to cost analysis to determine their economic applicability on a case-by-case basis.

7.3.4.3 Bottle/Can/Container Cleaning

Overview – *Bottle/Can/Container Cleaning*

The use of disposable bottles and cans has eliminated the dominance that returnable bottles used to have in the market. However, new bottles and cans can still contain foreign debris.

Bottle washers have two basic configurations: soaker washers and hydro-spray-washers. Steps in pre-used bottle washing include:

- Pre-rinse
- Label removal
- Caustic wash
- Rinse

Water use depends on such variables as the type of bottle being washed and the organic matter in the bottle.

General BMPs – *Bottle/Can/Container Cleaning*

- Water efficiency can be achieved through caustic water recovery, recirculation of final rinse water for caustic makeup, and reuse of water for the pre-rinse and label removal stages.
- For bottle washing systems, the water used for first flushing can often be recovered and reused.
- Membrane technology can also be used in some instances to recover water and chemicals used in the bottle washing process.
- Air blowing to clean new bottles saves water while ensuring that particles are removed before the bottles are filled.

7.3.4.4 Crate and Pallet Washers

Overview – *Crate and Pallet Washers*

Crates and pallets are integral parts of the food processing industry. Although they do not come into direct contact with the food, they need to be cleaned and kept free of debris so they do not soil the food containers. Crate and pallet washers have much in common with commercial dishwashers and laboratory cage washers. While both tunnel and cabinet washers are in use, tunnel washers are more common in larger operations. Tub, tote (wheeled container), and basket washers are also used. Baskets allow liquids to drain while tubs and totes are designed to contain liquids.

Equipment BMP Options – *Crate and Pallet Washers*

Water efficiency standards for crate and pallet washers have not been established. The company purchasing this equipment should compare equipment because these systems use significant volumes of water, energy, and detergent.

- Crate washers and pallet washers should be designed to recirculate water within the individual wash phases and to capture and reuse final rinse water for wash water use.
- Tunnel washers offer both water and energy saving potential. High-volume efficient models use five stages of cleaning. The pallets or

crates enter through a pre-rinse stage. Water used for this phase may be recirculated from the detergent wash stage overflow. The next stage is the detergent wash. Water efficient machines recirculate the hot detergent water through strainer and filter systems at high volumes. Internal water flow rates of over 100 gpm are common. The pallets or crates then move to a rinse stage. Some efficient models have a two-stage rinse process in which the final rinse is done with clean water that is then captured and used in a first rinse stage. Following the first rinse, that water may then be reused as makeup for the detergent wash. Tunnel washers costs are in the $100,000 and more range.

7.3.4.5 Equipment and Floor Cleaning

Overview – *Manual Cleaning*

A variety of situations require manual cleaning with spray hoses, pressurized spray rigs, cleaning brushes, cloths, and squeegees. Areas that cannot be cleaned by a CIP or COP system require manual cleaning, which can be one of the most labor and time intensive operations in a facility.

Design BMP Options – *Manual Cleaning*

Good layout and design of such areas as floors, exteriors of tanks and pipes, conveyor systems, and flumes are key to having facilities that are easy to clean.

Four principles should be incorporated into the design and layout of floors and walls:

- Proper sealing of floors and walls so that soil is easily removed and water does not penetrate.
- Sloping floors to floor drains so water can be removed easily.
- Minimizing floor joints and joints between floor and walls.
- Designing easily cleanable, well-sealed troughs and grates.
- Equipment design and layout are also critical for good cleaning. As with CIP and COP systems, crevices, sharp turns, and "nooks and crannies" where dirt and materials can accumulate should be avoided. For example, it helps to use welded tubes instead of bolted together angle iron supports, tanks and equipment with smooth easily accessible surfaces, and to leave room between equipment for ease of cleaning.

Operation, Maintenance, and User Education – *Manual Cleaning*

- Physical removal of waste product before washing saves water, chemicals, energy, and reduces pollution loading and pre-treatment costs. Floors should be dry cleaned with vacuum systems, brooms, or squeegees depending on the type of material being removed.

- For mixers, extrusion and molding equipment, conveyor belts, and other open equipment to which one can gain direct access, cleaning should start with physical removal of residual materials and then be followed by wet washing.
- Where water is used for cleaning, it is better to use a number of smaller volumes of water to clean than one very large volume. Four principles of wet cleaning are:
  - Use high-pressure, low-volume sprays.
  - Install shutoffs on all cleaning equipment.
  - Use detergents and sanitizing chemicals that are easily removed with minimum water.
  - Install and locate drains and sumps so water and wastes enter quickly to prevent the need for extensive use of a hose as a broom to move the waste to the drain.

7.3.5 Commercial Landscape

Overview – *Landscapes*

Landscape industry businesses are involved with production, distribution, and services associated with ornamental plants, landscapes and garden supplies, and equipment. Their activities involve nurseries and growers, landscape architects, irrigation designers, water managers, contractors and maintenance firms, and horticultural distribution centers. The public sector is involved with parks, schools, botanic gardens, and roadway landscaping. According to a 2011 study[162] conducted by the California Landscape Contractors Association (CLCA), the environmental horticulture industry has a total employment impact of nearly 260,000 full and part-time jobs. This figure does not include a large unreported element of landscape-related employment activity.

The 2011 CLCA study determined that environmental horticulture sales were $17.2 billion and the total economic impact to the California economy in 2007 was $25 billion, representing just over one percent of the entire state economy. The study found that the environmental horticulture industry payroll was $11.6 billion and total labor income impact was $8.28 billion. These figures do not include the economic contribution from a large unreported element of landscape-related industry in California.

This section addresses landscape BMPs and makes recommendations for CII water users. Many of the landscape BMP recommendations contained

The Task Force included landscape BMPs that recognizes the design and operating standards developed by DWR in the model landscape ordinance required by AB 1881 (Model Water Efficient Landscape Ordinance (MWELO) found in the California Code of Regulations, Title 23, Division 2, Chapter 2.7, which became effective in January 2010) and encourages their application to existing landscapes

[162] Palma, M A, Hodges A, and Hall CR. 2011. *Economic Contributions of the Green Industry to the California Economy in 2007.*

in this section come from the Model Water Efficient Landscape Ordinance (MWELO) found in the California Code of Regulations, Title 23, Division 2, Chapter 2.7, which became effective in January 2010. The MWELO document applies primarily to new and rehabilitated landscapes of 2,500 square feet or more. It is important to note that the landscape standards contained in MWELO were developed through input and full vetting of the issues from a broad base of stakeholders, including public interest groups, water providers, and the landscape industry. For that reason, many of the standards or BMPs contained in the MWELO form the basis for the recommended BMPs contained in this report. Since the MWELO standards do not apply to existing landscapes or to rehabilitated landscapes of less than 2,500 square feet, the BMPs recommended in this report would also apply to similar categories of existing CII landscapes. The MWELO document may be found at: www.water.ca.gov/wateruseefficiency/docs/MWELO09-10-09.pdf. In addition to MWELO, other pertinent landscape BMP resources are cited at the end of the section.

This report also includes a number of BMPs not addressed in the MWELO document, including the use of alternative water sources, graywater, artificial turf, alternative turf types, in-line drip (also called subsurface) irrigation, site review prior to design, site inspections during landscape installation, record keeping, and communication plans.

In addition to MWELO, the CUWCC has adopted a landscape BMP (#5) that, among other elements, requires signatory water providers to offer and conduct site water audits and to make recommendations for water use efficiency. Since CUWCC signatories account for approximately 90 percent of the urban water use in California, encouraging CII businesses to contact their water provider for a free site survey appears to represent an opportunity to capture additional water savings and thus is considered a CII BMP.

Water Use Information – *Landscapes*

Reported CII landscape water use represents nine to ten percent of urban water use and 25 percent[163] of total CII water use. However, landscape water use can range from zero to 100 percent at individual CII sites.

While much has been written about landscape BMPs, water saving studies for particular BMPs are limited and can have a wide range of values. This report provides the water savings from known studies.

Technical Feasibility – *Landscapes*

The landscape BMPs discussed in this report are all technically feasible. However, the cost-effectiveness of implementing a particular BMP may vary considerably from site to site, and, in some cases may be impractical. However, all of the BMPs discussed should, at least, be considered for implementation.

[163] East Bay Municipal Utility District and City of San Diego Water Department

BMP Options – *Landscapes*

Unlike indoor use in the CII sector, BMPs for landscape water use efficiency apply across all CII sectors and NAICS codes, with only their application and cost-effectiveness varying from site to site.

For the purpose of this report, the topics referenced below are considered landscape BMPs. The use of municipal recycled water is also considered a BMP and is discussed in Section 9.0. Municipal recycled water used in the landscape needs to meet certain water quality standards that address human and plant health concerns.

Savings Potential – *Landscapes*

The metric deemed appropriate for determining landscape water use efficiency is "water use divided by the irrigated area" and may include the following units of measure over time:

- Hundred cubic feet (ccf) per square foot
- Gallons per square foot
- Acre feet per acre

Knowing the irrigated area and the water use, an efficiency standard can be applied using known evaporation-transpiration (ET) data. ET data is accessible throughout California through an internet available through the DWR's weather station network.

The water savings from various landscape conservation measures can vary significantly due to the many variables affecting landscape water use. For example, the water savings from the largest study of "smart" ET controllers conducted in California cited an average statewide water savings of 6.1 percent[164]. However, a summary of 14 studies compiled by the U.S. Bureau of Reclamation cited "smart" controller water savings up to 41 percent with an average savings of around 25 percent. In a study conducted by the Southern Nevada Water Authority, water savings of 75 percent was cited by converting traditional landscapes to Xeriscapes. In a study conducted by the City of San Diego Water Department, water savings of five to six percent was cited as a result of City sponsored water audits for commercial landscapes. A water use survey conducted on hundreds of single-family residences in California found that 42 percent of the properties over irrigated by 138 percent. However, taking the single-family sector as a whole, the potential water savings was just over 15 percent. The City of San Diego Water Department estimates a potential landscape water savings of 25 percent from its customer base.

The studies indicate that sites properly managed following a landscape conversion to Xeriscape can achieve significant water savings. Based on

[164] East Bay Municipal Utility District, et al. 2009. *Evaluation of California Weather-Based "Smart" Irrigation Controller Programs*.

landscape water use data[165] in the CII sector, this would indicate a potential annual average landscape water savings of approximately 70 MGD in California.

7.3.5.1 Onsite Water Sources Landscape BMPs

Reusing onsite water can represent a significant water source available for landscape use. Potential onsite CII water sources for use on the landscape include cooling tower blowdown water, reverse osmosis (RO) reject water, graywater, retention basins, rainwater harvesting, and others. However, cooling tower blowdown and reverse osmosis (RO) reject water are high in TDS and may require further treatment or blending with other water sources before they may be used on the landscape. In addition, cooling tower blowdown water may contain biocides as part of the treatment process, which could be harmful to plants if untreated. Other onsite water sources may also have limited use because of water quality constraints.

Rainwater Harvesting

Rainwater harvesting, as the name implies, relies on catching and storing rainwater. It involves the use of tanks, cisterns, and catchment basins. Catchment basins may include the construction of berms and/or swales and are referenced in MWELO, Section 492.15. Detailed information on rainwater harvesting may be found at www.arcsa.org.

Retention Basins

Retention basins serve as a reservoir to collect rainwater and indoor water for such multiple purposes as soil percolation, runoff control, and landscape irrigation. There are standards and codes that address the construction of retention basins. Information on storm water retention can be found at a website sponsored by the California Storm Water Quality Association where there is a fact sheet for free downloading: https://www.casqa.org/store/products/tabid/154/p-171-fact-sheet-se-2.aspx.

The Regional Water Quality Control Board (RWQCB) governs storm water discharges via a permitting process. The permit requirements can vary from one RWQCB region to another. Permit information may be found at the RWQCB website at http://www.waterboards.ca.gov/water_issues/programs/stormwater/docs/stormwater_factsheet.pdf

Graywater

The use of graywater is allowed in the CII sector per Appendix G, Title 24, Part 5, of the California Administrative Code. Technically, since graywater is defined as “untreated wastewater” from bathroom sinks, showers and baths, and clothes washers, it is generally most practical for institutional use. Information on

[165] CII landscape use = Total urban use x 35% (CII use) x 25% (CII landscape use)

California graywater standards may be found at: www.water.ca.gov/wateruseefficiency/docs/Revised_Graywater_Standards.pdf

7.3.5.2 Design Factors Landscape BMPs

Landscape Alternatives

An important BMP includes consideration for the incorporation of permeable hardscapes into the landscape. Permeable hardscapes include the use of:

- Decking
- Gravel pathways or pervious pavers (used for driveways, walkways, patios, and others)

Landscape Design

The importance of appropriate landscape design cannot be overstated since a well-designed landscape can save water and minimize long-term maintenance costs. For large California urban water providers,[166] turf can account for approximately 50 percent of outdoor plant material and is responsible for approximately 70 percent of outdoor water use. Limiting turf to larger functional areas, and eliminating turf from narrow and other difficult to irrigate areas during landscape design, would substantially reduce outdoor water use. Landscape design BMPs are found in MWELO, Section 492.61. BMP landscape elements not addressed in MWELO include the use of synthetic turf, alternative turf choices, and subsurface irrigation.

Site Inspection

Prior to beginning the design process a physical site inspection will help designers understand and address issues important for water efficiency such as grading, solar orientation, wind direction, existing plant material, and others, as well as safety and operational considerations including underground utility lines and overhead structures.

Irrigation System Design

Proper irrigation system design, and understanding emerging water-efficient technology, is critical to efficient water use and involves numerous components ranging from the use of weather-based controllers to drip irrigation. BMP information may be found in MWELO, Section 492.7. Further savings can be realized by replacing overhead irrigation systems with some type of low volume irrigation. Please see the following case studies for examples of this type of landscape change: "Woodland Hills Country Club," "Brentwood High," and “West LA VA turf reduction” in Appendix C.

Subsurface Irrigation

In addition to MWELO irrigation BMPs, subsurface irrigation can be used to improve water use efficiency. Subsurface irrigation, also called ‘in-line drip irrigation’, is becoming increasingly widely used. Subsurface irrigation

[166] East Bay Municipal Utility District and the City of San Diego Water Department

minimizes soil evaporation, water loss due to wind drift, overspray, and runoff. It may also reduces pests and disease. Placing filter fabric a few inches below the drip line will help slow the percolation of water and help spread the water horizontally. An increasingly popular installation technique for subsurface drip irrigation for ground cover and shrubs involves placing the drip line on the surface and covering it with several inches of mulch. Because of the benefits of subsurface irrigation, it is recommended as a BMP, where practical.

Plant Material

A landscape should be designed to use low water-requiring plants best suited to the California climate. For example, the use of ornamental grasses, low-water use and deep-rooted ground covers, and alternative turf types, such as warm season turfs and buffalo grass, may result in substantial water savings. Warm season grasses are more typically found in southern California where the dormancy period, which results in a brown color, is much shorter than in northern California. Removing turf where it is not needed and replacing it with drought-tolerant shrubs and trees, permeable walkways, and mulch can lead to substantial water savings in commercial landscapes. Examples of turf removal areas can include non-playable areas of golf courses and decorative turf in front of Commercial buildings.

More information may be found at http://usgatero.msu.edu/v05/n21.pdf. A list of plants and their water requirements may be found in a document titled "Water Using Classifications of Landscape Species" (WUCOLS), located at: www.water.ca.gov/wateruseefficiency/docs/wucols00.pdf.

Hydro-zone

Plants should be grouped based on similar water requirements and site characteristics (e.g., root depth, solar radiation, location, slope, etc.), called 'hydro-zones', to help with irrigation design and application. The hydro-zone BMP is found in the MWELO document in Section 492.6.

Microclimates

A plant's water requirement can vary widely because of such influences as the amount of direct or indirect solar radiation (sun verses shade), wind, humidity, and temperature. These influences, called microclimates, need to be considered in the landscape and irrigation design process, and are referred to in the MWELO document in Section 492.6.

Grading

Appropriate grading should include a strategy to support plant health, reduce runoff, and retain more water on the site. BMP information on grading may be found in MWELO, Section 492.8.

7.3.5.3 Project Installation Landscape BMPs

Installation BMPs include:

- Communication between the designer, installers, and the end user.
- Installation per the approved specifications.
- Use of licensed contractors.
- Use of trained or certified workers.
- Installation of plants and irrigation system per BMPs.
- As-built documentation.
- Approved check-off list of installation, including controller maps, hydrozones, and station descriptions of plant type, irrigation method, and precipitation rate.

7.3.5.4 Operations and Maintenance Landscape BMPs

Maintenance

Proper landscape maintenance is critical to capturing a site's potential water savings over time. Maintenance BMPs include the development of a work schedule that addresses the need for:

- Use of trained or certified workers.
- Mulching.
- Irrigation system leak detection and repair.
- Review/fine tuning of the irrigation schedule.
- Winterization (if appropriate).
- Inspection of the site's back flow prevention device and water pressure.

In addition to the regular review of a landscape's various components, sites should also develop a communication plan between site staff and management that includes an emergency action plan for water shutoff.

Soil Management

Proper soil management is an important BMP because healthy soil can improve water use efficiency, plant health, and moisture retention. Information on soil management may be found in MWELO, Section 492.5.

Record Keeping

Proper record keeping involving the storage of design and as-built plans is important in detecting irrigation system problems and making repairs. Retaining information on advances in irrigation technology is also important as it can lead to further water savings if incorporated into the landscape.

Management: Communication

An important BMP includes performing regular site monitoring and communication between site staff and management to ensure that the irrigation schedule is correct, the irrigation system is functioning properly, the necessary repairs are being made, and the site is meeting its water budget.

7.3.5.5 Water Use Identification Landscape BMPs

Landscape Budgets

Water budgets involve developing a maximum applied water allowance for a given site. A landscape budget should be defined between the site owner and manager, water service provider, and landscape maintenance staff. Individuals responsible for irrigation programming, inspections, and audits to ensure experience and proficiency in water conservation techniques should be carefully selected. The water budget formula may be found in Section B1 of the MWELO document. Other information on landscape budgets may be found in MWELO, Section 492.4, and at the sites referenced in the "Irrigation System Design" section.

Metering/Submetering

Landscape water use needs to be metered or submetered[167] in order to determine water use efficiency for site water management. The MWELO document requires the installation of a dedicated water meter for new and rehabilitated landscapes 5,000 square feet or greater, and recommends dedicated irrigation meters for landscapes less than 5,000 square feet. Although not required by MWELO, existing landscapes should also be submetered with monthly reading of a submeter to help save water.

Irrigation Audits

Irrigation audits represent an opportunity to review the system's water use efficiency and make the necessary repairs and adjustments. Information on irrigation audits may be found in MWELO, Section 492.12.

Irrigation Scheduling

Proper management of a site's irrigation schedule is a critical component of efficient landscape water use. Information on irrigation scheduling may be found in MWELO, Section 492.10 and at the sites referenced in the "Irrigation System Design" section. Information on irrigation scheduling using weather data can be found at http://wwwcimis.water.gov/cimis/data.jsp.

[167] A submeter is defined as any meter downstream of a water provider master meter

7.3.6 General Building Sanitary and Safety Applications

Overview

CII businesses account for 15 to 25 percent of the total urban municipal water demand, according to the 2000 report, *Commercial and Institutional End Uses of Water*.[168] As significant water users, commercial and institutional facilities have the opportunity to conserve this precious resource, save energy, and minimize facility operational costs in the process.

Domestic water uses in sanitary fixtures account for 45 percent of total water use within a facility. Depending upon the type of facility and its occupancy, restroom and other sanitary uses, such as laundry, can provide significant opportunities to reduce water use. Figure 7.58 depicts the percent of total water use used for domestic functions in certain CII sectors.

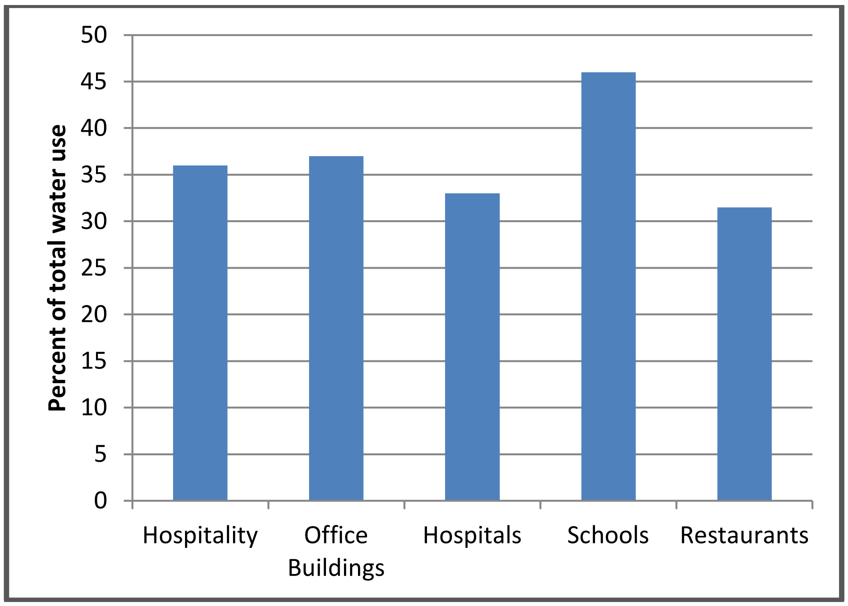


Figure 7.58 - Percentage of Water Used for Domestic Purposes
Created from analyzing data in: New Mexico Office of the State Engineer, Water Conservation Guide for Commercial, Institutional, and Industrial Water Users, July 1999 (original source: City of San Jose Environmental Services Department); Dziegielewski, et. al., Commercial and Institutional End Uses of Water, 2000; East Bay Municipal Utility District, WaterSmart Guidebook: A Water Use Efficiency Plan Review Guide for New Businesses, 2008; American Water Works Association, Helping Businesses Manage Water Use, A Guide for Water Utilities.

Technical Feasibility

All of the practices, products, and technologies described in this report section have been in existence for an extended period of time and found to be technically feasible. In each case, however, economic feasibility must be evaluated within the context of the physical condition and demands of the specific property or

[168] Dziegielewski B, et al. 2000. *Commercial and Institutional End Uses of Water*. 2000.

building being considered for high-efficiency sanitary fixtures and fixture fittings.

7.3.6.1 Toilet Fixtures (Water Closets)

Overview – *Toilet Fixtures*

The Energy Policy Act (EPAct) of 1992 established the maximum allowable flush volume for gravity tank-type, pressure assisted, electromechanical hydraulic, and flushometer-valve-type toilets sold in the United States at 1.6 gallons per flush (gpf).[169] The maximum flush volume for blow-out toilets, used primarily in locations subject to high traffic or heavy use (stadiums and other event venues), was set at 3.5 gpf. However, blow-out toilets[170] are no longer permitted in California. Due to the long useful life of toilets,[171] many toilets in CII use today are older and have flush volumes exceeding 3.5 gpf.

California's CalGreen code,[172] effective beginning in 2011, limits effective flush volumes for toilets (water closets) to 1.28 gpf [173] in new construction and renovations. In addition, Senate Bill 407 (2009) requires that ALL other commercial facilities be equipped with toilets flushing at 1.6 gpf or less on or after January 1, 2019.[174]

Although most early versions of the toilet fixtures flushed at 1.6 gallons or less, they did not necessarily perform well and thus did not always result in satisfied customers and users. As a result of these early problems, the plumbing industry embarked upon fresh product development to improve performance and restore customer confidence and satisfaction. Through extensive re-engineering of bowl hydraulics in the mid-1990s, manufacturers achieved significantly improved fixture performance. However, some fixtures remain today that do not meet user expectations for performance. As a result, the reputation of some early "low flow" toilet fixtures still exists, even though the products now available in the marketplace are superior to the early versions. Unfortunately, this carry-over reputation still influences the decisions of facility managers and design professionals as they attempt to implement water efficient practices and replace older fixtures with new high-efficiency products.

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169 California preceded this date with its own mandate for the 1.6 gpf maximum by about two years.

170 Blowout toilets are defined in the national standard ASME A112.19.2-2008/CSA B45.1-08 as follows: Blowout bowl — a non-siphonic water closet bowl with an integral flushing rim, a trap at the rear of the bowl, and a visible or concealed jet that operates with a blowout action.

171 Generally, the economic life of toilets is assumed to be 20 years for gravity-fed fixtures, 25 years for pressure-assist fixtures, and 30 years for flushometer valve-bowl combinations. In all cases, the physical life of these fixtures (when properly maintained) will be longer.

172 California Building Standards Commission (CBSC). 2010. California Green Building Standards Code – 2010 – CalGreen, CCR, Title 24, Part 11.

173 Effective flush volume as defined in CBSC, 2010. An exception to the 1.28 gpf maximum can be proposed where the project applicant chooses the performance path rather than the prescriptive path for indoor water use. Refer to paragraph 5.303.2 in the code. Some jurisdictions mandate the 1.28 gpf maximum without exceptions.

174 CUWCC. 2010. Interaction Among AB715 (Laird 2007), SB407 (Padilla 2009), and CALGreen Building Standards, August 26.

It is critical that facility managers use the information available today on fixture performance and durability to make their product purchase and replacement decisions. Performance information on many different models of toilets, gathered through independent laboratory testing, may be found at www.map-testing.com.

Types of Equipment – *Toilet Fixtures*

This section discusses the two common types of toilet designs installed in CII settings: tank-type toilets and flushometer valve and bowl combination toilets.

Tank-Type Toilets

Tank-type toilets are designed with a tank that stores and dispenses water to the toilet bowl to flush waste. Varieties of tank-type toilets include the standard gravity-fed units (found in most homes), pressure-assisted (also termed flushometer-tank toilets), and electrohydraulic-assisted toilets. Tank-type toilets are available as single, constant-volume flushing models or as dual-flush models, which include a full flush for solids and a reduced flush for liquids. Tank-type toilets are commonly found in residential and light commercial settings.

Flushometer Valve and Bowl Combinations

Flushometer valve and bowl combinations are tankless fixtures with either wall- or floor-mounted bowls attached to a lever- or sensor-activated flushometer valve. The valve releases a specific volume of water at a high flow rate directly from the water supply line (at line pressure) to the bowl to remove (flush) waste. Unlike tank-type toilets, flushometer combinations rely upon larger diameter water supply piping and high water supply line pressures to remove waste. These fixtures are also available as single, constant-volume flushing models, or as dual-flush models. Flushometer-valve-type toilets are used predominantly in public use facilities and high-use commercial settings.

A toilet flush can be actuated by manual mechanical levers, push buttons, or electronic sensors that trigger the flushing mechanism when a user has finished using the fixture. The hands-free sensors eliminate the need for human contact with the valve, but very often flush needlessly while the toilet is still in use,[175] as well as at other times. Studies have shown that hands-free sensor-activated valves actually increase water use when replacing conventional, manually-activated valves. As such, sensors themselves provide no additional water-efficiency benefits; however, they provide health and sanitation benefits in public use facilities since they offer an entirely hands-free option.

User expectations to be met when minimizing water use in a toilet operation include: (1) flush the toilet bowl clear, (2) transport waste through drainlines to the sanitary sewer, (3) operate reliably, and (4) have a leak-proof discharge valve.

[175] Known as “phantom flushes.”

Operation, Maintenance, and User Education BMPs
– Toilet Fixtures

Facility managers can reduce water use by taking simple steps to educate users on proper toilet use and maintenance:

- Train users to report continuously flushing, leaking, or otherwise improperly operating toilets to the appropriate management or maintenance personnel.
- Educate and inform users with restroom signage and other means to discourage the flushing of inappropriate objects such as personal hygiene products, wrappers, or other trash. Train custodial staff on how to handle the inappropriate disposal of such objects.

Tank-Type Toilets

For optimum tank-type toilet operation, consider the following:

- Periodically check to ensure the fill valve is working properly and the water level is set correctly. Check to see if water is flowing over the top of the overflow tube inside of the tank. Ensure that the refill water level is set approximately ¼-inch below the top of the overflow tube by adjusting the float to a lower position if the water level is too high. If the toilet continues to run (fill) after the float is adjusted, replace the fill valve. In order to prevent changes in tank water levels due to line water pressure fluctuations, only replace existing fill valves with pilot-type fill valves.
- Check annually to ensure the flapper is not worn, a condition that will allow water to seep from the tank into the bowl and down the sewer. To perform this check, drop a dye tablet or several drops of diluted food coloring in the tank. After ten minutes, if the dye has leaked into the bowl, then check for a tangled chain in the tank or replace a worn flapper. If leaking does not subside after a flapper valve is replaced, consider replacing the flapper seat and overflow tube assembly, which could also be worn. Further information and tips may be found at www.snwa.com/consv/leaks_toilets.html.

Flushometer Valve and Bowl Combinations

For optimum flushometer-valve-type toilet operation, consider the following:

- Annually inspect diaphragm or piston valves in flushometer-valve-type toilets, and replace any worn parts. To determine if the valve is in need of replacement, determine the time it takes to complete a flush cycle. A properly functioning flush valve should not have a flush cycle longer than four seconds.
- If replacing valve inserts, confirm that the replacements are consistent with the valve manufacturer's specifications, including the

rated flush volume. If replacing the entire valve, ensure it has a rated flush volume consistent with manufacturer specifications for the existing bowl, including the rated flush volume.

- Periodically check the control stop (which regulates the flow of water from the inlet pipe to the flushometer valve and is necessary for shutting off the flow of water during maintenance and replacement of the bowl or valve) is set to a fully open position during normal operation.
- Upon installation of a flushometer toilet, adjust the flush volume in accordance with manufacturer's instructions to ensure optimum operation for the facility's specific conditions. Periodically inspect the flush volume adjustment screw to ensure the flush volume setting has not been modified from the original settings; if it has, it could change the water use and performance of the product.
- Ensure that the line pressure serving the fixture meets the minimum requirements of the fixture manufacturer (minimums are commonly specified as 35 psi).
- If installed, check and adjust automatic sensors to ensure proper settings and operation to avoid double or phantom flushing.

Retrofit BMP Options – *Toilet Fixtures*

Tank-Type Toilets

Avoid retrofitting existing tank-type toilets with displacement dams or bags, early-closing toilet flappers, or valves with different flush volumes, because these devices could impede overall performance and could require increased operation and maintenance. Do not attempt to convert a single-flush 1.6 gpf toilet fixture to a dual-flush fixture with an after-market device.

The installation and use of these devices and other retrofit products can seriously affect fixture performance and could void manufacturer warranties.

Flushometer Valve and Bowl Combinations

In general, it is best to avoid valve retrofit options, such as valve inserts, that reduce the flush volume of flushometer-valve-type toilets. These products might not provide the expected performance when the original bowl is not hydraulically designed to function on a reduced flush volume. Double flushing commonly results when such a retrofit is made, negating any expected water use reduction. In addition, the use of these devices could void valve manufacturer warranties.

Dual-flush conversion devices are available for flushometer toilets. These devices usually replace the existing flush valve handle with a handle that provides a reduced flush volume for liquids and a standard flush for solids.[176] It should be noted that two types of dual-flush handles exist for such a retrofit, one in which the 'down' position of the handle activates a reduced flush and the 'up' position of the handle activates a full flush, and one with opposite positions. Water savings can be significantly different between the two types, because the 'normal' flush action by most users is a 'down' activation. Before embarking upon a full-scale retrofit, test the product on a select number of toilets to verify it achieves and maintains the desired performance. If feasible, remove automatic sensor system (if installed) and replace with manually activated flush valves, which are shown to significantly reduce water consumption.

Replacement BMP Options – *Toilet Fixtures*

Replace all toilets within the building to meet the California requirements as specified in CalGreen.[177]

Tank-Type Toilets

When installing new tank-type toilets or replacing older, inefficient tank-type toilets in accordance with CalGreen requirements,[178] choose WaterSense® labeled models (www.epa.gov/watersense/products). WaterSense® labeled tank-type toilets are independently certified to have an effective flush volume of 1.28 gpf or less, and pass a performance test to remove at least 350 grams or more of solid waste in a single flush.

Flushometer Valve and Bowl Combinations

When installing new or replacing older inefficient flushometer-valve-type toilets, choose models that are designed to use 1.28 gpf or less in accordance with the requirements of CalGreen. When considering 1.28 gpf or less flushometer toilets, carefully evaluate the physical conditions of existing drainlines and the availability of supplemental water flow upstream from the toilet fixtures to ensure that the conditions are appropriate for effective waste transport.

For maximum water savings and performance, purchase the flushometer valve and bowl in hydraulically matched combinations that are compatible in terms of their designed flush volume. A listing of matched and tested combinations may be found at www.map-testing.com/about/maximumperformance/flushometer.html.

Savings Potential – *Toilet Fixtures*

Water savings can be achieved by replacing existing 1.6 gpf and greater tank-type and flushometer toilets with high-efficiency models. Existing tank-type toilets can be replaced with WaterSense® labeled high-efficiency toilets, which

[176] When considering this type of retrofit, verify that the product has been certified to either ASME A112.19.10 *Dual Flush Devices for Water Closets* or IAPMO PS 50-2008 *Flush Valves with Dual Flush Device for Water Closets or Water Closet Tank with an Integral Flush Valves with a Dual Flush Device*.
[177] CBSC. 2010.
[178] CBSC. 2010.

can save between 1,400 and 2,100 gallons of water per user per year. Flushometer models can be replaced with high-efficiency models functioning at 1.28 gpf or less. To estimate facility-specific water savings use the following information:

Tank-Type and Flushometer Replacement with Efficiency Toilets

Current Water Use

To estimate the current water use of an existing toilet, identify the following information and use Equation 7.41 below:

- Flush volume of the existing tank-type toilet. Construction of new hotels, motels, apartment houses and dwelling with tank-type toilets using more than 3.5 gallons per flush was prohibited beginning in 1978. The law was expanded in 1983 to include virtually all toilets installed in California.[179] Toilets installed in California in 1992 and later generally have standard flush volumes of 1.6 gpf.
- Average number of times the toilet is flushed per day. This figure depends upon the facility's male to female ratio. Female occupants use toilets three times per day on average, while male occupants use the toilet once per day on average.[180]
- Days of facility operation per year.

Equation 7.41

Water Use of a Toilet (gallons/year) = Flush Volume (gallons/flush)
X Number of Flushes (flushes/day) X Days of Facility Operation (days/year)

Water Use After Replacement

To estimate the water use of a replacement tank-type toilet, use Equation 7.41, but substitute the flush volume of the replacement tank-type toilet. WaterSense®-labeled toilets use no more than 1.28 gpf on average.

Water Savings

Calculate the expected water savings by subtracting the water use after replacement from the current water use.

Savings Potential - California – *Toilet Fixtures*

An estimate of total potential statewide water savings that could result from the replacement of existing CII toilets with high-efficiency toilets was made in

[179] State of California Department of Water Resources, 1984. *Bulletin 198-84 Water Conservation in California*. Page 56.
[180] Vickers A. 2001, *Handbook of Water Use and Conservation*.

2005.[181] That analysis estimated the savings potential as being between 26,000 and 38,000 af/yr of water. Another 3,000 to 5,000 af/yr could be saved through legislation, codes, and standards applied to new construction.[182]

7.3.6.2 Urinal Fixtures

Overview – *Urinal Fixtures*

The Energy Policy Act (EPAct) of 1992 established the maximum allowable flush volume for all urinals sold in the United States in 1994 or after as 1.0 gallons per flush (gpf). Many urinals in facilities nationwide were installed prior to 1994, and thus, flush at higher rates, often between 1.5 and 3.5 gpf.

Many urinal fixtures installed today are high-efficiency urinals (HEUs). An HEU is defined as a fixture that flushes at 0.5-gallons or less. This definition includes existing 0.5-gpf urinals and non-water urinals, as well as the one-quart (0.25 gpf) and one-pint (0.125 gpf) urinals currently available in the marketplace from several manufacturers.

California's CalGreen code,[183] effective January 1, 2011, effectively limits flush volumes for urinals to 0.5 gpf[184] in new construction and renovations, thus mandating HEUs as the only urinal design allowed.

A current listing of HEUs available in the marketplace may be found at: www.map-testing.com/info/menu/urinals-and-heus.html.

Types of Equipment – *Urinal Fixtures*

Flushing Urinals

A flushing urinal is defined in the American national standard as "a plumbing fixture that receives only liquid waste and conveys the waste through a trap seal into a gravity drainage system."[185] Flushing urinals use water to remove (i.e., flush) the liquid waste from the fixture. Flushing urinals are available in several different designs and technologies. The most commonly used urinals found in California CII applications are washdown (or washout) urinals and siphonic urinals. Both require the user to depress a flush handle to activate a flushometer valve. Both types rely upon the supplied building water pressure for effective evacuation of waste. Gravity tank-type urinals are much less common and,

[181] Koeller J. 2005. *Evaluation of Potential Best Management Practices – High-Efficiency Plumbing Fixtures – Toilets and Urinals*.
[182] Provisions for HETs were subsequently mandated by the California Building Standards Commission through the provisions of CalGreen.
[183] CBSC. 2010. *California Green Building Standards Code – 2010 – CalGreen, CCR, Title 24, Part 11*.
[184] Effective flush volume as defined in CBSC, 2010. An exception to the 0.5 gpf maximum can be proposed where the project applicant chooses the performance path rather than the prescriptive path for indoor water use. Refer to paragraph 5.303.2 in the code. Some jurisdictions mandate the 0.5 gpf maximum without exceptions.
[185] American Society of Mechanical Engineers. ASME A112.19.2-2008/CSA B45.1-08*: Ceramic Plumbing Fixtures*.

similar to a tank-type toilet, rely upon the release of water stored in an in-wall cistern to provide the necessary head pressure to remove waste from the urinal. Siphonic jet urinals have an elevated flush tank and operate by using a siphon device to automatically discharge the tank's contents when the water level in the tank reaches a certain height. This type of urinal requires no user assistance.

Flushing urinals can be equipped with electronic sensors that activate the flushing mechanism when a user has finished using the fixture. As with toilets, sensors that activate a urinal flush valve provide no additional water-efficiency benefits; however, they provide health and sanitation benefits in public use facilities because they offer a hands-free option. If not properly maintained, however, automatic flush sensors can cause double or 'phantom flushing' of the urinal, actually increasing the water used at a facility.

Flushing urinals come in two basic types—standard, single-user, and trough-type, multi-user fixtures. Trough-type urinals are large fixtures designed for multiple users in high-traffic places, such as stadiums and sports arenas. Trough-type urinals are sold in 36-, 48-, 60-, and 72-inch lengths. Some older models were designed to run continuously, and consequently, consumed large amounts of water. New trough-type urinals use flushometer valves on preset timers, or they are equipped with electronic sensors.

Non-Water Urinals

Some urinals do not use water to flush the liquid waste from the fixture. A non-water urinal is "a plumbing fixture that is designed to receive and convey only liquid waste through a trap seal into the gravity drainage system without the use of water for such function."[186]

Most non-water urinals use a specially designed trap that allows liquid waste to drain out of the fixture, through a trap seal, and into the drainage system. Some use a cartridge that contains a liquid barrier seal to prevent the escape of odors and sewer gases. Other models feature cartridge-less designs that use a liquid barrier seal in the urinal's trap. A third type uses a self-sealing, mechanical waste valve trap that does not require a liquid barrier seal. Currently, U.S. plumbing codes prohibit these self-sealing mechanical trap designs.

Operation, Maintenance, and User Education BMPs – *Urinal Fixtures*

Flushing Urinals

For optimum flushing urinal performance, consider the following:

- Annually inspect the flushometer diaphragm or piston valves and replace any worn parts. If replacing valve inserts, verify that the

[186] American Society of Mechanical Engineers. 2006. ASME A112.19.19-2006: *Vitreous China Nonwater Urinals*, and International Association of Plumbing and Mechanical Officials. 2004. IAPMO Z124.9-2004*: American National Standard for Plastic Urinal Fixtures*.

replacements are consistent with the valve manufacturer's specifications, including the rated flush volume. If replacing the entire valve, ensure it has a rated flush volume consistent with manufacturer specifications for the urinal fixture itself. That is, the urinal fixture should be designed to function at the lower flush volume of the high-efficiency valve.

- Annually check and adjust automatic sensors, if installed, to ensure they are operating properly in order to avoid double or phantom flushing.
- Flushing urinals equipped with automatic flush sensors will often have an override switch allowing maintenance personnel to activate the flush manually. Activating the override switch may release a larger volume of water than is typical for the standard flush. Train custodial and maintenance personnel on how to clean and maintain urinals with automatic flush sensors to ensure that the urinal is returned to its intended flush volume after maintenance operations are completed.
- Train users to report continuously flushing, leaking, or otherwise improperly operating urinals to the appropriate management or maintenance personnel.

Non-Water Urinals

- If non-water urinals are selected for the facility, regularly clean and replace the seal cartridges or other materials as specified by the manufacturer, and rigorously follow all other manufacturer-provided instructions. Proper maintenance is vital to long-term performance of non-water urinals.
- Consideration should also be given to the enzyme products currently available in the marketplace for urinals; these tablets and pucks are specially formulated with the enzymes needed to forestall or prevent drainline buildup and, in some cases, the odors associated with non-water urinals.

Retrofit BMP Options – *Urinal Fixtures*

In general, avoid aftermarket parts for urinal retrofits that are designed to reduce the flush volume of valves. This includes aftermarket flushometer valve inserts that result in a lower flush volume, unless those inserts are rated to provide a flush volume compatible with the existing urinal fixture. Confirm compatibility with the urinal fixture manufacturer, as many new urinal fixture models are designed to function at several different flush volumes. If the flush volume of the valve insert is not compatible with the urinal fixture, it may not provide the expected performance, potentially leading to double flushing.

Replacement BMP Options – *Urinal Fixtures*

If feasible, replace all urinals in the building to meet the California requirements as specified in CalGreen.[187]

Choose WaterSense®-labeled models (www.epa.gov/watersense/products) when installing new flushing urinals or replacing older, inefficient flushing urinals. WaterSense®-labeled flushing urinals have been independently tested and certified to function at no more than 0.5 gpf. In addition, WaterSense®-labeled flushing urinals must meet specific criteria for flush performance and drain trap functionality and they are designed to be non-adjustable above their rated flush volume. These features provide for the longevity of water savings. The WaterSense® specification is applicable to the:

- Urinal fixtures
- Pressurized flushing devices that deliver water to urinal fixtures
- Flush tank (gravity-type) flushing devices that deliver water to urinal fixtures

It is important to choose a valve and fixture combination with matching rated flush volumes to ensure high performance and water savings.

Non-water urinals can also be considered during urinal installation or replacement. When considering the installation of non-water urinals or very low volume flushing urinals (e.g., one pint per flush urinals), it is critical that the condition and design of the existing plumbing system be evaluated and the expected usage patterns be assessed in order to ensure that these products will meet the expectations of the facility manager and users. Facility managers should be aware that non-water urinals are subject to rapid build-up of struvite[188] in the urinal drainline, which may lead to complete blockage of the drain. Preparation for such potential blockage issues must be accounted for making the decision to replace older water inefficient urinals with high-efficiency urinals (HEUs).

- As a good rule of practice, adhere to the guidelines outlined in the IAPMO Green Plumbing and Mechanical Code Supplement,[189] which requires at least one water supply fixture unit (i.e., a faucet or some other water using fixture) to be installed on the drainline upstream of the urinal fixture drain to facilitate drainline flow and

[187] CBSC. 2010.
[188] The inorganic mineral sediments found in non-water urinal plumbing drain pipes are comprised primarily of struvite ($MgNH_4PO_4.6H_2O$) Magnesium Ammonium Phosphate Hexahydrate, also known as MAP. Other inorganic mineral sediments occur as well, such as Hydroxyapatite $Ca_5(PO_4)_3(OH)$ and Calcite ($CaCO_3$) but at much lower concentrations. These sediments are soft, whereas sediments left in drainlines by flushing urinals are of entirely different material (calcite) and are hardened to the wall of the drainline and more difficult to remove. However, sediments resulting from flushing urinals require a much longer time than non-water urinals to build up and close off a drainline.
[189] International Association of Plumbing and Mechanical Officials. 2010. *Green Plumbing & Mechanical Code Supplement*. Page 9.

rinsing. Supplemental water or even periodic manual flushing of the drainlines is important because these non-water and very-low-volume urinals deliver little to no water to the drain to flush out any solids that may build up over time.

- It is also important to carefully adhere to manufacturer-recommended cleaning and maintenance requirements to ensure products continue to perform as expected.

Savings Potential – *Urinal Fixtures*

Water savings can be achieved by replacing existing flushing urinals with WaterSense®-labeled flushing urinals, which use no more than 0.5 gpf. If an older, existing flushing urinal is replaced with a WaterSense®-labeled model, a facility may save between 200 and 1,600 gallons of water per user per year. Assuming that the average urinal is flushed approximately 18 times per day and is in use 260 days per year, replacing a single inefficient 1.5 gpf flushing urinal with a WaterSense®-labeled 0.5 gpf model could save more than 4,600 gallons of water per year. There are, however, a large number of HEUs being offered by various manufacturers that function with one pint of water (0.125 gpf). The savings estimate should reflect the rated flush volume of the urinal selected. To estimate facility-specific water savings, use the following information:

Urinal Replacement – High Efficiency Urinal or Non-Water Urinal

Current Water Use

To estimate the current water use of an existing flushing urinal, identify the following information and use Equation 7.42 below:

- Flush volume of the existing urinal. Urinals installed prior to 1994 have flush volumes that typically range between 1.5 and 3.5 gpf. Urinals installed in 1994 or later generally have flush volumes of 1.0 gpf or less.
- Average number of times the urinal is flushed per day, which depends upon the number of male occupants in the building. Male occupants use the urinal two times per day on average.[190]
- Days of facility operation per year.

Equation 7.42

Water Use of a Urinal (gallons/year) = Flush Volume (gallons/flush) X Number of Flushes (flushes/day) X Days of Facility Operation (days/year)

[190] Vickers A. 2001. *Handbook of Water Use and Conservation*.

Water Use After Replacement

To estimate the water use of a replacement urinal, use Equation 7.42, substituting the flow rate of the replacement urinal.

Water Savings

The expected water savings is determined by subtracting the water use after replacement from the current water use.

Savings Potential - California – *Urinal Fixtures*

An estimate of total potential statewide water savings that could result from the replacement of existing CII urinals with high-efficiency urinals was made in 2005.[191] That analysis estimated the savings potential to be between 20,000 and 24,000 af/yr of water. Another 2,000 to 3,000 af/yr could be saved through legislation, codes, and standards applied to new construction.[192]

7.3.6.3 Shower Systems

Overview – *Shower Systems*

Residential-type showerheads are employed in a number of institutional and commercial applications, including dormitories, military housing, mixed-use commercial-residential projects, incarceration facilities, and transient lodging (hotels and motels). Specialized showers installed for safety purposes (eyewash and similar applications) are not included in this discussion.

Showerheads come in a variety of shapes, sizes, and configurations, including:

- Fixed showerheads, affixed overhead and permanently attached to the wall
- Handheld showerheads attached to a flexible hose that can be detached from the wall and moved freely by the user
- Body sprays (including spas and jets) that spray water onto the user from a direction other than overhead, usually from a vertical column on the shower wall

Each type is uniquely suited to perform a specific function.

To reduce overall water use, the Energy Policy Act (EPAct) of 1992 established the maximum allowable flow rate for all showerheads sold in the United States as 2.5 gpm. California's CalGreen code[193] limits flow for residential showers to 2.0

[191] Koeller J. 2005. *Evaluation of Potential Best Management Practices – High-Efficiency Plumbing Fixtures – Toilets and Urinals*.
[192] Provisions for HEUs were subsequently mandated by the California Building Standards Commission through the provisions of CalGreen.
[193] CBSC. 2010. *California Green Building Standards Code – 2010 – CalGreen, CCR, Title 24, Part 11.*

gpm[194] in new construction and renovations. It also prohibits multiple-head shower systems. Since 2011, manufacturers have designed and market showerheads that use as low as 1.0 gpm of water.

Recent consumer market research identified three key performance attributes to ensure user satisfaction under a variety of conditions: flow rate across a range of pressures, spray force, and spray coverage. Each of these criteria can be tested using a specific protocol that measures accuracy and reliability. All three criteria must be met to produce a “satisfactory” shower without using more water.

Operation, Maintenance, and User Education BMPs – *Shower Systems*

For optimum showerhead operation, system pressure should be tested to ensure that it is within the operating parameters of the showerhead necessary to ensure that the showerhead will deliver the expected flow and performance, usually between 20 and 80 psi. In addition, consider the following:

- Verify that the hot and cold water plumbing lines to the showerhead are routed through a shower compensating valve that meets the temperature control performance requirements of the American Society of Sanitary Engineers (ASSE) 1016 or American Society of Mechanical Engineers (ASME) A112.18.1/Canadian Standards Association (CSA) B125.1 standards when tested at the flow rate of the showerhead installed.[195] The compensating valve will prevent significant fluctuations in water pressure and temperature, and can reduce risks of thermal shock and scalding. A plumber can verify the compatibility of the showerhead and shower valve and, if necessary, install a valve that meets the recommended standards for showerhead flow rates.
- Periodically inspect showerheads for scale buildup to ensure flow is not being restricted; remove scale as needed.
- Train users to report leaking or malfunctioning showerheads to the appropriate maintenance or management personnel.

Retrofit BMP Options – *Shower Systems*

Because showerheads are relatively inexpensive, replacement is often more economical and practical than a retrofit. In general, avoid retrofitting existing inefficient showerheads with flow control inserts (which restrict water flow) or flow control valves (which can be activated to temporarily shut off water flow) to reduce the flow rate and save water. These devices may not provide adequate

[194] Effective flush volume as defined in CBSC, 2010. An exception to the 0.5 gpf maximum can be proposed where the project applicant chooses the performance path rather than the prescriptive path for indoor water use. Refer to paragraph 5.303.2 in the code. Some jurisdictions mandate the 0.5 gpf maximum without exceptions.

[195] For example, a 1.5 gpm showerhead must be accompanied by a compensating valve rated and certified to the standard at 1.5 gpm in order to safely protect the bather.

performance or physical safety in some facilities, and can lead to user dissatisfaction.

In certain circumstances, single shower stalls may have multiple showerheads that can be activated simultaneously or individually by the user. In many cases, when these showerheads operate simultaneously and water consumption exceeds the federal maximum flow rate of 2.5 gpm for an individual showerhead. In such cases, the showering system can be retrofitted to operate individually rather than simultaneously, or so total consumption is equal to or less than 2.5 gpm at any given time.

Replacement BMP Options – *Shower Systems*

When replacing old showerheads with new ones, choose WaterSense®-labeled models. WaterSense®-labeled showerheads (www.epa.gov/watersense/products) are designed to use 2.0 gpm or less, which is 20 percent more water-efficient than standard showerheads. In addition, WaterSense®-labeled showerheads are independently certified to meet or exceed minimum performance requirements for spray coverage and intensity (force). WaterSense® has established maximum and minimum flow rates at three different building line pressures: 80, 45, and 20 psi (the upper, mid, and lower range of potential household pressures).[196] In addition to the pressure and flow rate requirements, WaterSense® created criteria for spray coverage and intensity to ensure product performance under conditions of lower flow rates.[197] WaterSense®-labeled showerheads are independently tested and certified to meet these criteria before they receive the label.

While remodeling, avoid purchasing and installing multiple showerheads systems unless the heads can be operated separately or where the total volume of water flowing from all showerheads is never greater than the 2.0 gpm maximum prescribed by CalGreen.

Savings Potential – *Shower Systems*

If an older, existing showerhead is replaced with a WaterSense®-labeled model, a facility may save up to 1,200 gallons per showerhead per year. This replacement could result in Payback in as little as one year.[198] To estimate facility-specific water savings use the following information:

Conventional Showerhead Replacement

[196] The minimum flow rate is defined as a percent deviation from the maximum flow rate of the showerhead. For instance, the showerhead's flow rate at 20 psi cannot be less than 60 percent of the maximum flow rate (i.e., a showerhead with a maximum rated flow rate of 2.0 gpm will not flow at less than 1.2 gpm even in a living unit with very low water pressure).

[197] WaterSense requires that minimum spray force shall not be less than 2.0 ounces (0.56 newtons [N]) at a pressure of 20 ± 1 psi (140 ± 7 kPa) at the inlet when water is flowing. Also, the total combined maximum volume of water collected in the 2- and 4-inch annular rings shall not be less than 25 percent or more than 75 percent of the total volume of water collected.

[198] EPA's WaterSense. 2010. *WaterSense Specification for Showerheads Supporting Statement*. www.epa.gov/watersense/docs/showerheads_finalsuppstat508.pdf

Current Water Use

To estimate the current water use of an existing showerhead, identify the following information and use Equation 7.43 below:

- Flow rate of the existing showerhead. Showerheads installed since 1994 will usually flow at 2.5 gpm or less. Older showerheads may flow as high as three to five gpm. A simple measurement with a calibrated device can be used to determine the flow.
- The average shower duration is approximately eight minutes.[199]
- Average number of showers each person takes per day (usually one).
- Number of building occupants.
- Days of facility operation or residency per year.

Equation 7.43

Current Water Use of a Showerhead (gallons/year) = Flow Rate (gallons/minute)
X Duration of Use (minutes) X Uses per Person per Day
X Number of Building Occupants X Days of Operation (days/year)

Water Use After Replacement

To estimate the water use of a replacement WaterSense®-labeled showerhead, use Equation 7.43, substituting the rated flow rate of the replacement showerhead. WaterSense®-labeled showerheads use no more than 2.0 gpm.

Water Savings

The expected water savings is determined by subtracting the water use after replacement from the current water use.

7.3.6.4 Faucets

Faucets can be found in restrooms, kitchens, break rooms, and service areas in all CII applications. Lavatory (or restroom) faucets are designed for either private or public use. Private use faucets are generally found in homes, hotel guest rooms, dorms, barracks, and hospital patient rooms. Public use lavatory faucets are found in all other applications and are intended for unrestricted use by more than one individual (e.g., employees, visitors, or other building occupants) in facilities such as public restrooms in offices, malls, schools, restaurants, or other commercial, industrial, or institutional buildings. Different code requirements apply to public and private applications as noted below.

> A faucet accessory is defined as a component that can be added, removed, or replaced easily and, when removed, does not prevent the faucet from functioning properly. Faucet accessories include flow restrictors, flow regulators, aerators, and laminar flow devices. While faucet accessories can be incorporated into new faucet design to control the flow rate, most often, accessories are external components that attach to an existing faucet's end spout.

When improving faucet water efficiency in lavatories, there are two

[199] Mayer P W and, DeOreo W B. 1998. *Residential End Uses of Water*. Page 102.

different ways to apply technology: optimizing faucets and using faucet accessories.

In addition to typical, hand-operated components, lavatory faucets can be equipped with automatic sensors to trigger the on/off mechanism when a user places their hands under and removes them from the fixture. Automatic sensors do not provide additional water savings when compared to manually operated faucets,[200] but provide important health and sanitary benefits as a hands-free option. Some jurisdictions mandate the use of automatic sensors by code in certain applications for sanitary reasons.

Some restrooms can also be equipped with metered or self-closing faucets. When activated by the user, metered faucets dispense a pre-set amount of water before shutting off. Self-closing faucets, operated with a spring-loaded knob or other mechanical device, automatically shut the water off when the user releases the knob or lever.

CalGreen

California's CalGreen code,[201] effective beginning in 2011, limits flow rates for faucets in new construction and renovations as follows:[202]

Lavatory faucets (non-residential)	0.4 gpm
Lavatory faucets (residential)[203]	1.5 gpm
Kitchen faucets	1.8 gpm
Metering faucets[204]	0.2 gallons/cycle

Types of Equipment – *Faucets*

The standard flow rate of a faucet is dictated by its intended end use, as described below.

Private Use Lavatory Faucets

[200] Gauley B and Koeller J. March 2010. *Sensor-Operated Plumbing Fixtures, Do They Save Water?* In most cases, automatic sensors open the faucet valve completely when in use, whereas users of manually controlled faucets typically do not turn the tap fully on. All independent studies performed to date of faucet use in non-residential applications show that water use is significantly higher at installations equipped with sensor-activation when compared to traditionally manually operated faucets.

[201] CBSC. 2010. *California Green Building Standards Code – 2010 – CalGreen, CCR, Title 24, Part 11.*

[202] An exception to the faucet maximums can be proposed where the project applicant chooses the performance path rather than the prescriptive path for indoor water use. Refer to paragraph 5.303.2 in the CalGreen code.

[203] Applies to residential uses within an institutional setting and to residential within mixed use commercial structures.

[204] No gpm flow rate maximum.

The EPAct of 1992 originally established the maximum flow rate for all private use lavatory faucets sold in the United States as 2.5 gpm at 80 psi of line pressure. In 1994, the ASME A112.18.1 national standard lowered the maximum flow rate for lavatory faucets and lavatory faucet replacement aerators to 2.2 gpm at 60 psi in response to industry requests for conformity with a single standard. In 1998, the U.S. Department of Energy (DOE) adopted the 2.2 gpm at 60 psi maximum flow rate standard for all faucets (see 63 FR 13307; March 18, 1998). This national standard is codified in the U.S. Code of Federal Regulations at 10 CFR Part 430.32. Public Use Lavatory Faucets.

Public Use Lavatory Faucets

The ASME A112.18.1 American national standard was further amended in the mid-1990s to change the maximum flow rate for public faucets to 0.5 gpm; the three major model plumbing codes[205] all incorporated that standard by reference. Though not a federal regulation, 0.5 gpm became the national maximum permitted flow rate in all public use applications governed by one of the three plumbing codes, regardless of the EPAct. Despite these code requirements, many old and new public use faucets still have higher flow rates, typically between 2.0 and 2.5 gpm in violation of the prevailing national standard and plumbing codes.

Metering Faucets

Metering faucets are frequently found in public use applications, especially in high-traffic rest rooms. The EPAct of 1992 further addresses these types of faucets and sets a maximum water use of 0.25 gallons per cycle (gpc). It is important to note that there is no maximum flow rate per minute for metering faucets.[206]

Kitchen Faucets

Similar to lavatory faucets, the EPAct 1992 originally established the maximum allowable flow rate for kitchen faucets as 2.5 gpm at 80 psi pressure. The ASME A112.18.1/CSA B125.1 national standard lowers the maximum flow rate for kitchen faucets and kitchen faucet replacement aerators to 2.2 gpm at 60 psi. In response to industry requests for conformity with a single standard, DOE adopted the 2.2 gpm at 60 psi maximum flow rate standard for all faucets in 1998 (see 63 FR 13307; March 18, 1998). This national standard is codified in the U.S. Code of Federal Regulations at 10 CFR Part 430.32.

Thus far, national codes and voluntary standards have not attempted to further address the efficiency of kitchen sink faucets because their use is largely volume-

[205] International Plumbing Code (IPC), Uniform Plumbing Code (UPC), and National Standard Plumbing Code (NSPC)

[206] While EPAct, CalGreen, and the national standards and model codes all set a maximum quantity of water per cycle (event), there is neither time period nor maximum flow rate specified. Therefore, one cycle of use could consist of operating for 15 seconds at 1.0 gpm and be fully compliant with EPAct (12 seconds for CalGreen), OR operate for 30 seconds at 0.5 gpm (24 seconds for CalGreen), or any other combination that yielded a quantity of water at or below the prescribed maximum.

dependent. State and local jurisdictions have, in some cases, adopted lower maximum thresholds (CalGreen maximum flow rate is at 1.8 gpm at 60 psi). However, lowering the flow rate of kitchen faucets could lead to increased wait times for filling containers or for receiving hot water, which would affect performance and likely create user dissatisfaction.

Service Sink Faucets

Service sinks used in CII applications are multipurpose. Service sinks can be found in janitorial closets, laundries, laboratories, classrooms, or other areas. Federal regulations do not limit the flow rate of these faucets, but flow rate should be carefully considered for the intended end use, expected performance, and with water efficiency in mind.

Other Specialized Faucet Types

In addition to the service sink faucets noted above, there are other faucet functions that do not fall within the regulated categories of lavatory and kitchen faucets and, as such, have no Federal maximum flow rate. For example, these include sinks used for removing makeup in a theater setting, sinks used for washing athletic gear in a gymnasium, and sinks used for bathing infants, all of which require higher flow rates to accomplish the intended tasks.

Operation, Maintenance, and User Education BMPs – *Faucets*

For optimum faucet operation, test the system water pressure to ensure that it is between 20 and 80 psi, the range necessary for the faucet to deliver the expected flow and performance. In addition, consider the following:

- Periodically inspect faucet aerators for scale and sediment buildup to ensure flow is not being restricted. Inspection should occur every 6 to 12 months, depending upon local water quality. Clean or replace the aerator or other spout end device, if necessary.
- If installed, check and adjust automatic sensors to ensure that they are operating properly to avoid faucets from running longer or more frequently than necessary.
- Post materials in restrooms and kitchens to educate users of the facility’s water-efficiency goals. Remind users to turn off the tap when they complete their use.
- Train users to report continuously running, leaking, or otherwise malfunctioning faucets to the appropriate maintenance or management personnel.
- Do not use running water to thaw food products, and discourage this practice in food service operations.

Retrofit BMP Options – *Faucets*

For lavatory faucet retrofits in public restrooms, install faucet aerators or laminar flow devices that function at no more than 0.4 gpm, the CalGreen maximum.

For kitchen faucet retrofits, install aerators or laminar flow devices that achieve a flow rate of no greater than 1.8 gpm in accordance with CalGreen. Install temporary shut-off or foot-operated valves for kitchen faucets and faucets in food service operations. These valves close during intermittent activities such as scrubbing or dishwashing. The water flow can be reactivated at the previous temperature without the need to remix hot and cold water.

For all faucet retrofits in medical facilities (including medical research and patient care facilities), install laminar flow devices instead of faucet aerators. Since laminar flow faucets do not inject air into the water, there is a lower risk of bacterial contamination.[207] See Appendix C, California Hospital, for a case study.

For service sinks and specialized applications, install retrofit devices that reduce the water flow, but without inhibiting the function of the sink (i.e., if the sink's function is volume dependent, do not reduce faucet flow rate to the point that it has to be used significantly longer).

Replacement BMP Options – *Faucets*

For lavatory faucet replacement in private restrooms, look for WaterSense®-labeled lavatory faucets and faucet accessories (aerators or laminar flow devices) (http://www.epa.gov/watersense/products), which have flow rates of 1.5 gpm or less at 60 psi, no less than 0.8 gpm at 20 psi, and are compliant with CalGreen.

Savings Potential – *Faucets*

Water savings for both private and public use lavatory faucets can be achieved by retrofitting existing faucets with aerators or by replacing existing faucets with more water efficient ones. The same amount of water savings can be expected for a retrofit or replacement; however, retrofitting existing faucets with aerators will yield the shortest Payback period because of minimal costs. Retrofitting private use lavatory faucets used in dorms, barracks, hotels or hospital patient rooms with WaterSense®-labeled faucet accessories (such as an aerator) may save a facility between 160 and 220 gallons of water per user per year. Since WaterSense®-labeled faucet accessories typically cost less than $10, these devices normally pay for themselves in less than one year. At the same time, retrofitting public use faucets to reduce the flow rate to the CalGreen maximum of 0.4 gpm could save a facility between 150 and 600 gallons of water per user per year.

To estimate facility-specific water savings and payback, use the following:

[207] Federal Energy Management Program. n.d. "Federal Energy Management Program (FEMP) Online Training Center: Water Management Training, Faucets and Showerheads." http://femptraining.labworks.org/mod/resource/view.php?id=60

Faucet Retrofit or Replacement

Current Water Use

To estimate the current water use of an existing lavatory faucet, identify the following information and use Equation 7.45 below:

- Flow rate of the existing lavatory faucet. Faucets installed in 1996 or later generally have flow rates of 2.2 gpm or less (commercial applications may be as low as 0.5 gpm). Faucets installed between 1994 and 1996 generally have flow rates of 2.5 gpm or less. A simple measurement with a calibrated device can be used to determine the existing flow.
- Average daily use time. The average residential lavatory faucet use is approximately eight minutes per person per day.[208] For commercial and industrial applications, usage is approximately one-fourth of that amount.
- Number of building occupants.
- Days of facility operation per year.

Equation 7.44

Water Use of a Faucet (gallons/year) = Flow Rate (gallons/minute) X Daily Use Time (minutes/day/person) X Number of Building Occupants X Days of Facility Operation (days/year)

Water Use After Retrofit or Replacement

To estimate the water use after retrofitting or replacing an existing faucet with a water-efficient model or aerator, use Equation 7.44, substituting the flow rate of the retrofit or replacement. WaterSense®-labeled aerators use no more than 1.5 gpm. Manually operated public use lavatory faucets can be retrofitted with 0.5 gpm aerators.

Water Savings

The expected water savings is determined by subtracting the water use after replacement from the current water use.

[208] Mayer P W and DeOreo W B. 1998. *Residential End Uses of Water*.

7.3.7 Pools, Fountains and Spas

Overview

Pools, spas, and ornamental fountains with recirculating filtration and disinfection equipment can be found at homes, schools, gymnasiums, hotels, apartments, public parks, water parks, hydrotherapy pools, and businesses. These features provide recreational opportunities and aesthetic and artful attractions that benefit the community.

According to a 2009 Kenilworth Media, Inc. study,[209] there are 5.1 million in-ground pools, 3.7 million above-ground pools, and 6.6 million hot tubs in the United States. In 2007, approximately 131,000 new in-ground pools were sold with the Southwest (California, Nevada, Arizona, and Utah) accounting for 23 percent of sales nationally. Commercial pools (apartments, hotels, and motels) and public pools account for only three (3) percent of existing pools, but these commercial and institutional pools are the largest in size and water capacity. While the number of ornamental fountains is much smaller, they use essentially the same type of filtration and disinfection technology as pools.

According to the CUWCC's report, *Evaluation of Potential BMPs - Pools, Spas, and Fountains Purpose*, the number of commercial and institutional pools including apartment complex pools, in California is estimated to be 115,100 (Table 7.41). The report further estimates that there are 1.4 million hot tubs in California. If 90 percent of these hot tubs are residential, then there may be as many 140,000 commercial hot tubs in the state.

Table 7.41 - Estimated Number of Pool and Spa Facilities in California

Type	Number
Hot Tubs	1,400,000
In-ground Pools (residential)(single family)	1,062,000
In-ground Pools (multi-family, apartment)	50,000
In-ground Pools (commercial, public)	55,000
In-ground Pools (hotels & lodging)	10,000
Above-ground Pools (residential)	1,000,000
Olympic Pools	100
TOTAL (estimated)	3,577,100

This document describes water use by commercial and institutional pools, spas, and fountains, and it focuses on ways to achieve a higher degree of water use efficiency including information on: (1) evaporation, (2) filtration, (3) leaks, people use, and maintenance, and (4) total dissolved solids control.

[209] Pool & Spa Marketing, March 2009 www.poolspamarketing.com

System Components and Characteristics

Water use is the common denominator for swimming pools, hot tubs, splash pools, ornamental fountains, and similar water features. Although some "fill and dump" type systems (dumped and refilled ever day or two) are still unfortunately found, the use of recirculating filtration and disinfection equipment has been the industry standard for years. The few existing fill and dump facilities are being eliminated, so this report concentrates on pools, fountains, and other water features equipped with recirculation systems.

Evaporation, backwash, control of TDS, and cleaning and vacuuming of pools all are common, necessary elements associated with pools and fountains. Leaks, poor chemical and equipment maintenance, drag- and splash-out, and other wasteful practices all result in preventable water loss.

The first step in understanding how to reduce water use for pools, hot tubs, fountains or water features is to examine how modern systems work. Components of a modern recirculating system include a strainer, filter, pump, dump valve and intake (drain and skimmer), return flow connections, and piping. Figure 7.59 illustrates these features for a typical swimming pool. The illustration represents perhaps the most complicated type of system since it includes a heater.

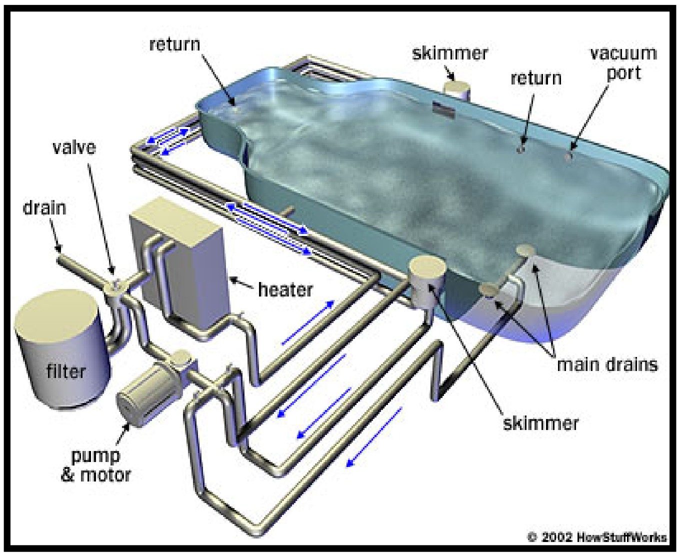

Figure 7.59 - Diagram of a Swimming Pool Mechanical System

The overflow and fill system of a pool can include perimeter-type overflow gutters, surface skimmers, other surface water collection system components, and their associated interconnecting piping. Most pools are also equipped with an equalization tank that operates at the same level as the water in the pool, providing a place separate from active pool use to reduce turbulence. The equalization tank prevents the fill or float valve from bouncing around when the pool is in use, which would result in wasting water. Figure 7.60 illustrates such an equalization tank and float valve.

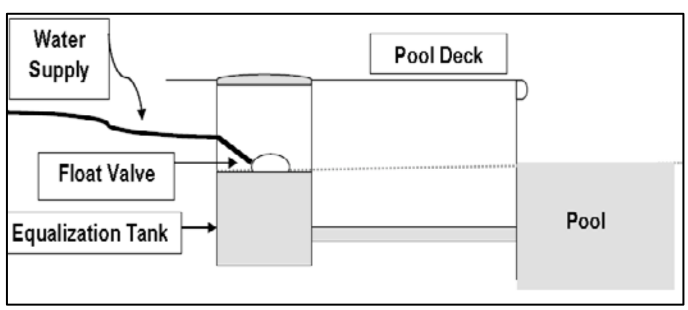

Figure 7.60 - Equalization Tank and Float Valve

The fill valve is most often a simple float assembly, but other water level devices, ranging from sonic sensors to elevation pressure sensors, are available. Pool overflows are usually simple standpipes or overflow thresholds that allow water to flow freely into the sanitary sewer or drain when the prescribed water level is exceeded.

The type and size of pools and spas varies depending on intended use and location. With the exception of official Olympic pool dimensions, there is no "standard size." However, Table 7.42 summarizes a “typical size” for pools and spas for various intended uses, ranging from above-ground residential pools to public pools to hot tubs.

Table 7.42 - Typical Pool Sizes*

Type of Facility	Area Sq. Ft.	Depth Feet	Volume Gallons
Hot tub	40	3	1,122
Above-ground	252	4	7,540
In-ground residential (single family)	450	4.5	15,147
In-ground apartment	800	4.5	26,928
In-ground hotel	1,000	4.5	33,660
In-ground public	4,000	5	149,600
Olympic	14,432	8	863,611

*Based upon examination of multiple pool installer web sites and conversation with officials from the Association of Pool and Spa Professionals - Southern California Chapter.

Equipment Operation

Turnover

Commercially operated pools, from apartment pools to public community pools, must comply with the operational requirements of the health codes. In California, pools used by the public must have turnover rates as shown in Table 7.43.

Table 7.43 - Required Public Pool Turnover Rates*

Type of Pool	Turnover Rate
Swimming Pool	Every 6 hours
Wading Pool	Every hour
Spa	Every 30 minutes

*California Health and Safety Code, Sections 116025-116068

Draining

Draining pools, spas, and fountains must be performed in accordance with local ordinances. Most require that water from swimming pools, spas, or decorative fountains be dechlorinated or debrominated prior to discharge to the street, storm drain, or sanitary sewer. Chlorine or bromine should dissipate within 48 hours for most pools. Some commercial pools operators may prefer to use dechlorination chemicals, but instructions must be carefully followed. Ordinances frequently require that the drain water not be discharged to the sanitary sewer. Owners of "salt pools" should consult their local wastewater and storm water officials before draining pools.

Water Losses

Pools, spas, and fountains with recirculation equipment have many ways in which water is lost, including:

- Evaporation
- Leaks
- Splash out
- Disinfection, cleaning and maintenance, and water quality control
- Filter operations

Controlling these losses and performing regular pool maintenance is critical to reducing water use and reducing waste.

The areas where savings can be found parallel these factors. Evaporation is the most significant component of water use and also drives the use of water for TDS control. Choosing the right filtration equipment is the second most significant way to reduce water use to minimize the amount of backwash required. The trilogy for maintaining water quality is filtration, sanitation (disinfection and pool cleaning), and circulation (keeping the water circulating through the filter and disinfectant feed system). Controlling water losses is described in the following subsections.

General BMPs

Regular inspection of equipment, checking for leaks, and keeping debris out of the pool are important components of proper pool operation. For pools with meters, readings of water use should be made at least every other week and records kept. All of these help ensure that both water and energy are used most efficiently.

Providing proper guidance on the operation of the equipment, maintenance of the pool and equipment, and timely repair of leaks all require more human intervention on a regular basis.

Potential Savings

Determining reductions in water loss by finding and fixing leaks, controlling splash-out and drag-out, providing shade and wind breaks, and implementing other BMPs is difficult to quantify. By modifying human behavior, using properly installed gutters and grates, installing and reading water supply meters to detect leaks, ensuring proper operation of equipment, and combining similar water use reductions could be in the range of tens of thousands of af/yr.

7.3.7.1 Evaporative Loss Reduction

Overview – *Evaporation Reduction*

Evaporation naturally occurs from all water surfaces. Evaporation includes natural evaporation and evaporation from heated pools and hot tubs.

<u>Natural Surface Evaporation</u>

In California, natural evaporation ranges from 40 inches per year in the northwest to 140 inches per year in the in the southeastern portion of the state along the Arizona border. In the populated areas where most of the pools and fountains are located, the evaporation rates are in the range of 50 inches to 75 inches per year, or 0.085 to 0.128 gallons per square foot per day.

The pool's surface area and location will determine how much evaporation occurs naturally. Pool and hot tub sizes range from 40 square feet (for hot tubs) to over 14,432 square feet (for Olympic pools). Table 7.44 summarizes natural evaporation from pools in various locations across California.

Table 7.44 - Approximate Average Annual Evaporation from Pools and Hot Tubs (gallons/year)

Typical Pool Area Square Feet		**Pool Size (surface area in square feet)**						
		40	**252**	**450**	**800**	**1,000**	**4,000**	**14,432**
City	Natural Evapor-ation (inches per year)	Hot tub	Above-ground pool	In-ground residential	In-ground apartment	In-ground hotel	In-ground public	Regulation Olympic
Sacramento	65	6,278	10,210	18,233	32,413	40,517	162,067	584,737
San Francisco	50	6,278	7,854	14,025	24,933	31,167	124,667	449,797
Berkeley	60	6,278	9,425	16,830	29,920	37,400	149,600	539,757
Fresno	75	6,278	11,781	21,038	37,400	46,750	187,000	674,696
Los Angeles	60	6,278	9,425	16,830	29,920	37,400	149,600	539,757
San Diego	60	6,278	9,425	16,830	29,920	37,400	149,600	539,757
Bakersfield	75	6,278	11,781	21,038	37,400	46,750	187,000	674,696
California Average	63.6	6,278	9,986	17,832	31,701	39,626	158,505	571,885
Source: Evaluation of Potential Best Management Practices - Pools, Spas, and Fountains Purpose, California Urban Water Conservation Council, September, 2010								

Heated Evaporation

A 2008 NRDC report[210] states that nationally only about 10 percent of pools are heated. By contrast, hot tubs are nearly always heated. Table 7.45 provides estimates of water loss from heated indoor pools, spas, and hot tubs. As the data shows, most heated swimming pool evaporation rates are similar to pan evaporation rates of 0.085 and 0.128 gallons per square foot per day. Hot tubs have a much higher evaporation rate of 0.41 to 0.45 gallons per square foot per day. Therefore, the average pan evaporation rate of 63.6 inches or 0.109 gallons per square foot per day is used for all pools and 0.43 gallons per square foot per day is used for hot tubs.

Table 7.45 - Evaporation from Heated Indoor Pools

Type of indoor heated pool	Water temp °F	Air temp °F	Evaporation Factor (gal/hr/sq ft)		Activity Factor	Gal/day/ Sq ft at 60% humidity	Gal/day/ Sq ft at 50% humidity
			60% humidity	50% humidity			
Residential	85	87	0.02	0.028	1	0.06	0.08
Hotel	82	84	0.019	0.026	1.3	0.07	0.10
Hot Tubs	104	88	0.071	0.079	2	0.41	0.45
Health/ Competition	79	81	0.018	0.023	1.6	0.08	0.11
Heated Public	85	87	0.02	0.028	2	0.12	0.16

Source: Derived from Dehumidifier Corporation of America, Cedarburg WI

Spray Evaporation

Spraying is one factor that results in evaporation from fountains and water features in pools. Spraying creates additional water surface, which, in turn, causes additional evaporation. Although sprays create more wetted surfaces from which evaporation occurs, fountains and pools typically store the majority of their water in covered pool sumps, thus significantly reducing evaporation when the spray features are not in use.

BMP Options – *Evaporation Reduction*

There are three basic ways to reduce pool water evaporation:

- The first is to shade the pool and reduce wind movement across the pool with fences and walls, non-shedding hedges, or other barriers.
- The second is to limit sprays, waterfalls, and other features that increase contact area to atmosphere to just those needed for aesthetic value or for aeration of the pool water.
- The third is to use chemicals or pool covers to retard evaporation.

[210] Hoffman H W and Koeller J. 2010. *Evaluation of Potential Best Management Practices – Pools, Spas, and Fountains Purpose.*

The overall evaporation reduction from the use of covers of all types is assumed to be 30 percent.

Traditional Pool Covers

Traditional pool covers reduce evaporation by covering the water surface. Pool covers have been used for years to reduce heat loss from heated pools, protect pools in the winter from debris, and to reduce evaporation. Covers can be made from several plastics such as UV-stabilized polyethylene or polypropylene or vinyl. They can be clear or opaque. The designs range from single sheet plastic membranes and bubble wrap type material to specially designed multi-layer insulated covers. In California, Title 24 requires that heated pools be covered when not in use. Covers also reduce the amount of debris falling into the pool, thus reducing backwash frequency, chemical use, and by extending the time between pool drain-and-fill events by reducing evaporation.

Literature varies on how much evaporation pool covers can eliminate, but generally appears to be in the range of 30 to 60 percent reduction. The U.S. Department of Energy estimates the percent of energy lost by evaporation to be 70 percent.[211] It also reports that energy savings of 50 to 70 percent and water savings of 30 to 50 percent are possible if pool covers are used properly. However, covers are only effective if they are used. A 2004 study[212] of pool cover usage in an inland area of Southern California revealed that the vast majority of consumers purchasing a pool cover do not use it regularly.

This report assumes an average potential reduction in evaporation of 40 percent for pools with plastic covers.

Liquid Evaporation Barriers

Liquid evaporation barriers are water-safe chemicals that form a thin layer at the water surface. Some of the more commonly used pool covers use long chain alcohols and an alumina salt. They are non-toxic and do not interfere with pool operations. The liquid must be replenished on a regular basis since it eventually evaporates.

Liquid barriers have been used for years. They offer both heat and evaporation loss control, but they work best where there is little movement of the water surface.

Although some claims are much higher, studies have shown that liquid barriers reduce heat loss by 15 to 55 percent,[213] depending on how the pool is used: the higher energy savings occur in pools that are used the least. Liquid barriers can

[211] U.S. Department of Energy. 2012. “Swimming Pool Covers.” Available at: http://energy.gov/energysaver/articles/swimming-pool-covers

[212] Koeller & Company. 2004. *Swimming Pool Cover Rebate Program Follow-up Customer Survey*.

[213] Flexible Solutions. n.d. “Efficiency Results.” Available at: www.liquidpoolcovers.com/effectiveness.html

be assumed to reduce evaporation in the range of 10 to 30 percent. This report assumes an average reduction of 20 percent when using liquid barriers.

The most important thing to consider with liquid barriers is that they are in place and minimizing evaporation as long as the liquid feed equipment is operating, even when the pool is being used. By contrast, pool covers must be removed and replaced by the pool owner and operator.

7.3.7.2 Leak Reduction

Overview – *Leak Reduction*

All pools, hot tubs, fountains and water features are subject to leaks. The most common locations for leaks are where the pool and pipes are joined, at separations along the pool top and the bond beam, in the piping either on the suction or return lines to the filtration system, and in the pool liner. Another leak area is found around the pump seals such as "O" rings.

If a pool is losing more than two inches of water per week, it may have a leak. For high evaporation areas, this threshold may be increased to three inches per week. Air bubbles in either the pump strainer basket or the water in the return line where the water enters the pool (even after three or four minutes of the pump running) may indicate that a leak exists in the suction side of the piping. The most obvious indicator of a pool leak is when wet spots appear around the pool, filter, or piping.

BMP Options – *Leak Reduction*

Installing a meter on the pool makeup line is the most effective way of monitoring pool or fountain water use as well as for checking for leaks.[214] In commercial and public pools and for larger water fountains containing 10,000 gallons of more, a makeup meter is essential to efficient operation.[215]

[214] This is not necessary on very small fountains pools, above-ground pools, or hot tubs, but if the pool or fountain holds over 10,000 gallons it should be considered.

[215] Owners and operators may also check for a leak in a pool by placing a five gallon bucket on a step in the pool where the bucket will be at least seventy percent submerged. The water supply to the pool should be turned off and the bucket filled to the exact same level as the water in the pool. After 12 to 24 hours, the bucket and pool water levels should be checked again. If there is no leak, the water levels should still be the same, but if the pool level is lower than the bucket level, it indicates that there is a leak below the water line of the pool. However, this method will not disclose leaks in plumbing above the water line.

7.3.7.3 Splash-Out and Drag-Out Reduction

Overview – *Splash-Out and Drag-Out*

"Splash-out" is the water lost as people in the pool cause water to move and splash against and over the sides. Similarly, "drag-out" is the water lost as swimmers exit the pool. The design of the edge of the pool and the "freeboard" or level of the pool water below both the edge and the top of the pool overflow help reduce water loss. Most commercial pools and many residential pools have gutter and grate systems around the edge of the pool to catch splashes. Troughs are built into the wall of the pool and drain back into the pool or can be used as skimmer-type devices. Figure 7.61 illustrates such a device.

Figure 7.61 - Pool Gutter and Grate System

BMP Options – *Splash-Out and Drag-Out*

- One of the simplest ways to reduce splash-out is to set the pool level several inches lower than the edge of the pool and the overflow. In addition to reducing the amount of water splashed-out, this practice also allows for the rainfall retention. Some pool officials recommend retaining at least four inches of freeboard.
- Another helpful design feature is beveling the edge of the pool so it slightly overhangs the pool. Doing so helps redirect splashes into the pool. It is important to remember, however, that the area slightly back from the pool edge must be graded to prevent dirty rainwater from flowing into the pool.

7.3.7.4 Disinfection and Water Quality Control

Overview – *Disinfection and Water Quality*

Based on California evaporation rates and the water quality recommendations of the Center for Disease Control, California pools would have to be dumped and refilled on an average of once every 27 months. The Association of Pool and Spa Professionals (APSA) recommends hot tubs be drained several times a year. Table 7.46 summarizes the water use implications for these dump and refill recommendations.

Table 7.46 - Water Typically Used in Pools

Type of Pool	Pool Volume	Gallons per year *(Dump every 27 months on average)*
Hot Tub	1,122	499
Above Ground*	7,540	3,351
In Ground Residential	15,147	6,732
Apartment	26,928	11,968
Hotel/Motel	33,660	14,960
Public	149,600	66,489
Olympic	863,611	383,827

Types of Equipment and Processes – *Disinfection and Water Quality*

Disinfection

Disinfection is an absolute necessity for all pools, hot tubs, and ornamental recirculating fountains. Without it, the water would harbor harmful bacteria, grow algae, and require frequent dumping and refilling. Chlorine is the most commonly used disinfection chemical. Larger pools sometimes use chlorine gas, while other pools may use chlorine that contains chemicals such as chloramines or sodium and calcium hypochlorite. These chemicals can come in powder, tablet, gas, or liquid form. Other chemical disinfections include iodine and bromine. Chlorine stabilizers, such as cyanuric acid, which is only used in outdoor pools, are frequently added to help retard the loss of chlorine.

A new type of chlorine disinfection system uses salt dissolved in the pool water and an electrolysis-type device to generate chlorine from the added salt. These systems are called "salt pools" and require the addition of salt to keep total dissolved levels between 2,000 and 3,500 ppm for proper operation of the equipment. Exact numbers are not available, but the percent of all pools currently using this method is assumed to be very small.

Ozone and ultraviolet light (UV) have also found applications in pool disinfection. With recent concern for cryptosporidium in some commercial pools, systems that include precoat filters, such as perlite or diatomaceous earth (DE), followed by UV disinfection have been installed in addition to chlorine disinfection.

Algaecides are sometimes used to control both green and mustard-type algae problems. Some of the first to be used were cooper compounds. While they work, they are toxic to plants and can stain pool surfaces. Quaternary ammonia compounds have been used successfully for a long time and do not have the plant toxicity of cooper if the pool water is ever to be used for irrigation.

Water Quality

Proper pool maintenance protects the health and comfort of pool users and reduces the long term operations and maintenance costs. Table 7.47 summarizes recommended minimum and maximum levels for constituents for conventional swimming pools.

Table 7.47 - Recommended Ranges for Selected Parameters for Conventional Swimming Pools[216]

Constituent	Minimum*	Maximum*
Total Dissolved Solids (TDS) - Regular Pools	300 ppm	2,000 ppm
Total Dissolved Solids (TDS) - Salt Pools	2,000 ppm	3,500 ppm
Cyan uric Acid	10 ppm	100 ppm
Free Chlorine	3 ppm	10 ppm
Hardness	150 ppm as $CaCO_3$	500ppm as $CaCO_3$
Total Alkalinity	60 ppm as $CaCO_3$	180 as $CaCO_3$
pH	7.2	7.6

*-ppm: parts per million and is equal to milligrams per liter (mg/L)
Source: Center for Disease Control (CDC), 2006. Healthy Housing Reference Manual.

Maintaining proper pH, alkalinity, and hardness levels reduces corrosion and prevents damage to pool surfaces. This extends equipment and pool life and reduces the number of times pools must be dumped and refilled. TDS control is a major factor in how much water is used in pool operations. All pools will eventually require the water to be either exchanged or treated to remove dissolved contaminants in the pool, such as: body salts, sun tan lotions, other substances applied to the body; the salts in the chemicals added to the pool to control biological growth; windblown dust and salts; and, the increases in salt concentrations in the pool water resulting from evaporation.

Maintaining the correct chemical balance of pool water will help delay the exchange of pool water. The same considerations hold for fountains, which often reach high TDS levels faster than pools because of higher evaporation rates from spraying.

Dilution

In warmer climates, such as much of California and the southwest, pools are typically kept full with circulation systems working year round. Some larger pools are equipped with conductivity controllers that dump water at a predetermined level of TDS. These systems dump a small amount of pool water and exchange it with fresh water, producing a reliable alternate water source that can be used for irrigation or other purposes. In all of these cases, water with high dissolved solids is simply dumped to drain and replaced with fresh water. The volume of replaced water depends on four factors:

- The volume of the pool
- The dissolved solids in the makeup water
- The type and amount of treatment chemicals added
- The local evaporation rate

[216] Center for Disease Control and Prevention and U.S. Department of Housing and Urban Development. 2006. “Chapter 14: Residential Swimming Pools and Spas.” Available at: http://www.cdc.gov/nceh/publications/books/housing/cha14.htm

Chemicals

Treatment chemicals like cyanuric acid can accumulate over time and reduce the overall effectiveness of chlorine. The use of calcium hypochlorite tablets can add calcium hardness and can negatively affect pool equipment.

BMP Options – *Disinfection and Water Quality*

Maintaining the correct chemical balance of pool water will help save water by:

- Delaying the exchange of pool water needed, reducing the number of times a pool must be drained and refilled.
- Reducing the number of filtration system backwashes needed.
- Reducing the potential for corrosion or other factors that can cause leak losses.

Additionally, in recent years, the use of Reverse Osmosis and Nanofiltration (RO and NF) have shown significant promise in reducing water lost through the necessary dumping of pool water to reduce dissolved minerals buildup. For example, Clean Water Products[217] of Tucson, Arizona, one of the first in this market, reports that they can recover up to 78 percent of the water previously wasted. In addition, as shown in Figure 7.62, the system is portable. Other companies throughout the Southwest are beginning to offer similar services. If reverse osmosis systems similar to those used by Clean Water Products were employed, water use for water quality control could potentially be reduced by 78 percent.

Figure 7.62 - Pool Reverse Osmosis System

7.3.7.5 Filtration

Filters for pool water treatment systems remove particulate matter from the water and keep the water free of pathogens. Filter systems consist of a pump to circulate water, and the filter. Strainer baskets catch larger debris both in the pool skimmers and just before entering the pump, significantly extending the time between backwashes and cleanings, saving both water and labor.

Types of Equipment – *Filtration*

There are three basic filter configurations. The most commonly used filter for both residential and commercial pools is the sand filter. Precoat filters (DE, perlite, and cellulose) and cartridge filters have also gained market share in recent years. The precoat filters include industrial systems that can significantly reduce water use in larger facilities. Each is described below.

[217] http://www.cleanwaterproducts.net/Swimming_Pools.html

Sand and Zeolite Filters

Figure 7.63 - Large Sand Filters of a Public Pool

Sand filters, like the two shown in Figure 7.63, are found in large commercial and public pools. As the name implies, sand or zeolite is used as the filter medium. Water is pumped under pressure through the filter. As it operates, particles carried by the pool water are filtered, they accumulate between the pore spaces of the filter, which increases the amount of pressure needed to push dirty water through the filter. When the pressure difference from the top of the bed to the bottom of the bed exceeds 8-10 psi, the filter should be backwashed.

During backwashing the flow of water is reversed, agitating the filter bed and causing the accumulated particles to be removed and discharged with the backwash water. A sight glass is used to determine when the water appears clear and the filter can be returned to normal operation. Sand filters are used on all size pools.

Cartridge Filters

Cartridge filters use pleated paper-type material and only need to be cleaned a few times a year. Old, single-use disposable filter cartridges that are full of waste should not be re-used. However, modern re-usable cartridges only need to be washed off with a hose and returned to the filter housing. Since cartridge filters do not need to be backwashed, they are the most water-efficient type available for all but the largest pools, and are being widely accepted in the residential and smaller apartment pool market. Because they are water efficient, some local governments are encouraging their use.

According to a 2008 National Resource Defense Council report to the CEC,[218] properly sized cartridge filter systems use less energy than comparable sand and DE filters in home use.

Precoat Filters

Precoat filters include conventional diatomaceous earth (DE), [219] cellulose,[220] or perlite[221] filters, as well as regenerative filters that reuse the filter media. These

[218] Rivera J, Calwel C and Moorefield L. 2008. *Synergies in Swimming Pool Efficiency: How Much can be Saved?* Available at: http://www.scribd.com/doc/17720453/NRDC-Report-Synergies-in-Swimming-Pool-Efficiency

[219] Diatomaceous earth is a white powder made from the "skeletons" of small aquatic plants in the algae family called diatoms. It is inert, but breathing the powder can be harmful since the skeletons are made up of silica materials. Residential and commercial filters typically use either DE or perlite media. In recent years, many wastewater utilities have placed bans on the discharge of diatomaceous earth to sanitary sewers since it tends to settle out and clog sewer lines. Settling tanks and bag filters are often required to remove the DE before the water can be discharged. The DE can either be disposed of in the trash or used as a soil amendment. DE has a bulk density of 19 pounds to 22 pounds per cubic foot.

[220] Cellulose is made from plant fibers. It is not widely used for pools, but is used in some food and beverage operations.

[221] Perlite is made from a silicon-based material found in volcanic deposits. When heated, it expands to form a very lightweight, chemically inert material that is used for filtration, as a soil conditioner, and insulation. Because it is so light weight, it tends to float on water when dry. It does

filters remove particles down to five microns in size, while sand and cartridge filters work in the 10- to 40-micron removal range.[222] Precoat filters have hundreds to sometimes over a thousand fabric-coated tubes inside a pressure container. The filter media (DE, cellulose, or perlite) is made into a slurry and mixed with the water in the filter. The media is then deposited on the tubes by the water being pumped through the filter. Conventional precoat filters must have the media replaced after each backwash.

With regenerative precoat filters, media is periodically "bumped" off of the filter tubes by backflow, air agitation, mechanical shaking, or a combination of the three. It is then recoated onto the filter cloth. Regenerative filters save significant volumes of water and filter media since the media can be recirculated up to 30 times before it is ultimately discharged to waste.

For large commercial pools, automated precoat, regenerative filter systems are available. These systems are also sometimes called industrial filters since their use originated in food process and water treatment operations. A significant water saving factor with these filters is that the internal filter media is recycled about thirty times before the medium is dumped and replaced. No water is lost in the recoating process. When the media is flushed, the only water dumped is the water in the filter plus one additional filter volume to make sure the vessel is completely rinsed. The backwash water needed is equal to twice the filter volume. This is different from home DE filters that use the pool pump to force water through the filter.

In addition, these large industrial units sometimes use air to "bump" the filter media off of the filter elements, thus eliminating another water use.[223] This air bumping makes regenerative precoat (industrial) filters very water-efficient. Since the perlite media can be bumped and redistributed about thirty times before it needs to be backwashed, the elapsed time between backwashing stretches to months rather than weeks or even days for large commercial pool sand filter systems.

Pool Vacuum Cleaners:

Pool vacuum cleaning equipment removes debris from the bottom and sides of pools. This equipment includes hand-held vacuum hoses that an operator draws along the bottom of the pool and automatic systems that move around the pool on their own.

There are four system types. The suction type is attached to the suction port on the pool and uses the pool filter to capture debris. This system is effective, but because the debris and dirt are captured on the filter, the filter requires more

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not have the strong tendency to settle out in sewer lines that DE does. For this reason, many wastewater utilities have allowed filter backwash water from perlite-coated filters to be discharged to sewers. Many utilities collect the backwash water and use the perlite as a soil amendment. Perlite has a bulk density of two to eight pounds per cubic foot.

[222] POOLplaza.com

[223] http://www.defenderfilter.com/

frequent backwashing, thus using more water. Three other cleaners do not use the filter to catch the dirt. One works off of the pressure side. The vacuum system discharges water flowing by using a small turbine that discharges into a strainer bag attached to the discharge. Another type is powered by electricity and uses a similar bag-type system. Stand-alone systems are powered by a separate pump and have filter bags to catch the debris for disposal. The filtered water is returned to the pool.

Water Use Information – *Filtration*

Figure 7.64 summarizes water use for various types of filtration systems for commercial pool operation. Sand filters require more water for backwashing than other filter types.

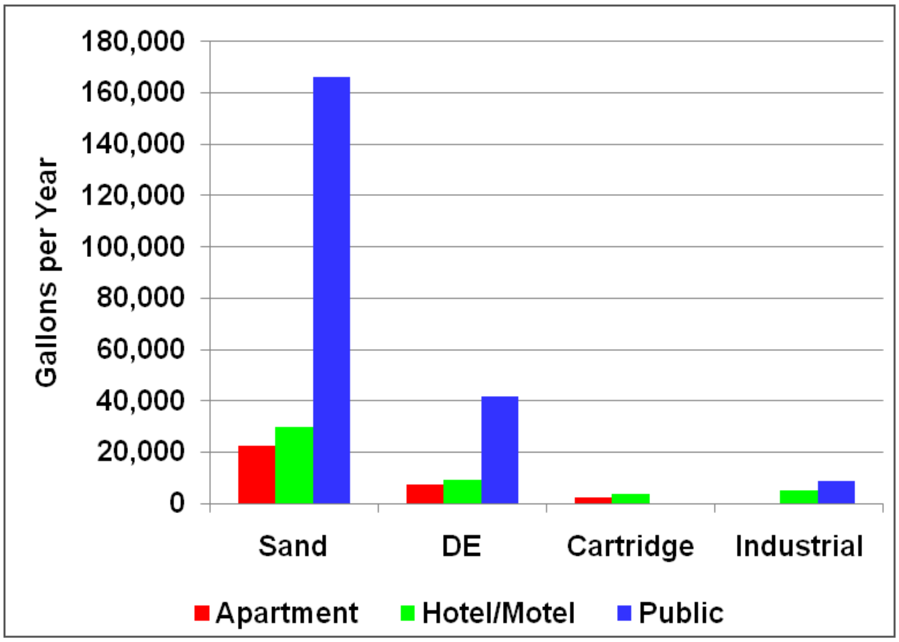


Figure 7.64 - Estimated Backwash Water Use per Year per Commercial Pool

BMP Options – *Filtration*

- As noted above (Section 7.3.7.4) managing pool water quality reduces the need for backwashing, and therefore, saves water.
- Backwash only when necessary, when diminished performance indicates filters should be backwashed.
- Backwash with the minimum water necessary to restore function.
- Use a pool vacuum cleaner that does not rely on the pool filter system to capture debris.
- Where feasible, choose a filtration system with a filter media that minimizes backwash requirements (both total volume required as well as frequency).

- For pre-coat filters, choose an air "bumping" system, where feasible, to further reduce water use.

Refer to Table 7.51 in Section 7.3.8 for a summary of selection factors to consider for new or replacement pool filtration systems.

Water Savings – *Filtration*

The water needed for backwash and filter cartridge cleaning varies significantly based upon the type of filter system used. For smaller pools, cartridge filters use significantly less water than sand and DE filters; for larger pools, industrial type filters use the least. Table 7.48 shows that the most efficient filters use between 68 and 98 percent less water than conventional sand filters.

Table 7.48 - Comparison of Backwash and Cartridge Water Use per Pool per Year for Different Types of Filters

	Estimated Use in Gallons Per Pool Per Year				Maximum Possible Reduction
	Sand	DE	Cartridge	Industrial	
Hot Tub	935	468	300		68%
Above-ground	4,189	1,466	800		81%
In-ground	8,415	2,945	1,200		86%
Apartment	22,440	7,480	2,500		89%
Hotel/Motel	29,920	9,350	3,600	5,000	88%
Public	166,222	41,556		9,000	95%
Olympic	959,568	239,892		17,000	98%

7.3.8 Water Treatment

Overview

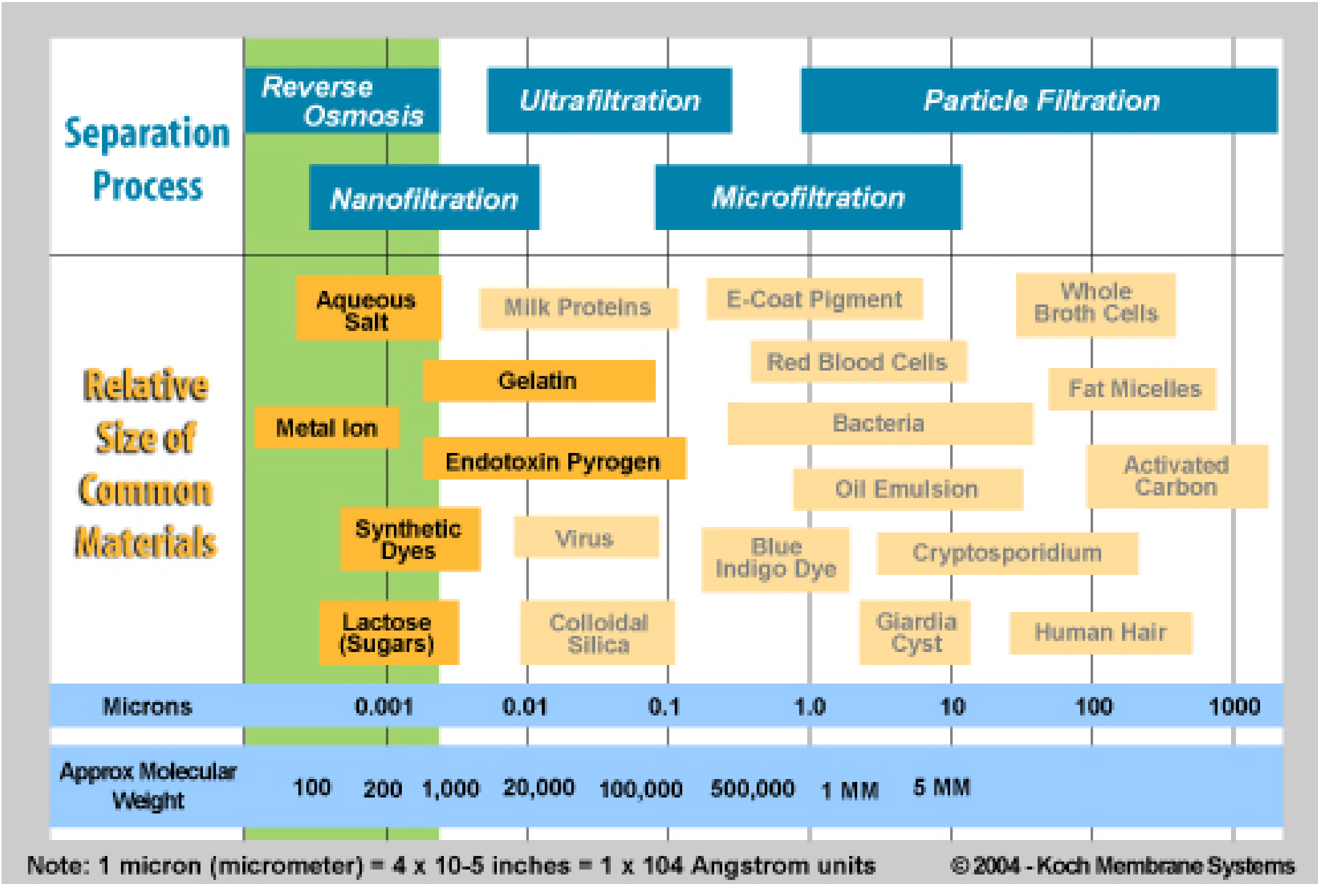
Water treatment is used in many commercial operations, including food services, laundries, laboratories, pharmacies, car washes, and food service establishments. Industrial water treatment technologies are commonplace but often require technologies not found in commercial settings. The type of treatment depends on the application and the required water purity for the intended use. Treatment techniques and levels range from simple cartridge filters and water softeners to the production of ultrapure water for medical, laboratory, and microelectronics operations. Table 7.49 summarizes common treatment systems.

Table 7.49 - Treatment Technologies

Type of Treatment		Brief Description of Application
1	Sediment Filtration & Removal	Removes particulate matter and some bacteria
2	Coagulation & Sedimentation	Removes sediment or precipitates formed in industrial operations and metal finishing operations
3	Plate and Frame Filtration	Filters sediment and precipitates
4	Softening	Removes magnesium and calcium hardness
5	Ion exchange	Removes cations and anions
6	Distillation	Removes cations and anions
7	Membrane technology	Reverse osmosis and nanofiltration removes pyrogens and cations and anions while microfiltration and nanofiltration remove very small particulates and colloidal material
8	Disinfection	Kills bacteria and deactivated viruses
9	Carbon Absorption	Removes organics and some metals

The first three treatment technologies entail filtrations. The next two remove salts and other dissolved minerals including hardness. Membrane technologies include (1) microfiltration, (2) ultra filtration, (3) nanofiltration, and (4) reverse osmosis (RO). The last two technologies, disinfection and carbon absorption, represent processes also commonly used by the CII sector.

To illustrate the application of these treatment technologies, Figure 7.64 shows the types of filtration processes and the types of constituents that the filtration process will remove.



Source: http://www.kochmembrane.com/sep_ro.html

Figure 7.65 - Removal of Particulates and Salts

The ultimate use of the water determines the level of water treatment needed. For potable water, removal of particulates to the 20-micron level is often sufficient, as long as the water is disinfected and the level of salts is not too high. For many industrial processes and for low pressure boiler feed, it is often necessary to remove hardness. For high-pressure boilers and many industrial operations, the level of needed purity can only be obtained by reverse osmosis. For microelectronics manufacturing and many pharmaceutical and laboratory operations “ultra-pure” water (UPW) is required. Additionally, removing organic material is also a common practice.

Treatment systems also provide the ability to use water that would be discharged as wastewater. This water is reusable either directly in the facility where it was generated or by municipal water recycling. The California Building Standards Commission (CBSC) is currently working on new standards for graywater and intends to include other onsite sources. The process is in the beginning stages.

The following section describes the major technologies used to treat water in the CII sectors.

7.3.8.1 Sediment Filtration and Removal Processes (Non-Membrane)

Overview – *Sediment Filtration/Removal*

Removing sediment, suspended solids, and other particulate materials from water is one of the most basic forms of water treatment. Many technologies have been developed over the years to accomplish this task. One of the most common processes is filtration. Sand and zeolite, precoat, cartridge, and bag filters are used in many commercial, institutional, and industrial processes. Another sediment removal technology is the use of centrifugal force.

Types of Equipment – *Sediment Filtration/Removal*

Sand and Zeolite

Sand and zeolite filters use a bed of sand (Figure 7.66) or zeolite to filter the water. Water is pumped into the top of the filter, where it passes through the sand bed, and particulates are captured. As it operates, a layer of material filtered out of the water builds up on the top of the sand bed. When the pressure difference from the top of the bed to the bottom of the bed exceeds 8-10 pounds per square inch, the filter should be backwashed. Special valves allow this to happen. The water moves from the bottom of the filter up through the filter material to the top, discharging the accumulated dirt on top of the filter. When the water in a sight glass appears clear, the dirt has been removed. Larger systems can use horizontal filters, which are simple tanks on their sides.

Figure 7.66 - Typical Sand Filter

Precoat Filters

Precoat filters include conventional diatomaceous earth[224] (DE), cellulose,[225] or perlite[226] filters, as well as regenerative filters that reuse the filter media. These

[224] Diatomaceous earth is a white powder made from the "skeletons" of small aquatic plants in the algae family called diatoms. It is inert, but breathing the powder can be harmful since the skeletons are made up of silica materials. Residential and commercial filters typically use either DE or perlite media. In recent years, many wastewater utilities have placed bans on the discharge of diatomaceous earth to sanitary sewers since it tends to settle out and clog sewer lines. Settling tanks and bag filters are often required to remove the DE before the water can be discharged. The DE can either be disposed of in the trash or used as a soil amendment. DE has a bulk density of 19 pounds to 22 pounds per cubic foot.

[225] Cellulose is made from plant fibers. It is not widely used for pools, but is used in some food and beverage operations.

[226] Perlite is made from a silicon-based material found in volcanic deposits. When heated, it expands to form a very light weight, chemically inert material that is used for filtration, as a soil conditioner, and insulation. Because it is so light weight, it tends to float on water when dry. It does not have the strong tendency to settle out in sewer lines that DE does. For this reason, many wastewater utilities have allowed filter backwash water from perlite coated filters to be discharged to sewers. Many utilities collect the backwash water and use the perlite as a soil amendment. Perlite has a bulk density of two to eight pounds per cubic foot.

filters remove particles down to five microns in size, while sand and cartridge filters work in the 10- to 40-micron removal range.[227] Refer to Section 7.3.7.5 for a detailed discussion on Precoat Filters.

Cartridge Filters

Cartridge filters use pleated filter elements made from paper or other material. Most use washable filter elements with a range of filter elements, typically in the range of 1.0 to 20.0 micron particulate removal (Figure 7.67).

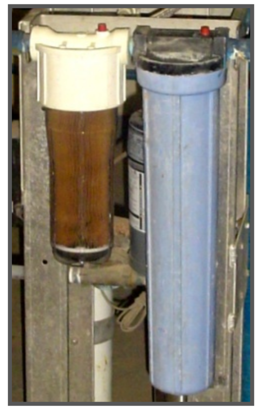


Figure 7.67 - Small Cartridge Filters

In the past, disposable filter elements were used, with filter replacement taking place each time the pressure across the element built up. Re-usable cartridges are now available. Because these filters do not need to be backwashed, they are the most water-efficient type available for all but the largest systems and are finding wide acceptance in the residential and smaller apartment pool market. Their water efficiency has led some local governments to encourage their use.

Bag Filters

As the name implies, bag filters use a filter cloth housed in a cylinder. Bags are generally washable and can be used many times as long as the substance removed does not stick to the bag. Bags of various micron sizes can be purchased. In some cases fine metal mesh can be used instead of cloth.

Figure 7.68 - Cyclone Separator with Bag Filter

Cyclone Separator

Cyclone Separators (hydrocyclones) and centrifuges remove larger particles and sludge from water by centrifugal force. These separators are often used to remove particulates of larger sizes, although some manufacturers report that their equipment can remove particulates as small as 20 to 30 microns. When used with a bag filter to filter the purge stream, they are capable of recovering almost all of the "purge water" from the separator (Figure 7.68). Even if a bag filter is not used, the purge stream can be less than the backwash water requirements of a sand filter according to some manufacturers (www.therodingroup.co.uk/cyclone-filtration-how-it-works.asp)

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Selection Considerations

All of the above processes will remove particulates and sediment from water. The choice depends on the type of particulates that need to be removed and a number of operational considerations. Table 7.50 summarizes these filter options.

Table 7.50 - Non-Membrane Particulate Removal Systems

Type of Filter	Particle Removal range (Microns)	Requires Replacement Elements
Cyclone Separators	> 20	No
Sand Filters	> 20	No
Cartridge Filters	1.0 to 20	Yes
Precoat Filters	>5.0	No
Bag Filters	1.0 to 20	Yes

Cyclone separators are inexpensive and low cost to operate. Their applicability includes areas where cooling tower side stream treatment or industrial continuous solid - liquid separation is needed. They also find use for raw surface water intakes where larger sediment must be removed. Since post filtration of the purge water with the sediments is possible, they can be extremely water efficient. Their application must be evaluated on a case–by-case basis.

For finer filtration, filters are commonly used. The selection and operation of these filters depends on the type of sediment to be removed and the end use of the water. Filtration systems for commercial operations can range from a few hundred dollars to tens of thousands of dollars. For large industrial operations, the cost can be in the $100,000's depending on volume of water treated and design. Sand filters tend to be more expensive that coated media and cartridge filters. To help understand some of the cost consideration, Table 7.51 shows selection factors for swimming pools. These factors are generally applicable across commercial and institutional lines.

Table 7.51 - Filter Selection Factors for Pool Filters*

	Sand	**Coated Media**	**Cartridge**
Frequency of Cleaning	Every week	4-8 weeks	Depends on unit
When to clean *(Difference in pressure across filter)*	5-10 psi	8-10 psi	8-10 psi
How cleaned	Backwash	Backwash[(a)]	Take apart & wash with hose
Filtration *(microns)*	20-40	5	10 (can vary on cartridge)
Time between media replacement	3-6 years	Every recoat	2-4 years depending on filter
Cost of media	$0.50 to $1.00/lb	$0.15 -$0.50/lb	$15-$100 each
Residential use	Yes	Yes	Yes
Commercial use	Yes	Yes[(b)]	Not Recommended
Backwash flow time	2-5 minutes[(c)]	1-5 minutes[(c)]	Remove & wash
*Personal communications, 2010. Robert Hawkin and Scott Hyland, Neptune Benson, Coventry, RI			

(a) DE and Pearlite filters should be "bumped and swirled" to regenerate the porosity of the filter medium. Actual recoat is needed only when pressure drop across filter reaches 8-10 psi, significantly reducing the number of times that new filter media is needed.
(b) DE is not recommended for apartments, condominiums, or hotels since the filters quickly become clogged with the high rate of use. Specially designed DE and Pearlite filters are made for high volume use.
(c) Typical times. Filter must be backwashed until sight glass is running clear.

Figure 7.64 in Section 7.3.7.5 shows an analysis of potential backwash water use for swimming pools in California. As this figure shows, sand filters are the least water efficient.

BMP Options – *Sediment Filtration/Removal*

- Only use filters where needed.
- Choose sediment filters that require the least number of backwashes.
- Examine ways to reuse backwash water or purge water.
- When filters are used, install pressure gauges and use the gauges to determine when to backwash.
- Backwash based on pressure drop instead of by a timer or a schedule.
- Cartridge filters should be the only type used in most applications since they only need to be washed off with a hose and returned to the filter housing

7.3.8.2 Physical Sediment and Precipitate Removal

The reuse of water onsite often depends on the removal of sediment and precipitates produced by a process or operation. The two most commonly found examples are coagulation – sedimentation, and filter presses and filter belts. These water treatment processes are important BMPs, themselves, and when used in conjunction with onsite water recovery and reuse.

Coagulation - sedimentation is used where large volumes of water need to be treated. This process involves the addition of a chemical that causes particles to "clump" together (coagulate) to form heavy “flocs”, which then settle out (precipitate). A full technical discussion is beyond the scope of this document, but this type of treatment is often used to treat raw surface water or even wastewater streams that can be reused within the facility. Filtration often follows coagulation - sedimentation.

Precipitate removal is often found in plating operations and other industrial/commercial operations where metal salts are used. Leaf or belt presses are often employed to remove the precipitate. Technical details are beyond the scope of this document, but these water treatment processes are important to internal water reuse operations.

7.3.8.3 Softening

Softening is the process of removing magnesium, calcium, and related multivalent ions from water. Laundries, car washes, boiler feed-water, laboratory water, hot-water systems for restaurants and food-service establishments, and metal-plating operations commonly employ softening. The three most common ways of softening water:

- Nanofiltration (See section on Membrane Processes)
- Lime softening (only applicable to large municipal systems and not discussed in this document)
- Cation exchange resins or zeolite that exchange sodium or potassium for calcium and magnesium

Cation exchange resins and zeolites are the most commonly found softening processes in CII operations. Water is passed through a bed of resin from the top. As it passes through, sodium or potassium ions on the resin are released and replaced with the calcium or magnesium cations. As water passes through the bed, spent resin (resin that has given up its sodium or potassium ions) moves down the bed. As the process continues, hard water will use up all the salt, and softening will cease; therefore, softeners need to be regenerated with a salt (typically sodium chloride - salt or potassium chloride). Sodium salts damage plants and cause clay soils to deteriorate. Softeners are often a major salt input to wastewater streams that are being recycled. For this reason, the use of softeners or the use of sodium salts has come into question. Many septic systems are also converting to the use of potassium-based salts to prevent damage to plants and soil.

BMP Options – *Softeners*

- Do not recharge based on timers.
- Consider demand based softener regeneration. The best systems measure the hardness and only backwash when a preset percent of the resin bed is exhausted.

- Use water meters that actuate recharge with a predetermined amount of water based on the water chemistry of the source water.

7.3.8.4 Cation and Anion Exchange

Cation and anion processes – also known as strong acid/base resins – are used when extremely pure water is required. The equipment can be recharged on or off site.

BMP Options – *Ion Exchange*

- Use only when needed for required water quality.
- The resin bed should be instrumented to ensure that recharge is done only when a preset percent of the bed's resin has been exhausted.

7.3.8.5 Distillation

Distillation works by boiling water to form steam condensate using either an electric or gas water still. Solid contaminants remain behind as the steam is generated, then the steam is condensed into a purified water stream. Distillers can use large volumes of water if once-through cooling water is used in the condenser, or if a reject stream is discharged from the boiler to prevent scale build-up. These systems typically waste 15 to 25 percent of water entering the system.[228]

BMP Options – *Distillation*

- Eliminate once-through cooling.
- Maximize product water recovery as a percent of total water input to 75 percent or better.
- Install automatic water and gas or electric cutoffs when the receiving reservoir is full.

7.3.8.6 Carbon Adsorption

Carbon adsorption removes organic compounds such as those that affect taste and odor. In some cases, activated carbon is also used to remove heavy metals from water. The adsorption process depends on the physical characteristics of the activated carbon, the chemical compositions of the carbon and the contaminants, the temperature and pH of the water, and the amount of time the contaminant is exposed to the activated carbon.[229] Carbon adsorption can use either disposable cartridges or packed columns. Disposable cartridges are disposed of once the adsorptive capacity is exhausted. Alternatively, packed columns can be removed and recharged offsite.[230]

[228] East Bay Municipal Utility District. 2008. *Watersmart Guidebook—A Water-Use Efficiency Plan Review Guide for New Businesses*.
[229] North Dakota State University. *Treatment Systems for Household Water Supplies—Activated Carbon Filtration.*
[230] East Bay Municipal Utility District. 2008.

7.3.8.7 Membrane Processes

Overview – *Membrane Processes*

The development of membrane technologies has revolutionized the way in which water is treated. Microfiltration and ultrafiltration remove very small particulates and colloidal substances from water. They are also capable of filtering bacteria and some viruses. Micro and ultrafiltration materials include ceramics and polymers of various types. NF and RO remove dissolved solids ranging from proteins and sugars, to minerals and salts. NF and RO typically use thin film composites, cellulose acetate, and polysulfonated and polysulfone membranes. These processes can be made of either a bundle of tubes or spiral wound filters. These assemblies are then placed into long pipe-like pressure vessels. A variant is the submergible microfiltration membrane that works on a vacuum. It is often called a membrane biological reactor (MBR) used in wastewater treatment systems.

All four of the membrane processes are important ways to recover water for onsite reuse or for the treatment of recycled municipal wastewater where very high purity is required. Table 7.52 compares the general characteristics of the four membrane technologies.

Table 7.52 - Comparison of Membrane Technologies

Type of filtration	Microfiltration	Ultrafiltration	Nanofiltration	Reverse Osmosis
Pore Size Removal (Microns)	1.0 - 0.1	0.01 - 0.001	0.001 - 0.0001	<0.0001
Operating Pressure (psi)	<30	20 - 100	50 - 300	225 - 1,000
Operating Cost ($/1,000 gallons)	$ 0.50 - 1.00	$ 0.50 - 1.00	$ 0.75 - 1.50	$1.50 - 5.00
Source: Cartwright Consulting Company - http://www.cartwright-consulting.com				

Types of Processes – *Membrane Processes*

Micro- and Ultra-Filtration

Both microfiltration and ultrafiltration remove very small particulate matter from water. They find application in all areas of water treatment since these devices are able to remove *Giardia lamblia* cysts, *Cryptosporidium* oocysts, and other pathogens.

Because microfiltration and ultrafiltration are filtration processes, the membranes need to be backwashed periodically to flush precipitate from them. They also require periodic cleaning with detergent and either acid or alkaline cleaners. Both filtration processes typically have sediment filters placed ahead of them to remove larger particles before micro- or ultra-filtration, thus extending the time between backwashes and extending membrane life.

Ultrafiltration finds use in food processing operations where water must be removed from a liquid or slurry, such as the removal of whey from milk solids and water from tomato paste.

Nanofiltration and Reverse Osmosis

These technologies are capable of removing dissolved salts, proteins, and minerals at the molecular level. They find application in many industries. These two processes differ from filtration in two significant ways. Since only a portion of the water fed to the membrane is actually passed through it iscalled "permeate." The remaining water is the reject or retenate stream, and it is sent to discharge as a waste stream. This reject contains the salts and minerals left behind. Like filtration membranes, these membranes must also undergo periodic cleaning with detergent and either acid or alkaline cleaners. The water produced by these processes is exceptionally low in mineral and organic contaminates.

When selecting membranes that operate at the molecular level, several terms are of particular importance:

- Permeate - the product water that passes through the membrane.
- Retenate - the water containing the dissolved salts, minerals and other substances that is sent to waste.
- Rejection rate - the percent of salts that are removed by the process.

NF and RO processes should be preceded by particulate filtration. NF removes multivalent ions and is thus a softening process, but most water fed to RO systems has already been softened to remove hardness that would quickly foul the membrane. RO technology finds application is many diverse areas, including:

- Desalination of sea water and brackish waters
- Pre-treatment for the production of ultrapure water
- Treatment of water for kidney dialysis
- Laboratory and pharmaceutical water purification
- Plating water treatment and plating solution recovery
- Product recovery for precious metals

Modern large RO units have rejection rates of 90 percent or better and permeate recovery rates of 75 percent or better. For medical and laboratory operations, the size of the system helps determine the permeate recovery rates. Smaller systems with production rates (permeate) of under three to four gallons per minute typically have only a 50 percent recovery rate. The reject water is often usable for other purposes.

BMP Options – Membrane Processes

For micro and ultrafiltration membranes:

- Use pressure drop across the membrane to determine when to backwash so that backwashing is done only when necessary.
- Follow manufacturer's recommendation on membrane cleaning to minimize the number of cleanings needed.
- Pre filter water to remove larger sediment to minimize backwash and cleaning.
- Follow the BMPs for filtration for the pre filters.

For nanofiltration and reverse osmosis:

- Choose systems with the maximum permeate recovery rates.
- Clean according to recommendations from the manufacturer.
- Investigate ways of reusing the retenate.
- Ensure good pretreatment to minimize cleaning of the membranes.

Metal-Oxide Filtration (MOF)(Ceramic)

This filtration technology uses cross-flow membrane permeation technology with Metal-Oxide Ultrafiltration Membranes to separate and remove emulsified oil and grease, heavy metals, biological oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), volatile organic compounds (VOC), color, TDS, and turbidity from industrial wastewater.

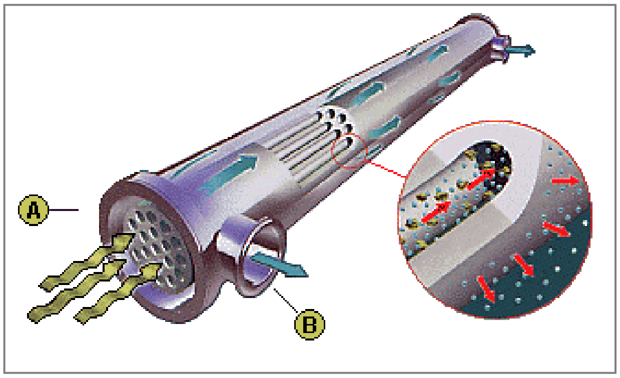

Figure 7.69 - Ceramic Membrane Diagram.
A) filtrate, retentate or concentrate
B) permeate, diffusate or filtrate

The separation process takes place inside the porous ceramic module where macromolecules and particles are continuously rejected on the surface of ceramic and water permeates across the ceramic membrane. Each ceramic module contains parallel flow channels where the feed material is introduced. As the contaminated fluid passes through these parallel flow channels the water is forced through the ceramic wall (filtrate), but pollutants (called concentrate) including fine suspended solids are rejected and returned back to the process feed tank (Figure 7.69).

The characteristics of MOF are similar to those of Ultrafiltration found in Table 7.52.

Table 7.53 - Other Membrane Technologies

Type of filtration	Metal Oxide Filtration
Pore Size Removal (Microns)	0.8 - 0.001
Operating Pressure (psi)	50 - 100
Operating Cost ($/1,000 gallons)	$ 0.50 - 1.00

The flow in this type of system is open-ended on both sides of the filter and the permeate is forced through the sides of the filter wall. This means that the filters do not need to be backwashed so they can be used for many years without replacement. This type of construction minimizes membrane fouling and can operate under the following conditions: normal operating pressure from 75 – 80 psi, 0-14 pH, and 0-300 degrees F.

7.3.8.8 Other Treatment Methods

Other treatment methods can consume small amounts of water if chemicals are fed in a liquid or slurry form. Disinfection technologies include use of chlorine compounds, ozone, hydrogen peroxide, and ultraviolet light. Other commonly used chemical feed systems add antioxidants, pH control, oxygen scavengers, and other chemicals used to condition the water for its intended use.

Other processes use water to make up the solutions, but this water becomes part of the product water and is not lost. Cleaning chemical storage areas does consume water, however. The potential for water savings by choosing among disinfection technologies is small, but wasting water in cleaning equipment and storage vessels can be reduced through use of waterless methods.

7.4 References and Additional Resources

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8.0 Standards and Codes for Water Use Efficiency

Plumbing and building standards and codes play an important role in governing the installation and use of water efficient products. This section provides detailed and technical discussion of standards and codes.

8.1 What are standards?

Webster's defines a standard as: "...something set up as a rule for measuring or as a model to be followed..." In the vast world of water-efficient products, standards (or "rules for measuring") are necessary to establish standard dimensional requirements and the minimum performance level for all manufacturers to meet with their products. Compliance with established standards, however, is voluntary. That is, until such time as an ANSI[231] consensus standard is adopted into law by regulation (e.g., building codes) or legislation (e.g., the National Energy Policy Act – EPAct), the standards have no force of law.

Once adopted, however, new products must be measured against relevant standards and meet specified minimum requirements in order to be sold in the marketplace.

Many different U.S. organizations are approved by ANSI as standards-writing bodies, having met certain stringent requirements. Standards committees and project teams are comprised of a variety of stakeholder interests, and are required by ANSI to maintain a "balance" of those interests. As such, these groups include representatives of manufacturers, laboratories, government, private sector consultants, and others. Generally speaking, standards (and their implementing codes) have focused primarily on protecting public health and safety. In the past 20 years, the goal of achieving water use efficiency has been added to the process in many cases.

8.2 What are codes?

Plumbing and building codes play an important role in governing the installation and use of water efficient products. Codes are promulgated by code authorities and adopted by jurisdictions to protect the health and safety of the citizens. It is important to note that, whereas the national standards approved by ANSI are voluntary consensus-based standards, the codes (which may or may not adopt the national standards by reference) are mandatory within the jurisdiction that adopts them.

Like the standards process, the codes process is complex. There once were five different plumbing code development organizations in the U.S., but mergers have reduced this number to two. The International Association of Plumbing and

[231] American National Standards Institute

Mechanical Officials (IAPMO) produces the Uniform Plumbing Code (UPC), and the International Code Council (ICC) produces the International Plumbing Code (IPC). These code-authoring organizations have a three-year development cycle to update their respective model codes. California, through its CBSC and the HCD,[232] uses the UPC as the model plumbing code for the State and makes modifications to that model code in order to address California-specific interests.

The plumbing codes have no legal status until adopted by cities, counties, or states. Where adopted, the codes become local ordinances and laws. All jurisdictions can amend the model code before and after adoption, and some do this to better suit local conditions. Each of the two plumbing codes contains more than 400 pages of complex requirements; few jurisdictions, however, have the ability to review and analyze every single provision before adopting the code as law.

8.2.1 EPAct

The National Energy Policy Act of 1992 (EPAct 92) sets maximum water consumption standards for showerheads, faucets, urinals, and toilets; pre-rinse spray valves (PRSVs) followed in 2005. Just how those standards are manifested in fixtures (toilets and urinals) and fixture fittings (faucets, showers, and PRSVs) is a function of standard setting and the adoption of those requirements into the plumbing codes as noted above.

8.2.2 National Plumbing Standards

The national plumbing standards are developed and administered in a consensus and balanced process.[233] The ASME, the ASSE, and the International Association of Plumbing and Mechanical Officials (IAPMO) are all accredited by the ANSI to develop U.S. standards for plumbing fixtures and fittings. Within these organizations, committees are developing and maintaining standards related to toilets, urinals, showerheads, faucets, pre-rinse spray valves, flushometer valves, and other fixtures and fittings used in indoor plumbing systems. In very recent years, many of these standards have been harmonized with their Canadian counterparts.

[232] http://www.hcd.ca.gov/

[233] Groups represented in the ANSI process as voting members include representatives of manufacturers, laboratories, government, private sector consultants, and others. No one group is allowed to dominate the standards-setting process.

Plumbing standards approved by ANSI and directly affecting water use efficiency are as follows:[234]

- ASME A112.19.2-2007/CSA[235] B45.1-07 – Ceramic Plumbing Fixtures
- ASME A112.19.5-2011/CSA B45.15-11 – Flush valves and spuds for water closets, urinals, and tanks
- ASME A112.19.14-2006 – Six-Liter Water Closets Equipped with a Dual Flushing Device
- ASME A112.19.10-2003 – Dual Flush Devices for Water Closets
- ASME A112.19.19-2006 – Vitreous China Nonwater Urinals
- ASME A112.18.1-2010/CSA B125.1-10 – Plumbing Supply Fittings
- ASSE 1002 – Anti-siphon Fill Valves (Ballcocks) for Gravity Water Closet Flush Tanks
- ASSE 1016 – Performance Requirements for Automatic Compensating Valves for Individual Showers and Tub/Shower Combinations
- ASSE 1037: Performance Requirements for Pressurized Flushing Devices (Flushometers) for Plumbing Fixtures
- CSA B45.5-10/IAPMO Z124-10 – Plastic plumbing fixtures

Water utilities in California have been directly involved in the national standard setting and code authoring processes for nearly 20 years.

8.2.3 National Green Building Standards

Many municipalities, other local authorities and state governments are developing guidelines and minimum standards for new construction and renovations. These actions mandate or "suggest" design or construction practices, technologies, performance thresholds, and metrics in a variety of categories including water use efficiency.

Typical water use efficiency categories within many of the national green building programs (guidelines and standards) include:

- Plumbing fixtures and fixture fittings
- Residential appliances (clothes washers, dishwashers)
- Water treatment equipment (softeners, filtering systems)
- Landscape & landscape irrigation

[234] Numerous other plumbing standards exist that have less-than-significant effects upon water use efficiency.
[235] Canadian Standards Association

- Pools, fountains, and spas
- Cooling towers
- Decorative and recreational water features
- Water reuse & alternate sources of water (graywater, rainwater and stormwater, cooling condensate and cooling tower blowdown, foundation drain water)
- Specialty processes, appliances and equipment (food service, medical, laboratories, laundries, others)
- Metering & submetering
- Once-through cooling
- Vegetated green roofs
- Building water pressure

Guidelines provide thresholds for efficiency, and are not generally written as regulations or law, and compliance is voluntary. Standards, on the other hand, provide definitive efficiency thresholds, are written in regulations or law.

For example, the well-entrenched LEED Program consists of a set of guidelines that designers and builders may choose to comply with although some jurisdictions are choosing to mandate compliance with LEED to some level and use credits as the measure of compliance. Currently, national green building ANSI standards intended for application within CII sectors include these initiatives:

- ASHRAE[236] ANSI Standard 189.1 Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings
- Green Globes-Green Building Initiative (GBI) ANSI Standard 01-2008: Green Building Assessment Protocol for Commercial Buildings
- ASHRAE Proposed ANSI Standard 191 - Standard for the Efficient Use of Water in Building, Site and Mechanical Systems

Comparisons of the provisions of these three ANSI standards with the requirements of the model “green” codes are shown in Tables 8.1-8.4

[236] American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.; www.ashrae.org

Table 8.1 - National Green Building Standards, Codes, & Guidelines

	Applications	Guidelines, code or standard?	Code-adoptable language?	Minimum thresholds or points?	Status
USGBC LEED-NC et.al.	All except Single Family Residential	Guidelines	No	Prerequisite + points	LEED 2009 mandates 20% reduction from baseline; 2012 version in development
USGBC LEED-Homes	Single Family Residential (SFR)	Guidelines	No	Both	Active – to be updated
Green Globes – Green Bldg Initiative 01-200XP	Residential above 3 stories + all commercial	ANSI Standard	Yes	Points	Final standard ANSI-approved; published in April 2010
ASHRAE S189.1 – High Performance Buildings	Residential above 3 stories + all commercial	ANSI Standard	Yes	Minimum thresholds	Final standard ANSI-approved; published in January 2010; now in sustaining process
ASHRAE S191 – Water Efficiency	All except SFR	ANSI Standard	Yes	Minimum thresholds	Process began July 1, 2008; provisions being drafted
ICC 700 - NAHB Green Bldg Standard for Homes	Residential	ANSI Standard	Yes	Points	Final standard ANSI-approved; published in Jan 2009 as ICC-700
IAPMO Green Plumbing & Mechanical Code Supplement	Residential above 3 stories + all commercial	Code	Yes	Minimum thresholds	Completed and published in February 2010
ICC Green Construction Code	Residential above 3 stories + all commercial	Code	Yes	Minimum thresholds	Development underway; 2nd draft changes considered by code committee in May 2011
U.S. EPA WaterSense® for New Homes	Residential	Guidelines	No	Minimum thresholds	Final specification issued in December 2009

Table 8.2 - National Green Building Standards & Codes

Comparison of specific water use efficiency provisions – maximum water use

PLUMBING	Green Globes GBI 01-200XP	ASHRAE SS189.1	ASHRAE S191 (draft)	ICC-NAHB HOMES	IAPMO Green Plumbing & Mech Code Supplement	ICC Green Code (draft)
Residential toilets (per flush)	HET: 1.28g - 4.8L	HET: 1.28g - 4.8L	HET: 1.28g - 4.8L	HET: 1.28g - 4.8L	HET: 1.28g - 4.8L	HET: 1.28g - 4.8L
Commercial toilets (per flush)				-	1.6g - 6.0L	1.6g - 6.0L
Urinals (per flush)	HEU: 0.5g/1.9L	HEU: 0.5g/1.9L	HEU: 0.5g/1.9L	HEU: 0.5g/1.9L	HEU: 0.5g/1.9L	HEU: 0.5g/1.9L
Residential & commercial "private" lavatory faucets (per minute)	1.5gpm – 5.7Lpm	1.5gpm – 5.7Lpm	1.5gpm – 5.7Lpm	1.5gpm – 5.7Lpm	1.5gpm – 5.7Lpm	1.5gpm – 5.7Lpm
Commercial "public" lavatory faucets (per min.)	0.5gpm – 1.9 Lpm	0.5gpm – 1.9 Lpm	0.5gpm – 1.9 Lpm	-	0.5gpm – 1.9 Lpm	0.5gpm – 1.9 Lpm
Commercial metering faucets (per cycle)	0.25 gpc – 0.9 Lpc	0.25 gpc – 0.9 Lpc	0.20 gpc – 0.76 Lpc	-	0.25 gpc – 0.9 Lpc	0.25 gpc – 0.9 Lpc
Residential kitchen faucets (per minute)	2.2 gpm – 8.3 Lpm	2.2 gpm – 8.3 Lpm	2.2 gpm – 8.3 Lpm	-	-	2.2 gpm – 8.3 Lpm
Residential showerheads (per minute)	2.0 gpm – 7.6 Lpm	2.0 gpm – 7.6 Lpm	2.0 gpm – 7.6 Lpm	2.5 gpm – 9.5 Lpm	2.0 gpm – 7.6 Lpm	2.0 gpm – 7.6 Lpm
Residential showering compartment – size increment		2600 sq. in – 1.7 sq.m.	3000 sq. in – 1.9 sq.m.	-	1800 sq. in – 1.2 sq.m.	-
Commercial pre-rinse spray valve (per minute)	1.6 gpm – 6.0 Lpm	1.3 gpm – 4.9 Lpm	1.3 gpm – 4.9 Lpm	-	1.6 gpm – 6.0 Lpm	1.3 gpm – 4.9 Lpm

Table 8.3 - National Green Building Standards & Codes

Comparison of specific water use efficiency provisions – maximum water use

Appliances, Equipment, Irrigation & Alternate Water	Green Globes GBI 01-200XP	ASHRAE SS189.1	ASHRAE S191 (draft)	ICC 700-(NAHB) HOMES	IAPMO Green Plumbing & Mech Code Supplement	ICC Green Code (draft)
Residential dishwasher (total water per full cycle)	Energy Star® & 5.8 gal – 22L	Energy Star® & 5.8 gal – 22L	Energy Star® & 5.0 gal – 19L	Energy Star®	Energy Star®	Energy Star®
Residential clothes washer (water factor)	Energy Star® & 6.0 gal – 23L	Energy Star® & 6.0 gal – 23L	Energy Star® & 4.5 gal – 17L	Energy Star®	Energy Star®	Energy Star®
Graywater treatment system	Encouraged through the treatment and use of alternate (non-potable) sources of water			Points available for use of alternate sources	Specific provisions for equipment installation & water treatment	
Rainwater harvesting	Encouraged through the treatment and use of alternate (non-potable) sources of water				Specific provisions for equipment installation & water treatment	
Landscape irrigation	Provisions are non-mandatory; no turf restrictions	ET-based; smart technology; restrictions on turf	ET-based; smart techno-logy; restric-tions on turf	Non-mandatory provisions; some turf restrictions	Only as related to treatment & use of water from alternate sources; no specific landscape provisions	
Water features (fountains, etc.)	Use alternate water sources (non-potable); recirculation required			-	Use alternate water sources (non-potable)	
Residential water softeners	Demand-initiated regeneration control required	-	-	-	Permitted where water hardness ≥ 8 grains/gallon (137 mg/L)	Demand-initiated regeneration required; max water use 5 gal (19L) per 1K grains of hardness removed; salt efficiency requirements
Water-powered pumps	-	-	-	-	Water-powered sump pumps prohibited	Prohibited

Table 8.4 - National Green Building Standards & Codes

Comparison of specific water use efficiency provisions – maximum water use

Metering and Commercial Food Service	Green Globes GBI 01-200XP	ASHRAE SS189.1	ASHRAE S191 (draft)	ICC 700- (NAHB) HOMES	IAPMO Green Plumbing & Mech Code Supplement	ICC Green Code (draft)
Sub-metering tenant water use (usage per day)	No	Yes, where >1000g-3800L	Yes, where >1000g-3800L	-	Yes, where >500g – 1900L	All tenants
Sub-metering processes – industrial/ commercial (usage per day)	No	Yes, where >1000g-3800L	Yes, where >1000g-3800L	-	Yes, where >1000g-3800L	Yes, where >1000g-3800L
Sub-metering irrigation	No	Yes, <25,000 sq.ft. – 2300 sq.meters	Yes, <10,000 sq.ft. 930 sq.meters	-	Yes, <15,000 sq.ft. – 1400 sq.meters	Yes, all automatic systems
Building Meter Data Management System	Require remote data communication to central system, recording hourly consumption data			-	Connection to central building system not required	
Commercial food service – ice makers	Energy Star® (air cooled)	Energy Star® (air cooled)	Energy Star® (air cooled)	-	Energy Star® (air cooled)	Energy Star® (air cooled)
Commercial food service – food steamers (per hour)	2.0 g – 7.6 L	2.0 g – 7.6 L	2.0 g – 7.6 L	-	2.0 g – 7.6 L	2.0 g – 7.6 L
Commercial food service – dishwashers	Energy Star®	Energy Star®	Energy Star®	-	Energy Star®	Energy Star® OR meet specified thresholds
Commercial food service – combination ovens (per hour)	-	10 g – 38 L	10 g – 38 L	-	10 g – 38 L	-
Commercial food service – dipper wells (per minute)	-	-	-	-	-	6.0 g – 22.7 Lpm

8.2.4 WaterSense®

As early as 2003, and with encouragement from water efficiency advocates, the USEPA began investigating the feasibility of developing a voluntary product-labeling program directed at market enhancements for water efficient products. This effort came to fruition in mid-2006 when the USEPA officially rolled out the WaterSense® program.[237] USEPA officials fashioned WaterSense® along the same lines as the ENERGY STAR® initiative, which certifies select products with an energy-efficiency mark. The ENERGY STAR® logo has notable cachet among consumers and specifiers and is credited with helping sell 1.5 billion qualified products since the label was introduced in 1992.

[237] http://www.epa.gov/watersense/

There are *very significant differences* between the two programs, however, including: (1) WaterSense®-labeled products must meet certain performance requirements above and beyond just water consumption[238] and (2) products applying for the voluntary WaterSense® label must be independently tested by an approved laboratory[239] and found compliant with the appropriate performance specification.

Some of the current (tank-type toilets, urinals, showerheads, residential lavatory faucets) and proposed[240] WaterSense® specifications may appear to relate only to residential applications. However, residential occupancies are frequently found within the commercial and institutional sectors, including:

- Commercial mixed-use projects that include some residential occupancy
- Transient lodging projects (hotels and motels)
- Institutional projects with onsite residency, such as colleges and universities, fire stations, and similar government-operated operations

While the existing WaterSense® specifications are considered standards, they are not mandatory in California.[241]

8.2.5 California Code

Proactive involvement of water efficiency interests in standards and codes (including both water service provider and manufacturer interests), have progressed plumbing fixtures towards more efficient technologies and products. As a result, the California legislature has considered a number of initiatives directed at reducing urban water demand by adopting these efficiencies into California practice. On October 11, 2007, California Assembly Bill 715 (AB715) was signed into law by the Governor, setting a new standard for the state with regard to plumbing fixtures.

Among other things, AB715 provided that, effective January 1, 2014, toilets and urinals sold or installed in California could not exceed effective flush volumes of 1.28 and 0.5 gallons, respectively.[242] AB715 further called for the CBSC to

[238] The performance requirements for WaterSense products are directed at assuring user satisfaction with the product's ability to perform the task(s) for which it is intended.
[239] Energy Star products were self-certified by the manufacturers as meeting the program specifications.
[240] Products that are being or will be considered for WaterSense specifications and labeling: flushometer valve toilets, residential water softeners, glassware washers, pre-rinse spray valves, irrigation controllers, moisture sensors, autoclaves, food disposers.
[241] Nationally, some states and municipal jurisdictions have mandated compliance with WaterSense for certain new construction projects, although such is not widespread at this time.
[242] AB715 defines the effective flush volume of a dual flush toilet as the average flush volume of one full flush and two reduced flushes. The standard for dual flush toilets allows for a full flush maximum of 1.6 gallons and a reduced flush maximum of 1.1 gallons, although many dual flush toilets function satisfactorily on less that these amounts.

develop the specific language in the State codes that reflected these new requirements.

Following AB715, the CBSC began work on a set of State "green" codes that became mandatory beginning in 2011. These provisions were released in 2010 in the form of the California Green Building Standard Code[243] (CalGreen), adopted into Title 24 of the California Code of Regulations. Provisions within CalGreen affect all types of CII uses in one way or another, although much of the code has been "reserved" for future development. Chapter 5 of CalGreen covers Nonresidential Mandatory Measures, which are largely directed at plumbing and outdoor water use. Appendix A5 of CalGreen covers Nonresidential Voluntary Measures, which focus mostly on plumbing and outdoor water use. However, voluntary measures in CalGreen may be adopted as mandatory by jurisdictions that desire to go beyond the minimum State mandates. Table 8.5 compares the provisions of AB715 with those of CalGreen and Senate Bill 407 (which was directed at replacing non-EPAct-compliant fixtures with EPAct-compliant fixtures).

[243] http://www.bsc.ca.gov/CALGreen/default.htm

Table 8.5 - CII Toilet and Urinal Fixtures in the California Codes

Condition, Activity, or Event	AB 715 (2007)	SB 407 (2009)	CalGreen (2010)
Sale of toilet and urinal fixtures through retail or other outlets	**All fixtures sold or installed after Jan 1, 2014 must be HETs or HEUs[3]**	**Not addressed**	**Not addressed**
Existing[1] multi-family residential - Institutional			
Resale	Not addressed	As of Jan 1, 2019, requires written disclosure by Buyer to Seller of non-compliant fixtures in property	Not addressed
Renovation[2]	All fixtures installed after Jan 1, 2014 must be HETs or HEUs[3]	Renovated MFR must be 1.6 max (toilets) or 1.0 max (urinals) on or after Jan 1, 2014 to obtain bldg or occupancy permit	1.28 maximum[3] IF prescriptive path is chosen (per 4.303.1) – Jan 1, 2011
All other MFR	Not addressed	ALL MFR must be 1.6/1.0 max by Jan 1, 2019[6]	
Existing[1] Commercial-Industrial			
Resale	Not addressed	As of Jan 1, 2019, requires written disclosure by Buyer to Seller of non-compliant fixtures in property	Not addressed
Renovation[244]	All fixtures installed after Jan 1, 2014 must be HETs or HEUs[3]	Renovated Comm'l must be 1.6 max (toilets) or 1.0 max (urinals) on or after Jan 1, 2014 to obtain bldg or occupancy permit	1.28 max (toilets) and 0.5 max (urinals)[3] IF prescriptive path is chosen (per 5.303.2) – Jan 1, 2011
All other Commercial	Not addressed	ALL Commercial must be 1.6 max on or after Jan 1, 2019[245]	

[244] SB407 applies only where building additions increase total building size by more than 10 percent OR for building alterations or improvements, where the total construction cost estimated in the building permit exceeds $150,000

[245] Places continuing responsibility on the owner of rental property to guarantee that the toilet "shall be operating at the manufacturer's rated water consumption at the time that the tenant takes possession."

New multi-family residential - Institutional	All fixtures installed after Jan 1, 2014 must be HETs or HEUs[3]	Not addressed	1.28 max (toilets) and 0.5 max (urinals)[3] IF prescriptive path is chosen (per 4.303.1) – Jan 1, 2011
New Commercial - industrial			1.28 max (toilets)[3] and 0.5 max (urinals) IF prescriptive path is chosen (per 5.303.2) – Jan 1, 2011

8.2.6 Other Standards

The Energy Star® Program, the Consortium for Energy Efficiency, and the U.S. Department of Energy have all promulgated other standards that affect the performance of water-using appliances and equipment, including clothes washers, dishwashers, steam cookers, and ice-makers, as well as the plumbing products mentioned previously. The various efficiency thresholds specified within these programs and mandates are displayed in Table 8.1 - 8.4.

Information/materials on EPAct 2005/NAECA standards:

Schedule for development of appliance and commercial equipment efficiency standards:

http://www.eere.energy.gov/buildings/appliance_standards/2006_schedule_setting.html

Commercial Clothes Washers and Dishwashers (agenda/presentations at 4/27/06 DOE public meeting on rulemaking): http://www.eere.energy.gov/buildings/appliance_standards/residential/home_appl_mtg.html

Automatic Commercial Ice Maker Standards:

http://www.eere.energy.gov/buildings/appliance_standards/pdfs/epact2005_appliance_stds.pdf (Page 18)

Pre-rinse Spray Valves http://www.eere.energy.gov/buildings/appliance_standards/pdfs/epact2005_appliance_stds.pdf (Page 10)

Information/materials on WaterSense® specifications:

Toilets
http://www.epa.gov/watersense/products/toilets.html

Urinals
http://www.epa.gov/watersense/products/urinals.html

Bathroom Lavatory Faucets
http://www.epa.gov/watersense/products/bathroom_sink_faucets.html

Information/materials on Energy Star® specifications:

Residential Clothes Washers
http://www.energystar.gov/index.cfm?c=clotheswash.pr_crit_clothes_washers

Commercial Clothes Washers
http://www.energystar.gov/index.cfm?fuseaction=clotheswash.display_commercial_cw

Residential Dishwashers
http://www.energystar.gov/index.cfm?c=dishwash.pr_dishwashers

Commercial Dishwashers
http://www.energystar.gov/index.cfm?c=new_specs.comm_dishwashers

Automatic Commercial Ice Makers
http://www.energystar.gov/index.cfm?c=new_specs.ice_machines

Commercial Steam Cookers
http://www.energystar.gov/index.cfm?c=steamcookers.pr_steamcookers

Information/materials on CEE specifications:

Residential Clothes Washers
http://www.cee1.org/resid/seha/rwsh/rwsh-main.php3

Residential Dishwashers
http://www.cee1.org/resid/seha/dishw/dishw-main.php3

Commercial, Family-Sized Clothes Washers
http://www.cee1.org/com/cwsh/cwsh-main.php3

Commercial Ice-Makers
http://www.cee1.org/com/com-kit/files/ProgramGuidanceIceMachines.pdf

http://www.cee1.org/resrc/facts/com-ice-fx.pdf

Spec Table: http://www.cee1.org/com/com-kit/files/IceSpecification01Jul2011.pdf

Commercial Dishwashers
http://www.cee1.org/com/com-kit/files/ProgramGuidanceDishwashers.pdf

http://www.cee1.org/com/com-kit/files/DishwasherSpecification.pdf

Pre-rinse Spray Valves
http://www.cee1.org/com/com-kit/files/prv-guides.pdf

Commercial Steam Cookers
http://www.cee1.org/com/com-kit/files/ProgramGuidanceSteamers.pdf

http://www.cee1.org/com/com-kit/sc-hc-specs.pdf

Specification: http://www.cee1.org/com/com-kit/files/SteamerSpecification.pdf

9.0 Public Infrastructure Needs for Recycled Water

CII water users can contribute to better management of California's water by replacing potable or fresh water with recycled water or by using less water following the BMPs cited in other sections of this report. This section focuses on CII use of recycled water, as defined in Box 9.1, obtained from a municipal recycled water service provider. One of the fundamental challenges to increasing CII use of recycled municipal water is infrastructure limitations. After a brief initial discussion on the history and status of municipal recycled water in the state, Section 10 focuses on public infrastructure needs for increasing CII recycled water use, as required by California Water Code Section 10608.43. It addresses some of the issues associated with onsite infrastructure, which is frequently a limiting factor in integrating municipal recycled water into a CII user's water supply. The section also includes a brief discussion of funding mechanisms and descriptions of successfully implemented projects.

Box 9.1. Recycled Water Definition

"Recycled water" is defined in the Water Code (see glossary) as wastewater treated to a quality suitable for beneficial use. The Water Code definition neither designates the source of the wastewater nor indicates a certain level of treatment. In the context of this section, the discussion of recycled water is focused on treated wastewater of municipal origin and will usually be referred to as "municipal recycled water." It is distinguished from onsite reuse, which is an internal iterative or cascading use of wastewater through multiple cycles or processes and is discussed in other sections of this report. Municipal wastewater is considered to be community wastewater containing a domestic wastewater component.

For this report, the term "infrastructure" is separated into two components: "public infrastructure" and "onsite infrastructure." "Public infrastructure" refers to facilities serving the general community, including wastewater collection and treatment, and municipal recycled water storage and distribution to customers. "Onsite infrastructure" refers to facilities located on customer sites that might include additional water treatment, municipal recycled water plumbing, and modifications of industrial processes (Figure 9.1). CII water users can improve water management by using lower quality water appropriate for non-potable uses by identifying alternative water sources, such as low quality groundwater, as discussed in Section 7.3.1. CII businesses commonly reuse water within their facility, either by cycling water multiple times through an individual process, such as a cooling tower, or by cascading reuse by passing water from one process to another until its quality is no longer suitable for another use. In many instances, Industrial wastewater may also be treated and delivered to another site for reuse, such as food process discharge water being used for agricultural irrigation. Significant water savings can be achieved by internal reuse or reuse of industrial water from another facility. BMPs and case studies for cascading reuse or multi-cycle recirculation or use are addressed in other sections of this report. This section focuses only on using externally-supplied municipal recycled water.

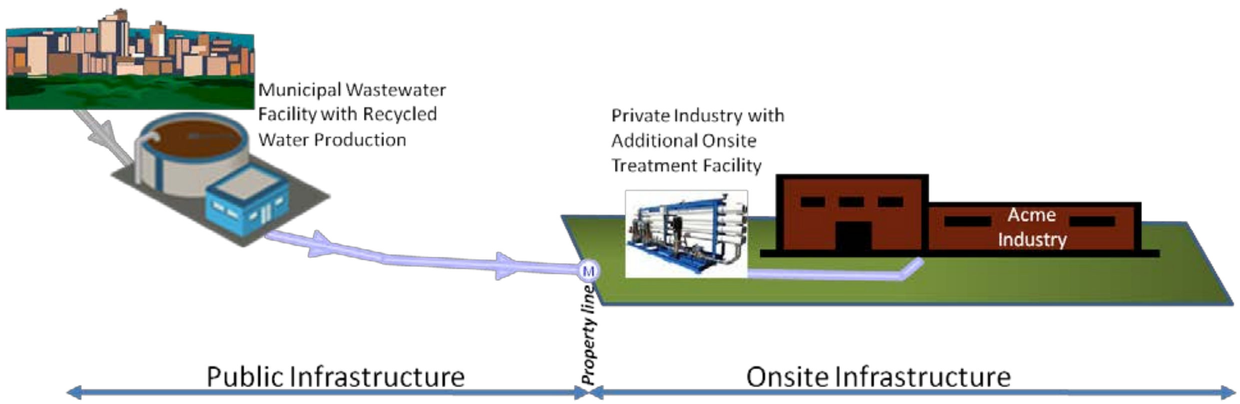

Figure 9.1 - Public and Onsite Recycled Water Infrastructure

Public Infrastructure is defined as community-based wastewater collection, treatment, and distribution system. Onsite Infrastructure is defined as customer-owned pipeline and or supplemental treatment system dedicated to treating water used at a commercial or industrial facility.

9.1 Municipal Recycled Water in California

Municipal recycled water is used extensively in California to meet municipal, environmental, commercial, industrial, and institutional water supply needs. Municipal recycled water projects are almost exclusively implemented at the local or regional level and involve multiple agencies working cooperatively to address wastewater and recycled water issues. Because of the link between wastewater and water supply quality, quantity, and reliability, as well as jurisdictional issues and distribution systems, implementing projects can involve extensive interagency collaboration. A brief, introductory discussion of municipal recycled water in California is included below.

9.1.1 History

Municipal recycled water has been used beneficially in California for over 100 years. In the earliest applications, farms located near urban areas in this drought-prone state used effluent from municipal wastewater treatment plants. Anecdotally, farmers gave cities easements for sewer mains in exchange for the right to pump untreated wastewater to irrigate their crops. By 1910, 35 sites were using municipal recycled water for agriculture purposes. San Francisco's Golden Gate Park initially used raw sewage for irrigation water, but later added a septic tank because of complaints from nearby residents. From 1932 to 1978, the McQueen Treatment Plant, the first documented California treatment facility dedicated to treating recycled water (RMC Water and Environment 2009), supplied recycled water in Golden Gate Park.[246] In 1952, 107 California communities were using municipal recycled water for agricultural and landscape irrigation. Following a national initiative to upgrade and improve the level of wastewater treatment in the 1970s, the diversity of municipal recycled water uses increased, and they now include landscape, agricultural, and golf course

[246] The plant subsequently was decommissioned. The San Francisco Public Utilities Commission is currently planning to construct a new facility to provide recycled water to Golden Gate Park again.

irrigation; commercial and industrial applications; environmental enhancement; groundwater recharge; and reservoir augmentation. Statewide surveys conducted since 1970 quantified annual volumes of municipal recycled water use and have shown a steady increase in the amount and types of uses for municipal recycled water in California (Figure 9.2).

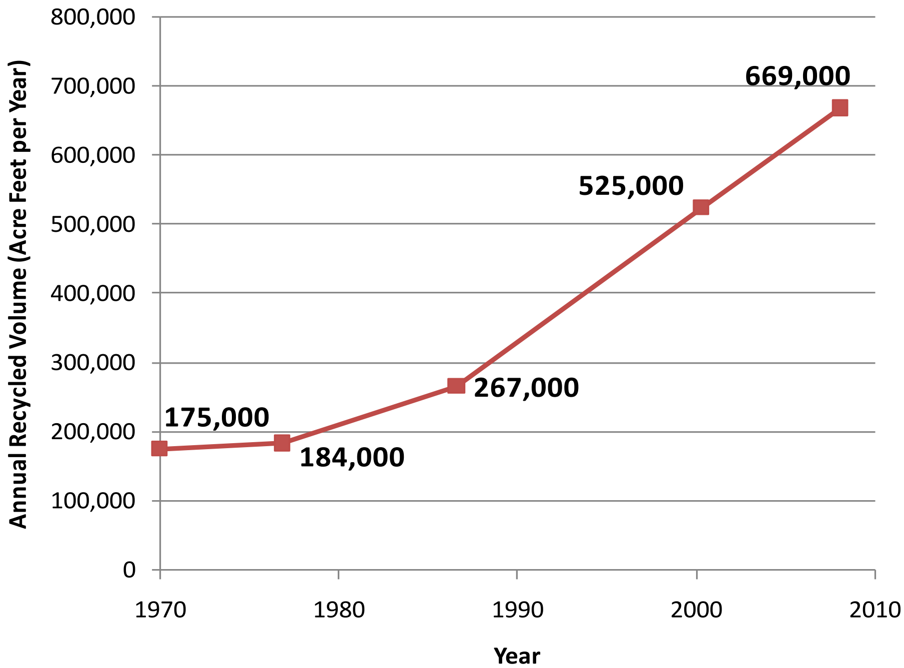

Figure 9.2 - Municipal Recycled Water Use in California Since 1970
Estimates are based on statewide surveys.

9.1.2 Potable and Non-potable Municipal Recycled Water Applications

Treated municipal wastewater is used as potable and non-potable supply. Currently, municipal recycled water is used to meet the water needs of the CII sector through non-potable systems and augmentation of groundwater aquifers used for potable water supply. Non-potable municipal recycled water is delivered from the recycled water treatment facility to water users via dedicated water pipeline systems and is typically used by the CII sector for manufacturing processes or landscape irrigation. Eighty-one percent of municipal recycled water use in California is for non-potable purposes and is delivered in these “dual distribution” systems. Municipal recycled water used for groundwater recharge or direct injection for a seawater intrusion barrier is indirectly available for potable reuse, including by CII sectors.

CII businesses benefit indirectly when a water service provider augments its potable water supplies by implementing potable municipal recycled water projects, such as groundwater recharge with municipal recycled water. Potable municipal recycled water projects are classified as either indirect potable or direct potable reuse. Indirect potable reuse projects incorporate municipal recycled water into a raw water supply such as a surface storage reservoir or a groundwater aquifer. The municipal recycled water mixes with the native water and often benefits from additional natural systems treatment. Direct potable reuse projects incorporate highly treated municipal recycled water directly into potable water treatment plants or water distribution systems. Currently indirect potable reuse through groundwater recharge is the only form of potable reuse permitted in California. Table 9.1 summarizes the indirect potable water use projects active in California in 2011. Some of the injection projects provide a dual benefit of protecting the groundwater basin from seawater intrusion by creating a hydraulic barrier, while augmenting the groundwater supply available for use. Several other indirect potable reuse projects are in pilot phase testing, including reservoir augmentation, and are expected to be operating within a few years.

Table 9.1 - Indirect Potable Reuse Projects Active in 2011

<table>
<tr><th rowspan="2">Project</th><th rowspan="2">Operating Agencies</th><th rowspan="2">Treatment[1]</th><th rowspan="2">Groundwater Recharge Method</th><th colspan="2">Municipal Recycled Water</th><th rowspan="2">Population Served Millions[4]</th><th rowspan="2">Initial Year of Operation</th></tr>
<tr><th>Volume TAFY[2]</th><th>Percent[3]</th></tr>
<tr><td>Montebello Forebay (Rio Hondo and San Gabriel River Spreading Grounds)</td><td rowspan="4">Sanitation Districts of Los Angeles County & Water Replenishment District</td><td>Tertiary</td><td>Percolation</td><td>50</td><td>35</td><td rowspan="4">4</td><td>1962</td></tr>
<tr><td>West Coast Barrier</td><td>Advanced</td><td>Injection</td><td rowspan="3">15</td><td rowspan="3">50-100</td><td>1994</td></tr>
<tr><td>Dominguez Gap Barrier</td><td>Advanced</td><td>Injection</td><td>2006</td></tr>
<tr><td>Alamitos Gap Barrier</td><td>Advanced</td><td>Injection</td><td>2005</td></tr>
<tr><td>Talbert Gap</td><td rowspan="2">Orange County Water District</td><td>Advanced</td><td>Injection</td><td rowspan="2">72 (104)[5]</td><td rowspan="2">50-100</td><td rowspan="2">2.4</td><td>1976</td></tr>
<tr><td>Anaheim</td><td>Advanced</td><td>Percolation and Injection</td><td>2008</td></tr>
<tr><td>Chino Basin Recharge</td><td>Inland Empire Utilities Agency</td><td>Tertiary</td><td>Percolation</td><td>5</td><td>8-13</td><td>0.8</td><td>2005</td></tr>
<tr><td colspan="8">NOTES:
1. Advanced treatment is reverse osmosis and advanced oxidation (ultraviolet plus peroxide).
2. TAFY=quantity of municipal recycled water injected or percolated to groundwater in thousands of acre-feet per year.
3. The average concentration in percent by volume of municipal recycled water to total recharged water.
4. Population served by distribution system connected to the groundwater recharge project.
5. The project is being expanded from 72 to 104 TAFY in 2011.</td></tr>
</table>

9.1.3 Current Statewide Recycling

The State Water Resources Control Board (SWRCB) with assistance from the DWR conducted a survey of agencies involved with the beneficial treatment, conveyance, or reuse of domestic wastewater as recycled water. The survey reported a total of 669,000 AF of municipal wastewater was treated and delivered for use in California in 2009.

Types of uses for municipal recycled water in California in 2009 are shown in Figure 9.2. The categories of CII use are commercial, industrial, golf course irrigation, landscape irrigation, and geothermal energy production. A few minor CII uses, such as toilet flushing and dust control, are in the "Other" category. These uses total about 34 percent of total municipal recycled water use in California and almost nine percent of the total 2.6 MAF CII water use (see Figure 3-1). Institutional uses were not categorized separately, however10,200 AF of the municipal recycled water uses reported by prisons, colleges, and military bases were for golf course, landscape, and agricultural irrigation.

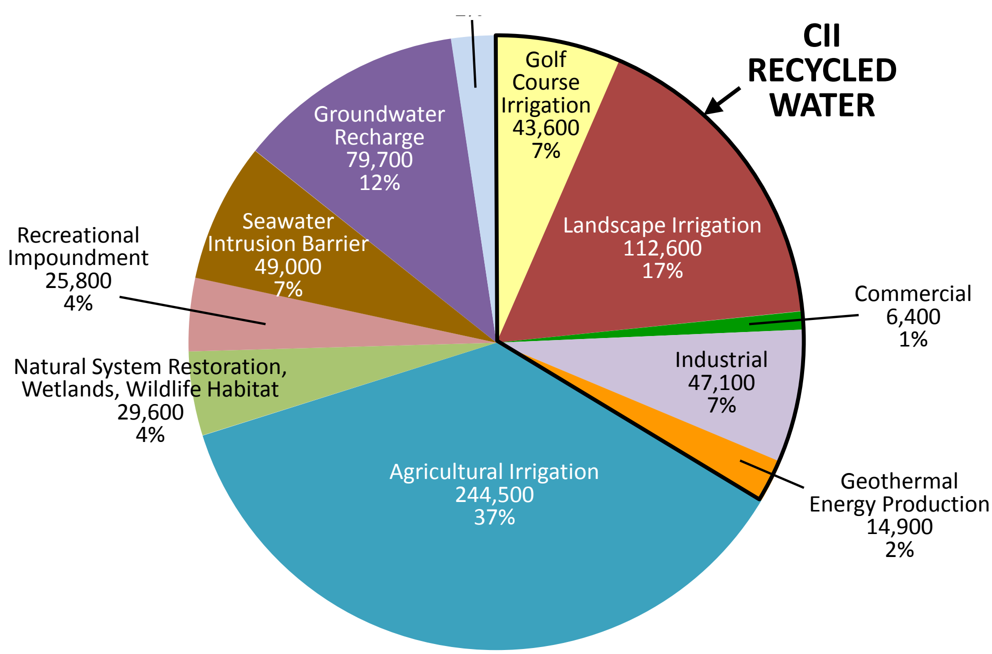

Figure 9.3 - Recycled Water Beneficial Use Distribution in 2009
2009 Municipal Recycled Wastewater Survey, showing beneficial use categories, volume of water in acre-feet beneficially used in 2009, and the overall percentage of the category based on the annual amount of water beneficially used.

9.1.4 Title 22 Levels of Treatment

The California Department of Public Health (CDPH) prescribes the levels of treatment required for municipal recycled water to protect public health. The levels of treatment are based on the levels of human exposure and the types of exposure that provide pathways to infection. The required levels of treatment are specified in Title 22 of the California Code of Regulations (Division 4, Chapter 3, §60301 et seq.). Title 22 regulations also specify monitoring and reporting requirements and onsite use area requirements.

Municipal wastewater can be treated to four levels, as described in Box 9.2. The levels of treatment are mostly governed by Title 22 requirements to protect public health. However, as described later in this section, water quality can be critical to determining appropriate CII applications.

A key component of incorporating municipal recycled water into CII applications is aligning potential uses to the availability of various levels of treated municipal recycled water. Determining municipal recycled water availability requires coordination with both the local water and wastewater agencies, because each jurisdiction has its own roles, authorities, and service areas with respect to municipal recycled water generation and distribution.

Table 9.2 summarizes CII applications allowed for levels of municipal recycled water treatment specified in Title 22. While Title 22 lists specific allowed uses, other uses are permitted on a case-by-case evaluation and approval by CDPH. For example, additional non-potable recycled water applications include geothermal power production and carpet-dying. In general, the linkage between level of recycled water treatment and potential uses specified in Title 22 is strongly influenced by the potential for direct human contact and ingestion, with higher levels of treatment (tertiary or advanced) required for open public access and worker contact issues.

Box 9.2. Wastewater Treatment Levels

Primary Treatment removes 70 to 85 percent of the organic and inorganic solids that either settle out or float to the top.

Secondary Treatment mixes the remaining suspended waste solids with microorganisms and air. The micro-organisms convert the waste solids to biomass that settles out.

Tertiary Treatment filters out most of the remaining solids through a granular media (sand or anthracite coal) or a membrane, with the final product water being disinfected with chlorine or ultraviolet light to kill off bacteria, viruses, and other microorganisms.

Advanced Treatment is any water treatment technologies beyond conventional coagulation, filtration and disinfection. These may include reverse osmosis, micro- or nanofiltration, ozonation, or advanced oxidation.

(Los Angeles County, 2005; AWWARF, 2006)

Indirect potable reuse through groundwater recharge has occurred in California since 1962. Title 22 does not specify specific treatment, design, or monitoring requirements for groundwater recharge although they are included in the Draft Regulations for Groundwater Replenishment with Recycled Water, currently being revised by the CDPH. Current regulations provide that CDPH will make recommendations to the RWQCBs for each project on a case-by-case basis. The recommendations are reflected in the requirements of water recycling permits issued by the RWQCBs. To provide a more systematic approach to regulating groundwater recharge, CDPH drafted regulations in the 1980s. The draft regulations were based in part on recommendations by the Scientific Advisory Panel on Groundwater Recharge and an earlier scientific panel. These draft regulations have evolved as new research and data from existing projects have become available.

Table 9.2 - Potential CII Applications for Municipal Recycled Water Based on Title 22 Requirements.

POTENTIAL COMMERCIAL (non-agricultural), INDUSTRIAL, AND INSTITUTIONAL USES	MINIMUM TREATMENT LEVEL[1,2,3]		
	Disinfected Secondary-23[4,5]	Disinfected Secondary-2.2[4,6]	Tertiary[7]
Landscape and Buildings			
Cemetery landscaping	X		
Decorative fountains			X
Drain trap priming			X
Fire protection, structural			X
Fire protection, non-structural	X		
Golf courses, restricted access	X		
Golf courses, unrestricted access			X
Landscape impoundments	X		
Landscaping, freeway	X		
Landscaping, restricted access	X		
Landscaping, unrestricted access			X
Toilet and urinal flushing			X
Commercial and Industrial			
Aquaculture		X	
Artificial snow making			X
Backfill consolidation around nonpotable piping	X		
Backfill consolidation around potable piping			X
Car washes			X
Cleaning roads, sidewalks and outdoor work areas	X		
Concrete mixing	X		
Cooling and air conditioning, mist generation			X
Cooling and air conditioning, no mist generation	X		
Dust control on roads and streets	X		
Industrial boiler feed	X		
Industrial process water, no worker contact	X		
Industrial process water, worker contact			X
Laundries			X
Nurseries irrigation	X		
Sod farms	X		
Soil compaction	X		

NOTES:
1. Title 22 of the California Code of Regulations (Division 4, Chapter 3, §60301 et seq.)
2. See Table 9-4 for references to CII case studies where these municipal recycled water uses have been applied.
3. Undisinfected secondary water is primarily used for agricultural applications and sanitary sewer flushing. Advanced treated water is used primarily for potable groundwater recharge applications. Neither application is presented in this table.
4. Title 22 identifies two levels of secondary treatment based on total coliform testing and differentiates recycled water use for each.
5. §60301.225.
6. §60301.220.
7. §60301.230.

CDPH has authority to protect sources of drinking water and regulate public drinking water systems. In its role of protecting drinking water sources, CDPH may specify requirements to be included in the water recycling permits issued by the RWQCBs. In regulating public water systems, potable water agencies obtain permits for operating water treatment plants or drinking water wells. For groundwater recharge projects using municipal recycled water, these CDPH permits have not been a focus. For future indirect potable reuse involving surface water augmentation or direct potable reuse, CDPH permits may play a more significant role.

In 2010 Senate Bill No. 918 (SB 918) was enacted. It added Chapter 7.3 to Division 7 of the California Water Code, which addresses the regulation of indirect and direct potable reuse. The following provisions were enacted:

- On or before December 31, 2013, CDPH shall adopt uniform water recycling criteria for indirect potable reuse for groundwater recharge.
- CDPH shall convene and administer an expert panel for the purposes of advising CDPH on public health issues and scientific and technical matters regarding development of uniform water recycling criteria for indirect potable reuse through surface water augmentation and investigation of the feasibility of developing uniform water recycling criteria for direct potable reuse.
- On or before December 31, 2016, CDPH shall develop and adopt uniform water recycling criteria for surface water augmentation, provided that CDPH submit the proposed criteria to the expert panel and the expert panel adopts a finding that the proposed criteria would adequately protect public health.
- CDPH shall investigate and report to the Legislature by December 31, 2016, on the feasibility of developing uniform water recycling criteria for direct potable reuse and shall complete a public review draft of its report by June 30, 2016.
- CDPH, in consultation with SWRCB, shall report to the Legislature as part of the annual budget process, in each year from 2011 to 2016, inclusive, on the progress towards developing and adopting uniform water recycling criteria for surface water augmentation and its investigation of the feasibility of developing uniform water recycling criteria for direct potable reuse.
- CDPH may appoint an advisory group, task force, or other group, comprised of representatives of water and wastewater agencies, local public health officers, environmental organizations, environmental justice organizations, public health nongovernmental organizations, and the business community, to advise the department regarding the development of uniform water recycling criteria for direct potable reuse.
- SWRCB shall enter into an agreement with CDPH to assist in implementing these provisions.

9.1.5 Regulatory Agencies and their Roles in Statewide Recycling

The current framework for regulating municipal recycled water has been in place since the 1970s. Primary authority for overseeing municipal recycled water is divided between the SWRCB and CDPH. A memorandum of agreement between the SWRCB and CDPH documents this arrangement and clarifies the roles of the agencies.

Four other state agencies are directly involved with municipal recycled water issues in California and implement various sections of state law: DWR, California Public Utilities Commission, HCD, and CBSC. Statutes governing municipal recycled water are currently contained within the Water, Health and Safety, and Public Utilities codes and regulations are in various subdivisions (titles) of the California Code of Regulations (CCR). State agency roles and responsibilities are summarized in Table 9.3.

Local city and county officials also have a regulatory role affecting municipal recycled water projects. In some cases, CDPH can delegate responsibilities to local officials if local municipal recycled water project sponsors agree with the delegation.

Nine RWQCBs, several CDPH district offices, 58 counties, and numerous cities have a role in monitoring water recycling. Statewide, many officials have a regulatory role governing some aspect of water recycling projects. In some cases, maintaining consistent application of laws and regulations has been a challenge.

9.1.5.1 Municipal Recycled Water Permits

Municipal recycled water permits may be issued by either individual RWQCBs or the SWRCB to producers of municipal recycled water, purveyors who supply their customers with municipal recycled water produced by others, or individual users of municipal recycled water. With a minor exception, municipal recycled water permits are issued by RWQCBs in the form of water reclamation requirements, waste discharge requirements, or master recycling permits. Master recycling permits combine provisions from both water reclamation requirements and waste discharge requirements, and the producer with a master permit is required to adopt and enforce a use ordinance.

Table 9.3 - Regulatory Agency Roles and Responsibilities for Regulation and Use of Municipal Recycled Water

Agency	Role	Responsibility	California CCR
Department of Public Health	Protects public health	• Adopts uniform recycled water criteria for non-potable and potable recycled water projects[1] • Provides recommendations for recycled water project permits • Reviews and makes recommendations on sites proposed for recycled water use • Oversees cross-connection prevention[2] • Oversees protection of drinking water sources • Regulates public drinking water systems	Titles 17 and 22
State Water Resources Control Board	Protects Water quality and water rights	• Establishes general policies governing recycled water project permitting • Oversees RWQCBs • Provides financial assistance to local agencies for recycled water projects • Allocates surface water rights	Title 23
Regional Water Quality Control Boards (nine)	Protects water quality	• Issues and enforces permits for recycled water projects, incorporating Title 22 requirements and CDPH recommendations • Protects surface and ground water quality from recycled water impacts	Title 23
Department of Water Resources	Manages statewide water supply	• Evaluates the use of and plans for potential future uses of recycled water through the preparation of the California Water Plan • Provides financial assistance to local agencies for recycled water projects • Adopts indoor plumbing standards for recycled water	Title 24 (California Plumbing Code, Chapter 16A, Part II)
Public Utilities Commission	Oversees rates and revenues of investor-owned utilities	• Approves rates and terms of service for the use of recycled water by investor-owned utilities	Title 20
Department of Housing and Community Development	Oversees building standards for dwellings, including institutions and temporary lodgings	• Adopts standards for graywater systems in residential structures • Adopts standards for nonpotable water systems within	Title 24 (California Plumbing Code, Chapter 16A, Part I; Chapter 6)
California Building Standards Commission	Oversees adoption of standards for buildings	• Will adopt standards for graywater systems in nonresidential structures in 2011 cycle of California Building Standards Code • Oversees the adoption of California Plumbing Code, including provisions added by other state agencies	Title 24 (California Building Standards)
Local Building Officials	Oversees building design, including plumbing	• Enforce building standards, including California Plumbing Code	Title 24
County environmental health departments	Protects drinking water systems	• Enforce cross-connection control • Review and make recommendations on sites proposed for recycled water use	Titles 17 and 22

NOTES:

1. As of November 2011, CDPH has adopted regulations in Title 22 for non-potable use of recycled water, but not for potable reuse projects. SB 918 requires CDPH to adopt uniform water recycling criteria for indirect potable reuse projects involving groundwater recharge and surface water augmentation.
2. May delegate some responsibilities for review of new sites and cross-connection control to the local County Health Departments with the permission of the local recycled water provider

Regardless of the form of the permit, the requirements applicable to municipal recycled water would be the same and incorporate applicable provisions of Title 22 regulations and recommendations of CDPH. In lieu of writing permits for each project, the SWRCB also has a statewide general permit for landscape irrigation with tertiary treated municipal recycled water. The variety of permitting approaches provides flexibility to adapt permits to the roles and authorities of agencies involved in municipal recycled water production or distribution.

As noted in Section 9.1.4, CDPH oversees protection of drinking water sources and issues permits to water agencies for public drinking water systems. To date, the drinking water permits have not played a significant role in regulating water recycling projects.

9.1.5.2 Municipal Recycled Water Policies

Municipal recycled water law in the state is based on the California Constitution (Article X, Chapter 2) which states that "... waste or unreasonable use or unreasonable method of use of water be prevented."

Issues of concern for permitting municipal recycled water to protect water quality include salinity management, regulation of incidental runoff, and evaluation of chemicals of emerging concern (CECs).

To address these issues, the SWRCB in 2009 adopted a Recycled Water Policy. Some key elements of the policy were:

1. Manage salinity for each basin/subbasin through development and implementation of salt and nutrient management plans.

2. Regulate incidental runoff through waste discharge requirements, which may include NPDES permits or stormwater permits with specific permit provisions.

3. Prioritize approval of groundwater recharge projects utilizing municipal recycled water treated by reverse osmosis.

4. Convene an expert technical panel to provide recommendations on monitoring of CECs for municipal recycled water policy.

9.2 Municipal Recycled Water Infrastructure

Municipal recycled water infrastructure begins with the wastewater collection system and ends with the plumbing on the recycled water user's site. Many infrastructure components and evaluation of other factors are needed to make a project feasible for municipal recycled water by CII businesses. A component overview is presented below; Section 9.3 focuses on issues pertinent to CII municipal recycled water use.

9.2.1 Wastewater Collection and Treatment and Municipal Recycled Water Distribution

Municipal wastewater recycling projects are generally infrastructure-intensive requiring a large capital investment, project siting, construction, maintenance, operation, and other significant challenges for the builder and operator of the project. Key project-specific variables affecting the infrastructure requirements for future water recycling projects in California are described below. This section addresses only non-potable recycled water treatment and distribution because most CII municipal recycled water applications are non-potable.

9.2.1.1 Source Control

The quality of municipal recycled water is affected by the quality of the source of potable water supply and the pollutants added to the water during use before the wastewater is discharged to wastewater collection system. Conventional secondary and tertiary treatments are very effective in removing organic matter and pathogens. However, these levels of treatment are not designed to remove many chemicals. While many chemicals are not harmful to the environment when discharged into a river, they may be detrimental to certain uses of municipal recycled water. For example, excessive boron can be toxic to landscape plants. Source control or industrial pretreatment programs are in place to require commercial and industrial water users to reduce or eliminate certain chemicals before releasing their wastewater into sewers. Source control can be an important factor for municipal recycled water projects because it may improve the quality to be acceptable to CII businesses without the need for expensive advanced wastewater treatment. Control of wastewater quality starts with the collection, pretreatment, and source control of sewage.

Other source control issues include:

- **Inflow and infiltration -** Sewage quality can be deteriorated through infiltration into the sewer system. For example, when sewers run through areas with brackish groundwater, salt concentration of the sewage can increase. Proper construction and maintenance of sewers can reduce the impacts of infiltration.
- **Source water -** Higher salinity water supply sources can contribute to higher salinity in sewage that passes through to municipal recycled water. For example, this could be true in system with both

high TDS groundwater and good quality surface water sources. Sewage salinity would increase when higher TDS groundwater is used during seasonal supply changes or when groundwater is used during drought conditions when surface water is unavailable. This salinity increase could result in additional treatment to achieve recycled water at a target quality and increase the waste byproducts of the recycling process.

- **Water softeners -** Home-based water softeners may introduce additional salts into the municipal waste stream. AB 1366 (2009, CWC §13148) enables local jurisdictions to regulate home self-regenerating water softener use to reduce the salinity of inflow to wastewater treatment facilities and water recycling facilities.

9.2.1.2 Treatment Approaches

The type and level of wastewater treatment required and selected for a water recycling project is one of the most important variables in determining the ultimate infrastructure cost for the project. According to the Recycled Water Task Force (RWTF) Water Recycling 2030 Report:

> *"The degree and type of wastewater treatment that is provided to make recycled water suitable for use depends on the types of use, the potential exposure of humans to recycled water and the public health implication, and the water quality required beyond health considerations. The basic levels of treatment include primary, secondary, and tertiary. Not all wastewater receives all three levels of treatment. Secondary treatment is commonly the minimum level of treatment for discharge to surface waters and for many uses of recycled water. Tertiary treatment is sometimes required for discharge to surface water to protect fisheries or protect use of the waters. Tertiary treatment is often required for recycled water where there is a high degree of human contact. Disinfection is usually required for either discharge or recycled water use to kill viruses and bacteria that can cause illness."*

The CDHS specifies the levels of treatment for recycled water and publishes the standards in Title 22 of the California Code of Regulations. Beyond the treatment required for health protection, certain uses have specific water quality needs. High sodium or boron in water can be harmful to crops. Water hardness can cause scaling in industrial boilers. Nitrogen and phosphorus can stimulate algal growth in ponds or cooling towers. Sometimes specialized forms of tertiary treatment are needed to remove specific chemicals that would make recycled water unusable."

The municipal recycled water treatment process consists of a series of steps or stages. The steps may include:

- Primary sedimentation
- Activated sludge secondary treatment
- Secondary sedimentation, potentially including nitrification and denitrification
- Chemical coagulation with alum and polymer
- Dual media filtration
- Advanced treatment processes, such as reverse osmosis (RO), etc.
- Disinfection using chlorination or sodium hypochlorite

Figure 9.4 illustrates examples of these steps combined in a treatment process.

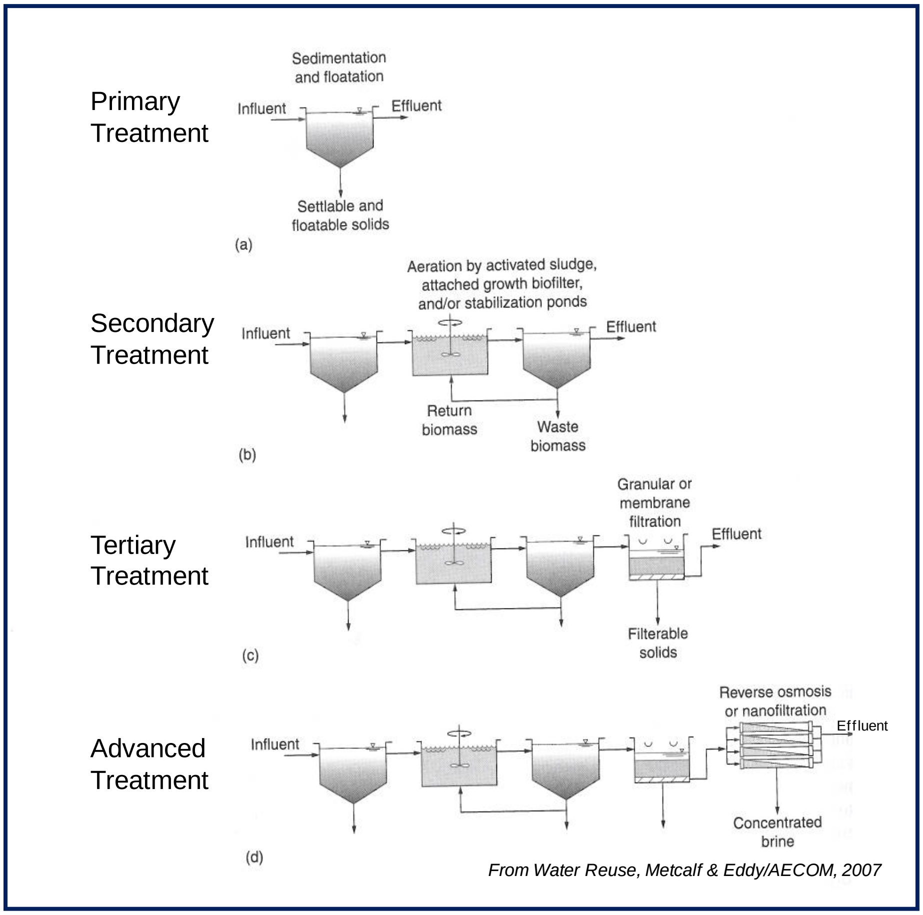

Figure 9.4 - Municipal Recycled Water Treatment Process

Schematic of possible treatment steps to achieve different levels of treatment and potential recycled water use.

With the exception of a few ocean discharges, all municipal wastewater in the United States must receive a minimum of secondary treatment. To avoid polluting sensitive rivers, bays, or estuaries, tertiary treatment by dual media filtration (or equivalent) is frequently required. To the extent that treatment is required to meet pollution control levels to protect receiving waters, the cost of treatment is typically borne by the wastewater agency and sewer users. In many cases, the treatment already in place to satisfy pollution control requirements is satisfactory for many CII municipal recycled water users. However, if specialized water quality needs of CII businesses require additional recycled water treatment, the cost of the additional treatment would be allocated to a water supply function.

Reducing the salinity of the treated wastewater flow entering the municipal recycled water distribution system in some cases is a key aspect of producing municipal recycled water. Reverse osmosis (RO) commonly is used to remove salinity. The RO process produces a concentrated salt solution called brine. Disposal of brine can be costly and environmentally challenging.

The Santa Ana River Interceptor (SARI) system provides an example of a regional solution to the brine disposal challenge. SARI is a pipeline that conveys saline waters from many brine producers in the upper Santa Ana River region to the Orange County Sanitation District for treatment and disposal into the Pacific Ocean. It segregates high-salt wastewater from domestic wastewater, thus protecting the quality of domestic wastewater for reuse.

9.2.1.3 Distribution System

The non-potable municipal recycled water distribution system typically includes a number of interrelated elements:

- **Delivery System -** A network of “purple pipes” (although large diameter pipes installed beneath streets are not always purple, purple is the color reserved for municipal recycled water distribution pipes) sized to meet peak recycled water distribution demands. The flow capacity of the distribution pipes generally decreases as the distance from the treatment plant or storage facility increases and water deliveries are made. Except in systems in which municipal recycled water is treated and approved for direct potable use, the municipal recycled water delivery system must always be segregated from the potable water delivery system.
- **Pumping** – Conveyance of municipal recycled water from the treatment facility to its ultimate point of use often requires pumping. Wastewater collection systems are typically designed to use gravity flow to move wastewater through sewer mains to a lower point for treatment. Consequently, the finished municipal recycled water product must sometimes be pumped back up to a higher elevation to maximize opportunities for use. Again, municipal recycled water pumping systems must be separated from potable water pumping systems.

- **Storage** – Municipal recycled water storage increases the efficiency of the municipal recycled water distribution system in three ways:
    - Municipal recycled water produced during a time of day or time of year when demand is low can be stored for use when demand is high, which provides for more complete utilization of this resource.
    - Properly sited storage reduces the capacity and size (and, therefore, the cost) of treatment, pumping, and distribution system pipe needed to meet peak irrigation demands
    - Allows for municipal recycled water to be pumped to storage during lower cost non-peak energy demand periods thus reducing operational cost and providing energy grid flexibility.
- **Backflow and cross connection prevention -** All recycled water delivery systems must include safeguards to prevent backflow, or the reverse flow of recycled water back into the public drinking water system. Additionally, a program must be in place to detect cross connections, or the inadvertent connection of the municipal recycled water “purple pipe” to a potable water delivery system.
- **Metering** – Recycled water use is typically metered and tracked separately from the potable water delivery system, a strategy that can also be helpful in identifying cross connections.
- **Supplemental or backup water supply** –The ability to add potable or non-potable water into the municipal recycled water system either to meet peak water demands in the municipal recycled water system or to provide a reliable backup supply to recycled water users in case the municipal recycled water supply is interrupted for any reason, such as a wastewater treatment malfunction, is commonly incorporated into municipal recycled water systems.

9.2.2 Onsite Infrastructure

If an existing water user is converting part or all of its use to municipal recycled water, its use site must undergo a use site retrofit and be designed to meet CDPH requirements before receiving that water. In new developments where municipal recycled water delivery is planned, sites can be designed from the beginning with separated potable and recycled water plumbing.

Onsite infrastructure modifications incur expenses for both users and suppliers of municipal recycled water. Onsite design criteria include use of purple pipes and appurtenances, overspray prevention, and separate potable water and recycled water systems with appropriate backflow prevention to avoid cross-connections. Other onsite issues may include the need for changes in onsite treatment processes and other operating criteria to accommodate the differences in water quality.

Prior to implementing onsite use of municipal recycled water, a user is required to:

- Conduct cross-connection testing
- Submit use site plans for review and approval by CDPH or the local county health department

These infrastructure modifications incur expenses for both users and suppliers of municipal recycled water.

9.3 Municipal Recycled Water CII Applications

CII businesses are currently successfully integrating municipal recycled water into many aspects of their process, as indicated in earlier sections of this report and in Table 9.4. Currently, municipal recycled water is being used for:

- Landscaping
- Process water
- Boiler/cooling tower applications
- Indoor (dual) plumbing

As indicated earlier, in 2009, commercial and industrial applications represent up to 30 percent of the total municipal recycled water use in California. These applications have the potential to be expanded. This section addresses the issues associated with expanding the CII use of municipal recycled water and factors to consider when implementing the applications.

Table 9.4 - CII Sector Municipal Recycled Water Applications

CII SECTOR	CII TASK FORCE REPORT SECTION	APPLICATION[1] Cooling Tower Make up	Indoor (Dual) Plumbing	Landscape Irrigation	Process Water	Boiler Feed	Other	CASE STUDIES[2]
Commercial and Institutional Sector Uses								
Office Buildings	7.1.5	✓	✓	✓				Irvine Ranch Water District supplies recycled water to dual plumbed office buildings throughout its service area
Prisons	7.1.6			✓			✓	Prisons in California use recycled water for agricultural and golf course irrigation.
Schools and Educational Facilities	7.1.8	✓	✓	✓				UC San Diego, San Jose State University, and some schools within IRWD
Vehicle Washing	7.1.9						✓	Marin Municipal Water District
Industrial Sector Uses								
High Tech	7.2.2.3						✓	Several proposed solar projects are planned, but have not yet begun construction or operation. South Bay Water Recycling provides recycled water to several high-tech industries for cooling server centers.
Petroleum refining and chemicals	7.2.2.4	✓				✓		BP Carson
Pharmaceutical	7.2.2.5	✓				✓		Amylin, Genentech
Power Plants	7.2.2.6	✓						Metcalf Energy Center (South Bay Water Recycling), Walnut Energy Center (Turlock)

NOTES:

1. Refer to Table 9.2 for a summary of municipal recycled water applications approved under Title 22 of the California Code of Regulations (Division 4, Chapter 3, §60301 et seq.), based on required treatment levels.
2. Case studies cited here are not the only locations where CII municipal recycled water is being used for the application, but they are merely cited here as examples. Case studies are included in Appendix B.

9.3.1 Water Quality Issues

Water quality is a key issue with almost every CII application of municipal recycled water use. It applies both to the quality of municipal recycled water currently available and to the needs of the proposed application. For example, proposed power plants are required by the CEC to consider recycled water for cooling tower use when the plant's application for certification is submitted. High concentrations of some dissolved minerals can affect the number of times water can be cycled through the cooling towers and the concentration of the discharge. These concentrations affect both the plant operation and waste disposal – both of which are costly to power plant operation. Table 9.5

summarizes key water quality issues and the BMP within this report where they are addressed.

Table 9.5 - Key Water Quality Issues for CII Municipal Recycled Water Applications

APPLICATION	KEY WATER QUALITY ISSUES	BMP
Dual Plumbing	Color	Tertiary treatment processes
Landscaping	Boron, salt	Source control, irrigation management
Process Water	Salt	Source control, reverse osmosis
Boilers Feed	Salt	Reverse osmosis
Cooling Tower Make up	Salt	Source control, onsite water conditioning
Car Wash facilities	Spotting	Add additional treatment to lower TDS

Supplemental treatment may be necessary to address water quality issues. In some cases, the water service provider provides additional treatment. For example, both the Long Beach Water Department and West Basin Municipal Water District operate recycled water plants that take wastewater effluent treated by other entities (and that meet Title 22 requirements for some reuses) and treat the effluent to higher standards. The more highly-treated recycled water is then distributed separately from its original inflow water.

In some cases, additional treatment is provided onsite by either the CII user or the municipal recycled water agency.

9.3.2 Supply Issues

Supply issues are those related to getting the municipal recycled water to the end user. Refer to Section 9.2.1 and Figure 9.1 for a description and schematic representation of public and onsite infrastructure.

9.3.2.1 Public Infrastructure

Development of a public infrastructure system is a substantial undertaking for a supplier. In most cases cooperation between water service providers and wastewater agencies is required for the planning, design, and operation of municipal recycled water systems. Municipal recycled water systems often cross jurisdictional boundaries between water service providers, cities, and wastewater agencies. Interagency agreements are often required to implement municipal recycled water projects. In some cases, supplemental agreements between local wastewater and water agencies are needed because some wastewater agencies are not permitted to deliver treated water or may prefer that potable water agencies take on the function of recycled water supply and/or distribution. Under current practices, a separate “purple pipe” infrastructure is required, which involves coordinating locations with existing infrastructure, monitoring cross-connection issues, and maintaining the system. It also involves conducting a customer survey to determine the financial viability of the system and whether the supplier is able to operate and maintain it.

Public infrastructure may also include planning and constructing a regional brine disposal system, such as the Santa Ana Regional Interceptor (SARI) system.

9.3.2.2 Onsite Infrastructure

If municipal recycled water available to a CII user does not meet the water quality standards to incorporate municipal recycled water into its water supply, then the CII user may:

- Install additional onsite treatment facilities
- Address differences in wastewater disposal issues – either to the existing wastewater provider or identifying onsite wastewater disposal options
- Modify the onsite process to accommodate different water quality

In addition, the CII user is responsible for installing the conveyance facilities (pipeline, valves, and pumps) necessary to deliver the recycled water from the property line to the point of use. The CII user must also operate and maintain any onsite infrastructure and train its employees to work with municipal recycled water. Onsite treatment plants require maintenance and potentially periodic component replacement, as well as additional energy and chemical costs. Backflow and cross connection monitoring and maintenance are also required by CDPH.

In most cases the cost of municipal recycled water is discounted relative to potable rates to encourage municipal recycled water use and offset onsite costs borne by CII customers. In some cases, the price savings a water agency provides to the CII user to receive municipal recycled water instead of potable water does not offset the additional costs incurred by receiving it. Water utilities have provided various mechanisms to assist the financing of onsite costs.

9.3.2.3 Supply Interruption, Backup Requirements

Most non-landscape CII municipal recycled water applications require a dependable water supply. If, for some reason, reliable municipal recycled water is not provided, then operations may need to be suspended. If supply reliability is a key issue for the CII user, then it may need to identify a backup water supply or require assurances from the municipal recycled water agency that supplies will not be interrupted. This can be a challenge for large water users and can also increase the costs for developing municipal recycled water supplies. Many municipal recycled water agencies ensure a reliable supply by designing the ability to add potable or suitable non-potable water into municipal recycled water systems during shortfalls or interruptions in the municipal recycled water supply.

9.3.2.4 Seasonal Demand

Seasonal demand for municipal recycled water is a challenge for municipal recycled water agencies. Landscape irrigation is the most common CII application of municipal recycled water. However, the demand for landscape irrigation is primarily a spring-summer-fall demand because winter rains reduce or remove the need for supplemental year-round irrigation in California. Landscape irrigators are important municipal recycled water customers because they are often high-volume users and are somewhat flexible in delivered water quality. Some water agencies have addressed this by ceasing winter production of municipal recycled water (which reduces revenue), developing winter storage, or supplementing peak demands with other supply such as non-potable groundwater.

9.3.3 Emerging Technologies

Because of the inherently high costs of dedicated municipal recycled water distribution systems, complexities in installing new infrastructure in areas with limited access, and the tendency for wastewater treatment facilities to be located downstream and at a distance from potential municipal recycled water users, extensive research is being done to develop alternative methods for distributing municipal recycled water. These include:

- Satellite Plants – A smaller wastewater treatment facility is located on a regional wastewater collection trunk line. It takes some of the raw sewage off of the trunk line, treats it to the recycled water standards for its local customers, and returns treatment residuals to the trunk line. In this way, treatment facilities can be located more centrally to the market for municipal recycled water.
- Potable System Distribution – If municipal recycled water were to be treated to a level that is acceptable for drinking, the municipal recycled water could be distributed in the same pipeline system as potable water, eliminating the need for a separate purple pipe distribution system. The added costs of recycled water treatment to potable standards might be more than offset by the elimination of a recycled water distribution system. Direct potable reuse is not currently authorized in California. However, SB 918, as described in Section 9.1.4, provides that this concept of direct potable reuse be studied further and that an expert panel make recommendations on it.

9.4 Public Infrastructure Needs for Increasing CII Municipal Recycled Water Use

The components of public infrastructure for specific municipal recycled water systems are described in Section 9.2.1. The needs for a local or regional system are specific to the unique characteristics of the area: the quality of wastewater, the locations and types of wastewater treatment in place to serve pollution control needs, the added treatment that might be needed to meet municipal recycled water customer needs, the types of municipal recycled water users and their needs, and the proximity of municipal recycled water users to the sources of municipal recycled water. These needs are determined through a systematic planning process to investigate all issues and assess the potential market for municipal recycled water and public acceptance of a project.

Comprehensive local planning to identify public infrastructure needs will support identification of aggregate statewide needs. Despite the gains in California's municipal recycled water use since the early 1990s, California is not on target to attain the various projections of 2030 recycled water use potential: 1.85 to 2.25 MAF (based on the RWTF of 2003) and 2.5 MAF (based on the SWRCB Recycled Water Policy). If the current pace of adding recycled water use that was set between 1990 and 2009 is maintained for the period between 2011 and 2030, the state will only be recycling about 1.1 MAF by 2030. Strong focus and direction are needed to make better progress to achieving a goal of at least two MAF by 2030. Water recycling goals will not be met with only non-potable reuse, and additional direct and indirect potable reuse will be required. A major challenge to meeting these goals is considered to be the overall pace of infrastructure construction is lower than anticipated.

This section addresses the requirement that the CII Task Force was directed by Water Code Section 10608.43(c): to evaluate "public infrastructure necessary for delivery of recycled water to the commercial, industrial, and institutional sectors." Barriers and solutions to increasing municipal recycled water use are included in Section 10. In particular, solutions to infrastructure barriers are discussed in Section 10.1.

9.4.1 Municipal Recycled Water Implementation

Municipal recycled water is produced and distributed locally. This local component allows suppliers to maintain control of their systems and meet the needs of their customers. It also enables water agencies with water source challenges to increase local supplies and reduce dependency on imported water.

Maintaining local and regional control of municipal recycled water works well. However, the State of California sees an overall benefit to expanding municipal recycled water use because doing so supports the overall objective of water supply reliability and sustainability.

The success of a local municipal recycled water project depends on good planning and local interagency cooperation. It enables alternatives to be evaluated and to develop an approach to address customer and water supply needs. It also considers both onsite and offsite infrastructure costs. Solutions to this obstacle are discussed in Sections 10.1.1 and 10.1.3. The CII Task Force encourages local planning efforts using good planning practices to maximize the implementation of municipal recycled water use. Recommendations to accomplish this goal are identified below.

9.4.2 Justification for Additional Municipal Recycled Water Funding

Infrastructure is a fundamental requirement for water recycling to support water resource supply goals. Infrastructure trends have been partially governed by shifts in the purpose of reuse as it evolved from wastewater disposal to an alternative water supply. Additionally, local water and wastewater agencies are postponing or shelving planned projects because of fiscal challenges. If additional projects are not implemented, increased municipal recycled water use may not occur.

Augmenting statewide municipal recycled water funding, even in light of current statewide budget issues is expected by the Task Force to provide long-term benefit to the state for the following reasons:

- Utilizing existing water supply efficiently can buffer against continued population growth and recurring periods of drought.
- Establishing and fully utilizing municipal recycled water supplies reduce the dependence on imported water.
- Developing local water resources will provide communities with increased self reliance in the face of potential climate change impacts to the state’s water system.
- Using municipal recycled water may reduce greenhouse gas emissions because less energy is needed to treat and reuse water locally than to convey fresh water long distances.

9.4.3 Known Issues

Section 10 addresses many barriers to increasing municipal recycled water use in California. Three infrastructure needs were identified:

- Local Delivery Infrastructure Needs – Some municipal recycled water service providers have been able to construct recycled water facilities. However, expanding customer bases and delivering municipal recycled water to identified customers has been problematic. Additional funding would support installation of additional conveyance and could also be used to support appropriate onsite infrastructure improvements.

- Brine Disposal Needs – This continues to be a significant obstacle to expanding municipal recycled water development, particularly in inland communities. As an example, Southern California has successfully developed portions of the Santa Ana Regional Interceptor, a brine export line. Expansion of infrastructure to dispose of brine would provide opportunities for additional municipal recycled water supply.
- Expanded potable reuse – Expansion of potable reuse infrastructure will avoid the costs associated with dual distribution of recycled water and user retrofits. At the same time, it may provide reliable drought proof supplies to allow local economic expansion.

9.4.4 Specific Public Infrastructure Needs

A statewide master plan for municipal recycled water could assemble the results of many independent local and regional planning activities. This master plan would provide a basis for targeting state and local efforts most effectively.

Statewide investment in supporting additional recycled water project implementation should focus on the following steps. Step 1 would begin immediately. Steps 2 and 3 would begin as soon as possible to support additional project development as Step 1 is implemented.

- Develop a Statewide Recycled Water Master Plan. Working with local and regional stakeholders, review the recently completed 2009 Municipal Recycled Water Survey and identify customer bases and geographical areas where the greatest additional benefit can be realized by increasing municipal recycled water use. Working with the stakeholders, identify specific projects and actions that can be implemented to realize the statewide municipal recycled water use potential of at least two MAF of municipal recycled water use by 2030. Evaluate whether the current approach to funding municipal recycled water projects (state grant and low-interest loan funding through DWR and SWRCB) is the most cost effective approach to implementing the master plan.
- Provide additional funding to existing municipal recycled water agencies with excess treatment capacity; to expand existing infrastructure, or provide grants for onsite infrastructure improvements with the goal of adding customers for municipal recycled water.
- Provide additional funding to brine management projects that would expand the use of municipal recycled water.

9.5 Funding/Cost

While identifying specific infrastructure necessary for delivery of municipal recycled water to CII sectors is not possible, the overall cost of this infrastructure may be estimated based on historic data and experience. The Recycled Water Task Force (RWTF) estimated in 2003 of state-wide capital investment between $9.2 and $11 billion (in 2003 dollars) was needed to increase all municipal recycling from 0.5 to 2.0 MAF (1.5 MAF increase) by 2030. The high cost of municipal recycled water projects may be reduced through regulatory streamlining, which is discussed in Section 10. The RWTF recommended increasing State and federal funding assistance to the local and regional agencies implementing and operating the water recycling projects. This recommendation has been implemented through grants and loans administered both by the SWRCB and the DWR and trough Title XVI federal funding.

Costs of water recycling projects have a wide range. San Diego area costs reported in 2010 for potable and non-potable reuse projects provide an indication of costs typically encountered including annual capital and operating costs. Proposed potable projects include estimated costs associated conveyance systems necessary to reach the ground or surface water recharge or blending sites, but do not account for wastewater benefits. Ranges of recycled water costs are estimated to be:

- Existing non-potable projects (4): $1,300 - $1,700 per AF
- Proposed non-potable projects (5): $1,000 - $2,400 per AF
- Proposed indirect potable projects (2): $1,400 - $1,800 per AF

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10.0 Evaluation of Institutional and Economic Barriers to Municipal Recycled Water Use

Municipal recycled water use in California increases the State's water supply resources and provides environmental benefit. As noted in Section 9, water recycling in California has achieved its some success, but continued barriers potentially hinder additional expansion. This section builds upon the background information provided in Section 9, identifies existing barriers, and proposes solutions to increase CII municipal recycled water use in California in accordance with Water Code Section 10608.43(d).

The CII Task Force developed a list of ten current barriers to improve the integration of municipal recycled water into CII applications. The CII Task Force evaluated obstacles and recommendations of the RWTF (DWR, 2003), and reviewed and assessed the current level of implementation of the recommendations. The CII Task Force also evaluated obstacles not addressed by the RWTF, drawing upon professional experience. Finally, the CII Task Force qualitatively ranked the barriers based on their potential to limit increasing local and regional recycled water use and identified possible solutions.

The CII Task Force's ranking of institutional and economic barriers to increase the CII use of municipal recycled water reflects a range of different factors related to CII businesses, municipal recycled water producers and distributors, and State policymakers and regulators. The barriers, listed below, are ranked according to the estimated level of importance in limiting statewide use of municipal recycled water (with number one being the largest barrier).

1. Infrastructure Cost and Feasibility
2. Regulatory Impediments
3. Awareness and Education of Recycled Water Quality
4. Public/Customer Acceptance
5. Cost for CII Users
6. Source Water Quality
7. Recycled Water Supply Reliability
8. Terminology Used in Describing Process
9. Data for Tracking Use
10. Institutional Coordination among Agencies

A summary of each barrier is included along with:

- Potential solutions – Suggestions by the CII Task Force to be taken to remove or lessen the barrier. These may include state funding or changes in state law.
- Implementers - Organizations or entities involved in recycled water and expected to be involved in implementing each solution, including water agencies, municipal recycled water users, and state regulatory agencies and may include the state legislature. Other stakeholders and organizations not listed here may be involved during the implementation process.
- Examples - Selected case studies that provide examples of good practices that support the suggested solutions.

Background

The 2003 RWTF report identified issues and made recommendations for addressing barriers. The 2009 State Water Plan Update (SWPU) provided a status report on implementation of the RWFT recommendations, as well as four additional new recommendations.

The RWTF identified and adopted 26 issues with respective recommendations to address obstacles, impediments, and opportunities that would allow Californians to increase their use of municipal recycled water. Additionally, the RWTF adopted 14 of the issues as key and deserving of more immediate attention:

- Funding for water recycling projects
- Community value-based decision-making model for project planning
- Leadership support for water recycling
- Educational curriculum
- State-sponsored media campaign
- Uniform Plumbing Code Appendix J
- CDPH guidance on cross-connection control
- Health and safety regulation
- Incidental runoff
- Uniform interpretation of State standards
- Water softeners
- Uniform analytical method for economic analyses
- Research funding
- University academic program for water recycling

While other issues were deemed to be important, the RWTF recommended these 14 as the focus of statewide efforts to increase the use of municipal recycled water.

The SWPU provided information on progress made in implementing a number of the RWTF's recommendations including:

- AB 334 (2003 statutes, chapter 172) allowing local water agencies more authority to address wastewater salinity levels from residential water softeners
- Symbol code changes to notify the public not to drink municipal recycled water
- Additional support by State agencies for municipal recycled water
- Development of a fifth grade water recycling educational curriculum
- Additional federal funding for water recycling through the U.S. Bureau of Reclamation
- SWRCB direction on regulation and enforcement of incidental recycled water runoff
- SWRCB funding for water recycling research

Subsequent to publication of the SWPU, Appendix J of the Uniform Plumbing Code (UPC) has been amended as recommended (now in Part II of Chapter 16A of the California Plumbing Code).

The 2009 State Water Plan also included four recommendations to increase recycled water use.

- State and local agencies and stakeholders should implement, as appropriate, the RWTF recommendations. The recommendations can be used as a toolbox for communities to improve their planning of recycled water projects.
- The SWRCB should establish a centralized data repository of recycling facilities and programs that contains basic information such as type of treatment, volume of water recycled, uses of recycled water, and costs of operation. Additionally, a systematic reporting process should be established to ensure maintenance and integrity of the data for future reference.
- State agencies should develop a uniform interpretation of state standards for inclusion in regulatory programs and integrated regional water management plans (IRWMPs), and clarify regulations pertaining to water recycling, including permitting procedures, health regulations, and the impact on water quality.

- The state should expedite the availability of funding for regional Salt Management Plans necessary to increase the potential of recycled water.

These previous recommendations served as a foundation as the CII Task Force developed the list of barriers and solutions discussed below.

10.1 Barrier: Infrastructure Cost and Feasibility

The topic of infrastructure cost and feasibility was discussed in detail within Section 9.4, Public Infrastructure Needs for Increasing CII Municipal Recycled Water Use. It is briefly summarized here, followed by potential solutions.

Cost and feasibility of water recycling infrastructure are the primary limitations on municipal recycled water use in CII applications. Two CII infrastructure limitations are:

- Delivery of municipal recycled water to the CII use site
- Onsite integration of municipal recycled water use at CII sites

Delivery of municipal recycled water is the primary responsibility of the supplier. The onsite facility modifications required to use the municipal recycled water primarily are the responsibility of the owner or operator of the CII site.

Currently, municipal recycled water is conveyed to customers through a dedicated (purple pipe) distribution system. This parallel distribution system, while a necessary and appropriate component of the State’s strategy to achieve the goal of increasing water recycling, is a limiting factor for many communities. The costs associated with designing, installing, and maintaining a separate water distribution system can be challenging, especially in dense urban areas with extensive existing buried utilities. Furthermore, traffic disruptions during construction result in inconvenience and additional costs.

Indirect and direct potable reuse can provide opportunities to use municipal recycled water without the need for complex dual distribution systems. The trade-offs to considering indirect and direct potable reuse instead of a dedicated, parallel distribution system include construction costs for:

- Advanced wastewater treatment facilities
- Transmission pipelines to convey municipal recycled water to groundwater or surface water sites
- Transmission pipelines to suitable locations for connecting directly into potable distribution systems
- Additional water quality monitoring to protect groundwater and public health

Indirect potable reuse through groundwater recharge has a long and successful history in California, and its continued expansion is expected. Advanced treatment technologies with proven performance and reliability that have been used for groundwater injection projects provide the foundation for other indirect and direct potable reuse projects. CDPH is currently in the process of updating and adopting the regulations associated with recharging groundwater with recycled water. CDPH released a copy of the draft regulations on November 21, 2011 and will continue to work towards developing a final proposed version of the regulation. A legislatively mandated path to the further evaluation of indirect potable reuse through surface water augmentation and a report to the legislature investigating the feasibility of developing regulatory criteria for direct potable reuse were included in Senate Bill 918, which was enacted in 2010.

10.1.1 Solutions

Solution 1: Conduct Local and Regional Water Recycling Planning by Analyzing Appropriate Options

- Agencies often plan water recycling projects with preconceived limitations that may preclude opportunities for exploring municipal recycled water markets outside of certain jurisdictional boundaries, taking advantage of certain sources of municipal recycled water, or exploring potable reuse. Conducting good planning using concepts found in the following resources can support successful recycled water program implementation:
    - Guidelines for Water Reuse (USEPA EPA/625/R-04/108)
    - Best Practices for Developing Indirect Potable Reuse Projects: Phase 1 Report01-004-01 (WateReuse Research Foundation)
    - Urban Water Recycling Feasibility Assessment Guidebook (CUWA)
    - Water Reuse Issues Technologies, and Applications (Metcalf & Eddy | AECOM)
    - Wastewater Reclamation and Reuse (Asano, ed)
    - Manual of Practice on How to Develop a Water Reuse Program (WEF)
    - Websites
        - EBMUD (http://www.ebmud.com/environment/conservation-and-recycling/recycling/about-recycled-water)
        - South Bay Water Recycling (http://www.sanjoseca.gov/sbwr/publications.htm)

  - LACSD (http://www.lacsd.org/waterreuse/recycledresources.asp)

Implementers: Water supply and wastewater agencies.

Example: City of Riverside Recycled Water Planning

The City of Riverside's Potable Reuse Project evaluated two options for expansion of its recycled water system. Both options provided approximately 10,000 AFY of additional water supply to its customers. The analysis offers helpful insight into the considerations involved in assessing how to effectively integrate municipal recycled water with existing potable supplies, considering costs, benefits, and implementability. The two options evaluated by the City of Riverside were:

- Purple Pipe: Municipal recycled water could be delivered to 740 customers by designing and installing 172 miles of distribution pipeline. The capital cost for the project would be $550 million, which is equivalent to $42/month for each customer. The current average user cost is $35/month.
- Indirect Potable Reuse: Design and installation of six miles of pipe at a capital cost of $95 million would enable conveyance of municipal recycled water to groundwater recharge basins. Existing infrastructure exists for groundwater extraction and distribution. The cost of this project is equivalent to $9/month for each customer.

Based on the analysis, the city considered the purple pipe option infeasible because of cost and community disruption. The city is currently implementing the indirect potable reuse option based on its lower cost and easier implementation.

Solution 2: Seek or Provide Funding Sources to Facilitate Local Projects

Funding and revenue structures are two key components to successfully plan and implement a municipal recycled water program. There is often strong support for a project, but making the actual implementation cost-effective for the involved parties can be challenging. Identifying how both onsite and offsite infrastructure will be funded and recycled water unit pricing are usually addressed on the local or regional level by the supplier, wholesaler, or retailers. Solutions range from a wastewater agency (i.e., supplier) paying a farmer or other recipient to "take the water" to advance treated water being priced at or just below potable water in areas with limited water supplies.

Various regional, state, and federal funding sources are available to local agencies to support development of projects for municipal recycled water use. These funds are often applied to the offsite infrastructure such as treatment plant upgrades to produce higher quality water or to the distribution system. This is discussed further in Section 10.1.5. Onsite infrastructure solutions are also discussed further in Section 10.1.6.

Regional agencies can develop financial incentives to facilitate local projects that have regional benefit. These approaches include providing loans or grants, with repayment through rate structures or other means. The examples provided below show how water agencies have helped overcome infrastructure cost barriers.

Implementers: Local, regional, and state agencies; local and regional water agencies.

Example: City of Santa Clara

Efforts by the City of Santa Clara to provide recycled water to Air Products, a provider of industrial gases, demonstrate how distribution system problems can be overcome. City staff realized that a new 1,300-foot pipeline would be needed to reach the Air Product facility fence line. The City applied for and received stimulus funds through the Bureau of Reclamation’s Title 16 Program.

Example: Central Contra Costa Sanitation District

The Central Contra Costa Sanitary District could provide up to 22,500 AFY to local refineries in Martinez, CA, if adequate funding were available. Municipal recycled water would be used to replace water from the Delta that is currently used for cooling towers and boiler feed. Producing and delivering municipal recycled water would require an estimated $100 million for construction of new tertiary treatment and distribution facilities. CCSD is seeking federal funding assistance through the Water Resources Development Act (WRDA).

Example: Metropolitan Water District of Southern California

The Metropolitan Water District of Southern California (Metropolitan) Local Resources Program (LRP) provides incentive funding in the amount of $250/AF for delivered municipal recycled water to its member water agencies. Funding focuses on developing water recycling and groundwater recovery supplies that replace existing potable demands or prevent a new demand on Metropolitan’s imported water supplies. These projects support either direct replacement of potable water or increased regional groundwater production. Metropolitan current program goal is to develop an additional 175,000 af of annual supply by 2025.

Solution 3: Include Evaluation of Onsite Retrofit and Other Modifications When Assessing Municipal Recycled Water Feasibility

An existing CII facility may need to modify onsite facilities or processes to convert from potable water use or integrate municipal recycled water into its water supply. Frequently, the costs of these modifications may be significantly greater than the savings of using municipal recycled water versus potable water. The modification costs can range widely, from very little to hundreds of thousands of dollars per site. These onsite costs should be considered during recycled water feasibility studies to assess the “true costs” of implementing a project because they could affect the overall project success and whether potential customers are actually able or willing to receive municipal recycled water. Proponents of municipal recycled water projects could also consider developing strategies for financial support of onsite facility or process modifications, as discussed in Section 10.1.6.

Implementers: Water supply and wastewater agencies, CII water users.

Example: British Petroleum Carson Refinery

The BP Carson Refinery (BP Carson) is located on 630 acres in Los Angeles County near the Long Beach and Los Angeles Harbors. It is one of the largest refineries in California and is a major producer of clean fuels. It processes a variety of different crudes from all over the world and supplies 25 percent of the Los Angeles gasoline demand and 15 percent of the jet fuel to Los Angeles International Airport. The refinery now uses municipal recycled water provided by West Basin Municipal Water District.

As BP Carson initially evaluated opportunities to incorporate municipal recycled water into its processes, it determined that a significant portion of the potential costs were associated with requirements to protect the public health and ensure the safety of public water supplies because both potable and municipal recycled water would be used at the facility. CDPH requires the use of air gaps to prevent backflow into the public drinking water system as a result of any inadvertent cross-connection between the potable and recycled water systems on the BP Carson site. The costs associated with the onsite modifications include air gaps for public health protection, instrumentation and controls systems, and storage tanks. In addition to protection of public health, these modifications provide an uninterrupted water supply.

Solution 4: Fund Development of Indirect and Direct Potable Reuse Regulations

Indirect potable reuse through groundwater recharge currently augments the groundwater supply available to potable customers, including CII businesses, thereby providing a more reliable and potentially cheaper water supply. The potential exists for expanding indirect potable reuse through surface water augmentation and, eventually, direct potable reuse. The Legislature, through SB 918 (2010 Statutes, Chapter 700), prescribes a pathway to address the public health issues of indirect and direct potable reuse and adopt regulations as appropriate. However, the ability of the CDPH to conduct advisory panels and draft appropriate regulations is uncertain without adequate funding.

Implementers: Legislature.

Example: City of San Diego Public Utilities Department

The City of San Diego is currently evaluating the option of augmenting drinking water supplies with advanced treated recycled water at its San Vicente Reservoir. The City is currently in the Demonstration Phase of the multi-phase and multi-year study, the project is assessing treatment requirements, reservoir studies, and pipeline alignments. One of the challenges the City of San Diego is addressing is how to move forward without specific state guidelines and requirements, as well as being responsive to public concerns. Augmentation of potable surface water reservoirs is currently occurring in other parts of the United States, including Georgia (Lake Lanier), and Virginia (Lake Occoquan).

Solution 5: Provide Greater State Funding for Municipal Recycled Water Projects Commensurate With Benefit to State

Because of the complex institutional structure for water supply and delivery in California, retail water agencies use a variety of approaches to assess the true costs for developing new water supplies. Major new water development projects are often sponsored by regional, state, or federal agencies; water recycling projects, on the other hand, are typically sponsored by local water agencies. The cost comparison conducted by local water agencies usually involves comparing the capital and operational costs of a new water recycling project to the marginal cost of alternative potable or fresh water supplies. Where water agencies rely on purchases of wholesale water, the marginal cost is the price charged by wholesale suppliers. This price is an average cost of existing water sources and does not reflect the marginal cost of new fresh water development by the wholesale water agencies, which is typically much higher than the price charged. Thus, a new water recycling project may be cost-effective when compared with alternative new fresh water supplies, but more costly from the local perspective than purchasing water.

State and federal funding subsidies can promote municipal recycled water projects that are cost-effective. Such subsidies may also be used where societal value is achieved through environmental benefits in waterways, such as the Delta and rivers, resulting from the use of municipal recycled water instead of fresh water. The environmental benefits can also include reduced energy use. These benefits may accrue statewide and warrant state financial assistance.

State and federal financial assistance in the form of low interest loans and grants to local agencies have been provided for many years. In fact, the State Water Board has provided over $760 million since 1978 for water recycling projects built for water supply purposes. In addition to State Water Board funding, DWR manages Proposition 84 Integrated Regional Water Management grants for water recycling. Nevertheless, the currently available funding is inadequate, especially in the form of grants.

Implementer: Legislature

Solution 6: Provide incentives for installation of customer-side (onsite) infrastructure

As described in Sections 9.2.2 and 10.1.3, onsite costs at customer sites can be considerable and can reduce the business benefits of incorporating municipal recycled water into CII applications. Municipal recycled water agencies should consider providing technical and financial assistance to reduce the cost to the customer or help the customer spread the costs over several years. The CPUC regulates water rates and other management of investor-owned water utilities. The CPUC should support rate structures and utility subsidies to provide an incentive to CII businesses to use municipal recycled water.

The State could also provide incentives or grants for developing facilities to treat wastewater generated onsite for use onsite.

Implementers: Water supply agencies, CPUC

Example: Metropolitan Water District of Southern California

During 2009, water supplies for the State and the Metropolitan Water District of Southern California (Metropolitan) were adversely impacted because of prolonged dry conditions. In response to water shortages, Metropolitan developed the Public Sector Program which provided incentives for onsite recycled water retrofits to expedite water users to convert potable distribution systems to municipal recycled water. Incentives of up to $500 per acre foot over a two year period were provided to qualifying projects. During the year-long program, Metropolitan’s Public Sector Program provided about $1.12 million to convert about 85 sites to recycled water. Estimated savings over the 25-year life of the conversions is estimated to be 83,278 acre-feet.

10.2 Barrier: Regulatory Impediments

The CII Task Force affirms the need for strong public health and environmental protection relative to the use of municipal recycled water. Statutory and regulatory requirements and the interpretation of those requirements by the SWRCB, the nine RWQCBs, the CDPH, and local health and local building officials have a significant impact on the costs associated with the production, delivery, and use of municipal recycled water. With some exceptions, these costs serve to protect public health, water quality, and the environment, and support public confidence in municipal recycled water. Occasionally, regulatory bodies throughout the State interpret the requirements differently. Complex and inconsistently implemented regulations may discourage recycling by creating regulatory uncertainty or confusion, as well as an unnecessary cost burden. This section is intended to provide recommendations on some key areas where the regulatory agencies can offer additional guidance and consistency and to identify areas where statutory or regulatory clarification may be needed. Where appropriate, recommendations build on existing successful efforts by the State regulatory agencies in improving regulatory oversight and permitting.

The three identified regulatory and statutory issue areas are:

- Re-codify and update the recycled water statutes
- Fund updates to recycled water regulations
- Implement consistent regulations and policies by the various regulatory agencies

10.2.1 Solutions

Solution 1: Revise Water Recycling Statutes

Currently, the recycled water statutes appear in various sections of the Water Code, Health and Safety Code, and Government Code. Re-codification of the laws to consolidate and simplify recycled water statutes into a section of the code dedicated to "water recycling" may help recycled water service providers, users, and regulators better locate, understand, and use the appropriate sections of the code.

The Task Force does not specifically endorse or reject any proposed changes, but does support further analysis. Such analysis should identify opportunities to increase recycling while continuing protect public health, water quality, and the environment and to include a determination of the nature and significance of problems of or impediments to reuse and how statutory changes would resolve the problems or impediments. Proposed changes that warrant further analysis:

- Evaluate current laws and regulations to determine if changes are needed to provide a simplified and consistently implemented permitting approach to govern most recycled water projects. Currently there are four different types of permits issued for recycled water projects.
- Have the CDHP regulate the use of "advanced treated" recycled water to be used for potable reuse, and have the RWQCBs regulate other uses of recycled water. "Advanced treated purified water" would constitute a level of treatment higher than tertiary treatment as defined in Title 22 of the current state regulations and would include treatment equivalent to reverse osmosis and advanced oxidation treatment processes.
- Determine if changing the definition of "waste" in Section 13050(d) of the Water Code and other sections of statute is needed to address a perception that recycled water is being regulated as a waste rather than as a valuable resource.
- Update the statutes to address CECs if an update to the State Board's Recycled Water Policy cannot adequately address the issues.

Implementers: SWRCB, CDPH, and Legislature.

Solution 2: Provide Consistent Implementation of the SWRCB's Recycled Water Policy and Revise Policy as Appropriate

This solution is presented in three parts, each with separate examples and/or implementers.

- Part 1 – Regional Board Consistency
- Part 2 – Recycled Water Policy Revisions
- Part 3 – Regulating Municipal Recycled Water Runoff

Part 1. The SWRCB's Recycled Water Policy provides for the development of stakeholder-driven regional or sub-regional salt and nutrient management plans to replace regulation of salts and nutrients solely on individual recycled water projects and to consider all relevant sources of salt and nutrients. This process enables salt and nutrient management plans to be developed and managed on a local and regional basis to address the issues unique to the region. However, this locally-driven process and inherent variability in regional boards can result in inconsistent application of the Recycled Water Policy. Of particular concern are consistency between the regional boards in the regulatory requirements for monitoring CECs and consistency of salt and nutrients management plans with State Water Board and CDPH efforts. Several successful efforts provide good examples to follow.

Developing specific guidelines for the regional boards to use in monitoring requirements for CECs and salt and nutrient management plans would promote consistent implementation of the Recycled Water Policy. Guidelines would be prepared by the State Water Board with input from the regional boards and the CDPH. It is assumed that the guidelines would support consistency, but would not prevent the individual attributes of stakeholder-led efforts.

The three examples provided below demonstrate good communication and approaches within individual state board regions. It is proposed that these types of practices be expanded to support better consistency between regional boards.

Implementers: RWQCBs, SWRCB, Stakeholders

Example: RWQCB Region 9

Following adoption of the Recycled Water Policy, Region 9 staff worked with stakeholders to develop and approve guidelines for the development of salt and nutrient management for the numerous small basins in the region. These guidelines allow stakeholders to focus their efforts on the highest priority basins and provide regulatory certainty for any agency/stakeholder that participates. DWR, through its Integrated Regional Water Management Planning Grant Program, has provided funding to assist in developing these plans.

Example: Central Valley Salinity Coalition (RWQCB Region 5)

In July 2008, the Central Valley Salinity Coalition (CVSC) was formed. It represents stakeholder groups working with the Region 5 in the CV-SALTS effort, and its purpose is to organize, facilitate, and fund efforts needed to fulfill the goals of CV-SALTS. CVSC coordinates the meetings of the CV-SALTS committees, maintains an independent web site, and manages the projects originating from this effort.

Example: RWQCB Region 4

In November 2010, Region 4 staff held an initial workshop to introduce the salt and nutrient plan concept to stakeholders. Since that time, five major basin groups have been formed to develop the plans: Central and West Basin, San Gabriel and Raymond Basins, San Fernando Basin, Pleasant Valley, Oxnard and Las Posas Basins, and Lower and Upper Santa Clara Basins. Each basin group has an assigned Regional Board staff person with local agencies taking the lead as stakeholders. One basin group (Santa Clara) is receiving IRWM funding for its plan. The Regional Board is providing guidance and updates for the plans through its website, an email distribution list, and stakeholder meetings.

Part 2. An expert panel on monitoring CECs made recommendations to the SWRCB in a report dated June 25, 2010. The SWRCB and CDPH should evaluate the recommendations, propose changes as appropriate to the SWRCB's Recycled Water Policy (adopted in 2009), and incorporate the recommendations into the groundwater recharge criteria being developed by CDPH. The policy update should also address the additional work needed to expand laboratory methods and monitor CECs.

Implementers: SWRCB in cooperation with CDPH, the Expert Panel, and other potential monitoring entities (US Geological Survey under its Groundwater Ambient Monitoring and Assessment - GAMA - program)

Part 3. MS4 permits (permits for discharge of untreated stormwater into local water bodies) issued by RWQCBs are a mechanism that can be used for regulating recycled runoff consistent with other landscape over-irrigation runoff. MS4 permits can put recycled water on par with other potable water supplies. Currently the SWRCB's Recycled Water Policy allows for both MS4 and NPDES permits to regulate runoff for recycled water landscape irrigation sites. The State Board should work with stakeholders to prepare a guidance document comparing the two permits to enable recycled water stakeholders and regulators to evaluate permitting opportunities and appropriate approaches.

Implementer: SWRCB.

Solution 3: Implement Consistent Use Site Oversight throughout the State

Where recycled water is proposed or being used is regulated by the RWQCBs and CDPH. CDPH reviews proposed use sites for compliance with Title 22 and

Health and Safety Code and Water Code requirements, and makes recommendations to the project proponent either through the Regional Board or in a manner consistent with Regional Board master permit requirements. This task can be delegated to county health departments as a fee-for-service with the permission of the project proponent, if the County follows CDPH regulatory guidance. Once recycled water use begins, the regulatory responsibility shifts to the RWQCBs through permit enforcement. The Regional Board permits incorporate applicable provisions of Title 22 regulations, as well as case-by-case recommendations from CDPH.

To the extent possible, CDPH recommendations to the Regional Boards should be consistent throughout the State based on the need for public health protection. They should not vary based on availability of local staff resources. CDPH and the RWQCBs need sufficient resources to ensure adequate public health protection. In addition, consideration should be given to delegating increased review, approval, and site oversight responsibilities to the recycled water service providers when the purveyor can demonstrate the necessary ability. To maintain consistency if oversight is delegated, state agency guidance and training for water service providers would be required.

Implementers: CDPH, RWQCBs, local County health departments, and recycled water service providers.

Solution 4: Revise Water Recycling Regulations and California Plumbing Code

Specific changes are needed to the water recycling regulations in Title 22 and Title 17 of the California Code of Regulations to eliminate unnecessary restrictions and inconsistencies, as well as to align recycling regulations with the California Plumbing Code (CPC). CDPH currently has areas of Title 22 and Title 17 out for review and update, but it does not have the resources needed to complete the updates. The regulations and the CPC need to be clear on the oversight needed for dual plumbed facilities. Proposed changes to Title 22 and Title 17 that should be considered are:

Title 17

- Revise the definition of “approved Water Supply” in Section 7383(a) as follows: “…State or local health agency.”
- Change definition to “Water Supplier” in Section 7583(l) to read “…is the entity that owns and/or operates the public water system.”
- Use the language found in Section 7585 which does not require the water agency to be “responsible for abatement of cross-connections which may exist within a water user’s premises.”

Title 22

- Add a definition for “Cafeteria” to Section 60301

- Amend “Operation requirements” section of Sections 60301 and 60304 to reflect new language recently adopted by the Building Standards Commission regarding requirement for cross-connection testing every four years.
- Modify the “Use Area Requirements” in Section 60310(i) to conditionally allow for the use of hose bibs at sites open to the general public.

Implementers: CDPH, DWR, CBSC.

Solution 5: Support the Ocean Plan Update Addressing Brine Disposal from Municipal Recycled Water and Groundwater Facilities

Salt removal and disposal from municipal recycled water and groundwater facilities are important parts of implementing the SWRCB’s Recycled Water Policy. In short, properly disposing of brine via ocean discharge is critical to implementing the Policy. Because brine disposal from municipal recycled water and groundwater facilities is not specifically addressed in the Ocean Plan, recent RWQCBs permits have taken a strict interpretation of the regulations by not allowing blending of brine water to meet the ocean plan standards for turbidity, based on guidance from the USEPA. As of the Fall of 2011, SWRCB has been in the process of revising its Water Quality Control Plan For Ocean Waters Of California (Ocean Plan) to address disposal of brine, including brine produced by reverse osmosis systems at recycled water and groundwater treatment facilities.

Ocean Plan review provides the SWRCB with an opportunity to develop a policy that recognizes the importance of advanced treatment in achieving the State’s water recycling goals while at the same time protecting beneficial uses in the ocean. Water agencies and potential dischargers should work with the State Water Board during development of the amendment and during public comment period to achieve an amendment that identifies appropriate and protective approaches to ocean brine disposal. Until the amendment is completed and approved by the State Water Board, potential ocean brine dischargers may consider postponing applying for an ocean outfall brine permit.

Implementers: SWRCB, USEPA, and potential ocean brine dischargers.

10.3 Barrier: Awareness and Education of Municipal Recycled Water Quality

Some CII businesses are not aware of how municipal recycled water can be managed and used in particular CII settings. As a result, some of these CII businesses resist using it. Municipal recycled water agencies and state agencies can support acceptance of CII use by educating how municipal recycled water can be properly and successfully used in unique water use situations for current and potential customers.

10.3.1 Solutions

Solution 1: Educate Potential Municipal Recycled Water Users and Suppliers

As indicated in Section 4.0, approximately ten percent of current CII water demands are met with recycled water. This number could be increased with expanded outreach to CII businesses, with focus on technical information, case studies, the types of municipal recycled water locally available, and the solutions recommended in this report. Municipal recycled water producers, State and local agencies, industry trade associations, the WateReuse California, Association of California Water Agencies (ACWA), and environmental advocacy groups should provide information about successful uses of municipal recycled water through workshops, at trade shows, in trade publications, at public forums and other venues. Finally, BMPs that address water quality issues such as onsite treatment and blending with other water sources should be developed.

In addition, agencies producing and supplying municipal recycled water must be educated and fully understand the unique water supply and quality needs of potential CII businesses.

Implementers: DWR, WateReuse California, recycled water users, trade groups, environmental advocacy groups, and ACWA

Example: University of California San Diego

The University of California San Diego recycled water project provides an example of how awareness barriers can be overcome. In 1998, the faculty opposed using municipal recycled water on campus. The City of San Diego arranged a tour of the North City Water Reclamation Plant, which calmed the faculty's fears when they understood the level of effort being put in the treatment to ensure the safety of the public.

Solution 2: Create and Promote Information on Use of Municipal Recycled Water in CII

WateReuse California, in conjunction with industrial trade associations and DWR, should create and disseminate information on recycling opportunities in various CII settings. The newly created Industrial Reuse Committee of the

WateReuse Association would be a good source for this information. This committee was formed to promote and maximize the use of municipal recycled water in industrial settings, and it includes representation from both the public (municipal agencies) and private (industrial users and potential users) sectors. The committee's work addresses the use of municipal recycled water in cooling towers, high purity settings, food/beverage processing, industrial processes in general, and internal reuse.

In addition, WateReuse California, in conjunction with industrial trade associations, should increase awareness by providing information at trade shows and in trade publications, and by speaking in non-traditional settings.

Implementer: WateReuse California, trade associations, water agencies, DWR

10.4 Barrier: Public/Customer Acceptance

Successful implementation of water recycling projects requires support from

- The general public
- Customers of municipal recycled water
- Neighbors of customers using municipal recycled water
- Policy makers and decision makers

As surveys (Haddad et al. 2009) have shown, public acceptance declines as the potential for human exposure increases. Other studies (WateReuse Research Foundation Projects 07-03 and 09-01) show that as people become educated about recycled water treatment effectiveness and reliability, they become more accepting of potable and non-potable recycled water use. Some members of the public and policy-makers have an aversion to water recycling, often based on a misunderstanding of its safety. Potential CII businesses will prefer water supplies other than municipal recycled water if they perceive that their customers will not accept products produced with municipal recycled water.

10.4.1 Solutions

Solution 1: Educate and Promote Municipal Recycled Water

Providing information to industries, residential customers, and water utilities about the safety protections and environmental, energy, and green house gas benefits of municipal recycled water helps overcome barriers to its use. As the RWTF concluded, the public responds positively to projects responsive to community needs, such as the need for a safe, reliable water supply. For municipal recycled water to gain additional public acceptance - and reduce a potential barrier to CII use - it is important that the public understand what municipal recycled water is, the different types and how they can be used, and the overall benefit to incorporating it into water supply resources.

An effective statewide information campaign would offer authoritative views from recognized experts including SWRCB, DWR, CDPH, and independent research groups, such as the Pacific Institute and environmental NGOs. This campaign would be similar in scope to the State’s multi-year and highly effective efforts to promote solid waste recycling and energy conservation (“Flex Your Power”). It would position water recycling like other types of recycling: as being part of good citizenship. Consider aligning water reuse with the sustainability/green movement. Business and industry groups should also actively support and promote municipal recycled water use throughout their industry and with their local elected officials. Additionally, a “tool kit” should be developed for use by agencies involved in producing or marketing municipal recycled water. Finally, it will be important to avoid conflicting statewide and local messages by using complementary programs and materials.

Implementers: DWR, WateReuse California, ACWA, and industry groups.

Examples: The Del Sur Planned Community Homeowners Association in the City of San Diego is an excellent example of how homeowners have been made aware of municipal recycled water use and signage in public areas. Del Sur’s vision is to be eco-friendly and embrace sustainable practices. Additionally, the City of San Diego has implemented the Water Purification Demonstration Project, which will examine the safety of augmenting a surface water reservoir with highly treated municipal recycled water. The demonstration phase includes a strong public outreach element as the city is giving tours to the public of the demonstration facility. Seeing and understanding the treatment facilities can raise the public’s level of confidence in the safety of the water supply.

Solution 2: Implement Community Value-based Decision-making Model for Project Planning

Public participation and representation is founded on the idea that those affected by decisions or policies should participate or be represented in policy-making processes. The public should be involved throughout all project phases, including planning, deliberation, decision, design, and implementation. The public commonly has full access to information on proposed projects, such as through the environmental review processes required by the California Environmental Quality Act (CEQA) and the federal National Environmental Policy Act (NEPA), but under these acts, the minimum public notification requirements are sometimes inadequate to engage the public. Public agencies that develop municipal recycled water projects are required to hold public meetings and consider public input as a basis for recycled water project decisions, but members of the public sometimes lack sufficient understanding of local water issues and alternative water resources options to establish a well-informed position on a project.

Early public involvement can assist the project proponent in identifying and responding to the concerns of the public. With the need to supply additional water in the State and the potential use of municipal recycled water projects to meet that need, decision-makers at water utilities and regulators should make an investment in engaging the public so that their decisions will most fully benefit their constituents, customers, and communities.

Determining a community's values, then making decisions based on that information is the foundation of a community value-based decision-making model. This model encourages participants to recognize that most people believe in a unified set of fundamental values, then takes them further into the realization that these values can be the basis for consistent and improved decision making. A values-based decision-making model should embody the general public participation principles listed in the introduction to this section.

Implementers: Water service providers.

10.5 Barrier: Cost of CII Users

Cost is often the most important factor for CII businesses in deciding whether to accept the use of municipal recycled water. Generally, CII businesses will assess the net cost of municipal recycled water in relation to the cost of potable or other fresh water sources. The key components of cost to CII businesses are:

- Price of recycled versus potable water
- Onsite costs to convert from potable to municipal recycled water
- Operating costs of using municipal recycled water compared to potable water

Use of municipal recycled water in some settings results in increased operating costs for the user. For example, municipal recycled water use in cooling towers may necessitate additional treatment or fewer cycles. Recycled water can result in increased flows or waste loads to the sewer, thus increasing sewer fees in many jurisdictions. Without recycled water service provider awareness of such costs, the pricing of recycled water can create a cost barrier. Higher net costs in using recycled water compared to using potable or fresh water can discourage CII businesses from accepting recycled water.

10.5.1 Solutions

Solution 1: Base Recycled Water Pricing on Total Cost of Use and Provide Incentives

As noted in Section 10.1, onsite capital and operating costs for recycled water can be greater than that of using potable water. In addition to direct funding assistance to customers to compensate for onsite costs, water pricing is another way water agencies can address onsite cost burdens.

One pricing approach is to price municipal recycled water relative to potable water, but adjusted to reflect onsite costs. Doing so generally results in recycled water being priced at a lower rate than potable water, but can result in variable rates among CII businesses for the same commodity.

CII businesses are frequently self-supplied and do not purchase fresh water from a water service provider. To encourage a self-supplied CII customer to convert to municipal recycled water, pricing would have to reflect the costs to the customer for obtaining water from its own source. This could also result in variable rates among CII businesses.

Finally, a third option is as presented in 10.1.6 – identify options for grants or loans for onsite retrofit of infrastructure or processes to receive recycled water. This could be justified to rate payers as providing cost-effective methods for freeing up potable water for potable uses. It also would allow a more streamlined municipal recycled water rate structure.

Implementers: Retail water agencies.

10.6 Barrier: Source Water Quality

Many CII uses are sensitive to water quality, and recycled water typically has more minerals and organic content than many available alternative supplies. Subtle changes in water quality, such as increases or decreases of certain minerals or chemical species, can dramatically change the suitability of recycled water or the treatment requirements for use in an industrial process. Landscape plants can be sensitive to certain chemicals potentially present in recycled water, such as boron, or can be affected by changes in soil conditions caused by using more saline sources. Indirect and direct potable reuse projects will need to be designed to protect the public health and to consider the potential for CECs or other public health-related issues. Many water quality concerns associated with recycled water can be and are addressed with additional treatment by the water utility, onsite treatment, or other water management practices.

10.6.1 Solutions

Solution 1: Provide Water Quality Suitable for Intended Use

To facilitate the use of recycled water in CII settings, it is critical to link water quality and CII needs. This can be accomplished by providing information on the quality of the municipal recycled water available, or by identifying opportunities to improve water quality for specific purposes, either by the supplier or the CII user. Water quality can either be improved by the supplier through additional treatment and/or source control, or the individual users can improve treatment and control processes to levels specific to its process needs.

Local agencies and WateReuse California, should work together and in cooperation with other trade groups to identify water quality issues for categories of CII businesses and solutions. Specific actions include:

- Collaborate between utilities and CII businesses to identify water quality issues and solutions. Those solutions may be technological and/or economic.
- Provide additional treatment and/or source control such that recycled water quality is fit for the purpose.
- Recycled water producers should develop rigorous water quality control practices.
- CII businesses should modify their operation to the extent practicable to accommodate the quality of available recycled water.

Implementers: Water supply agencies, CII businesses, WateReuse California, industry trade associations.

Example*:* San Jose State University

San Jose State University has completed an evaluation of source water options that was useful in selecting its cooling tower supply choice. A computer-based modeling program helped determine the program control limits for the cooling tower using both recycled water and well water. The modeling program determined that the plant could run the cooling water system at a maximum of six cycles with the new control using either recycled water or well water, keeping the sewer flow the same regardless of water source.

Example*:* The Pebble Beach Company

In 1994, the Pebble Beach Company teamed up with seven other local agencies in a unique private/public partnership to deliver recycled water for irrigation to seven golf courses in Pebble Beach, California, including world-renowned Pebble Beach Golf Links.

The golf courses began irrigating with tertiary-treated recycled water in 1994. During the first few years of operations, the project underwent constant review and modification.

It became apparent that the recycled water was of low quality when the golf courses began experiencing some problems with the turf grass on the greens. The problem was determined to be caused by high sodium concentrations – at times as high as 200 mg/L – and high concentrations of TDS concentrations – at times as high as 1000 mg/L.

As an initial solution, potable water was used periodically to flush salts away from the plant root systems. All of the involved organizations and agencies began studying technical solutions to improve water quality and quantity, as well as methods for financing the improvements. This work led the groups to begin Phase Two of the Water Reclamation Project with the intent of improving water quality and increasing the quantity of recycled water available for irrigation.

In 2006, a second project was commissioned to install advanced treatment for reducing sodium to a level satisfactory for the golf courses to use 100 percent recycled water without potable water flushes and to improve the storage capacity of recycled water by retrofitting an unused surface reservoir to meet the peak irrigation demands of the golf courses.

After three years of operation, no water quality issues are being reported, and the reservoir is meeting the seasonal irrigation demands.

Example: BP Carson

BP Carson, discussed earlier in 10.1.3, receives two levels of recycled water from its supplier, West Basin Municipal Utility District: recycled water treated by microfiltration and reverse osmosis and recycled water treated by nitrification. The Title 22 standard tertiary-treated recycled water stream originates from West Basin's Edward C. Little Water Recycling Facility and is conveyed to West Basin's Carson Regional Water Recycling Treatment Facility, where the additional treatment for the two levels of recycled water occurs.

Several water quality issues are addressed at BP Carson. First, recycled water entering the refinery treated with RO is corrosive, so a separate non-carbon steel pipeline/distribution system was built inside the refinery to accommodate the use of this water. Second, the municipal recycled water is high in iron and phosphates due to upstream water quality treatments and may limit the number of cycles the water can be used in the cooling towers, an effect that is reduced by the blending of RO water into the nitrified supply.

Chemical treatment programs need to be adjusted when switching from the city water supply to a predominantly recycled supply, especially in cooling towers. The water quality from the Carson Regional Facility is generally of very consistent quality, especially compared to standard municipal water, which can change seasonally or when water sources are switched. However, sudden quality changes can also occur with recycled water because of inflow variability. Good communication between the recycled plant operator and the refinery operators minimize the impacts of these changes.

10.7 Barrier: Recycled Water Supply Reliability

Recycled water is an extremely reliable supply in summer and winter, and in dry and wet years. There are some cases where reliability could be affected, including:

- Treatment and distribution systems may be subject to service interruptions due to operational issues that may be more complex than typical potable water treatment and distribution systems.
- Recycled water distribution systems are designed to a reliability standard necessary for an expected predominant use, usually

landscape irrigation, and then other uses with greater reliability needs are later connected.

- Potable water systems tend to have a much greater level of redundancy in the conveyance and distribution system than recycled water production facilities. This reduced level of on-stream availability discourages reuse by potential CII and landscape users with a service interruption standard more stringent than that of the recycled water system to which they may otherwise wish to connect.

Service interruption could cause production impacts or business impacts to an industry and, at certain types of industrial facilities, safety or environmental impacts.

10.7.1 Solutions

Solution 1: Consider Increased Recycled Water System Reliability Features and Backup Water Supply

The reliability of recycled water systems needs to be commensurate with the types of water demands being served and the needs of recycled water users. Alternatives include more robust recycled water treatment and delivery systems and alternative backup water supplies. Incorporating backup water supplies is often more cost-effective than increasing redundancy or capacity of recycled water facilities that will only be used in rare or infrequent situations. Alternative approaches are usually available to meet the reliability needs of the system, including:

- Provide recycled water storage backup supply for customers intolerant of service interruption.
- Encourage CII businesses to have onsite storage where appropriate.
- Provide a more robust recycled water plant design that includes redundant pumping systems, backup power supplies for critical equipment.
- Provide potable or other backup water supply at individual customer sites in the event of loss of recycled water at the user facility.
- Provide the ability to supplement potable or non-potable water to the recycled water distribution system to meet peak demands or replace recycled water during interruptions of recycled water availability.
- Provide a recycled water infrastructure system that can, if needed, be fed from multiple sources rather than from a single dedicated recycled water plant.

Implementers: Water supply agencies and users

10.8 Barrier: Terminology Used in Describing the Process

Many words and phrases used to describe recycled water are often not part of common terminology. Additionally, multiple terms often are used to describe the same product or technology. This terminology, which describes treatment technology, types of recycled water, and water quality issues, derives from engineering and regulatory sources, and it can be confusing to recycled water users and other stakeholders. The terminology needs to serve the needs of communicating with the general public, communicating between scientists and engineers, and communicating precise regulatory language. As is the case with any consumer product this is technology-based, such as cars or computers, it is not necessary that all forms be understandable by the general public. What is important is that the choice of words be appropriated for the audience, and a common vocabulary for public and media communications can facilitate understanding and public acceptance.

For example, the basic term ‘recycled water’ is used inconsistently within the water community. It is defined in the Water Code as wastewater treated to a quality suitable for beneficial use. The Water Code definition does not designate the source of the wastewater, nor does it indicate a certain level of treatment, only the fact that it is wastewater that has been treated and beneficially reused. “Recycled water” can be undisinfected secondary-treated wastewater used to irrigate an alfalfa field, or advanced treated wastewater used to recharge a groundwater aquifer. These variations in meaning may be a barrier in some situations.

Another example involves the signage required by Title 22 for areas irrigated with municipal recycled water. Title 22 requires signage stating “RECYCLED WATER – DO NOT DRINK.” Because recycled water used for landscape irrigation does not have to be treated to the same level as water used for indirect and direct potable water projects, this signage is valid for that application. But, it implies that all recycled water is not drinkable, which is not true. Some recycled water products are branded (e.g., NEWater in Singapore), some are simply called “recycled water,” and others are called reclaimed water. Professionals and public officials need to communicate using commonly understood terminology.

10.8.1 Solutions

Solution 1: Establish Terminology

Water recycling professionals should establish universal terminology that is transparent, comprehensible, and consistent with State statutes and regulations. One issue is whether there is a point at which water that has originated from municipal wastewater no longer carries the term “recycled water” - if it is treated to a point (such as advanced treatment) that it has unrestricted use. This issue will have to be carefully discussed and accepted by the regulators, the regulated community, and the public. The regulators have the responsibility of protecting public health and making sure that water from any source is monitored prior to being supplied to the public. This is a responsibility shared by water agencies. Additionally, there is enough of a percentage of the population concerned or opposed to “drinking” recycled water that inclusion of the public in these discussions will help to offset concern about its potable water sources.

Addressing this and other terminology issues will support CII acceptance. There have been situations in the past that negative publicity has prevented the use of recycled water by members of the CII community. By addressing the terminology and if there is a point at which recycled water no longer needs to be characterized as wastewater, the acceptance of recycled water at high levels of treatment could be benefitted.

It is recommended that a forum of water agencies, regulators, and interested parties be established to address this issue. Discussion and acceptance of the issues, as well as development of a common, implementable approach is the most appropriate path to establishing common terminology that is accepted and the used (see Section 10.8.2) when discussing recycled water.

Implementers: WateReuse California, water supply agencies and users, SWRCB, CDPH, DWR, and AWCA

Solution 2: Use New Terminology

If consensus can be reached about appropriate terminology for use in public communications, then the industry should communicate this consistent, clear terminology to water industry professionals and seek its widespread use. A strong campaign within the water and wastewater industries, water and wastewater users, as well as the public will need to occur.

This language should be carefully used in all media contacts, in project development, and education. Likewise, technical scientific and engineering terminology is needed for communication within scientific and engineering community, and, because the general public will not readily understand it, it may not be suitable for communicating with the general public.

Implementers: SWRCB, CDPH, DWR, WateReuse California, and ACWA

10.9 Barrier: Data for Tracking Use

The lack of reliable data about the quantity and types of water recycling occurring in California is a barrier to recycling in that public policies and goals about recycling need to be informed by facts. Management of the recycled water assets in California requires data.

10.9.1 Solutions

Solution 1: Create Unified Recycled Water Use and Compliance Reporting System

There should be consistent reporting requirements and a web-based reporting system that meets regulatory compliance needs of regional water quality control boards and data gathering needs of water supply planners. This system would help manage the data needed to evaluate attainment of State goals, such as the amount of recycled water produced, the fraction of total urban municipal and industrial (M&I) and agricultural demand met by recycled water (DWR, SWRCB), and reduction of discharge(SWRCB, RWQCBs). Options that may serve this purpose include a comprehensive plan to manage such data using an existing SWRCB-funded database constructed by the WRF or the existing SWRCB database, California Integrated Water Quality System (CIWQS).

Implementers: SWRCB, CDPH, WateReuse California, and DWR

10.10 Barrier: Institutional Coordination Between Agencies

In some areas, multiple utilities provide recycled water to a customer. The retail water service provider may have disincentives to substitute recycled water for the supply it currently supplies, especially in cases where the recycled water would be provided by a separate utility. Laws addressing duplication of water service within a service area can be found in California Public Utilities Code Sections §§1501-1507 and California Water Code Sections §§13580-13583. Disincentives can include lost revenue.

10.10.1 Solutions

Solution 1: Review Duplication of Service Regulations

Analyze duplication of service issues to determine the need to revise laws or regulations governing duplication of service. The basis of analysis should be case studies where partnerships were successful and where attempts to form partnerships failed to determine potential changes to laws, programs, or practices that can occur to facilitate future interagency cooperation. This review of duplication of service and other regulations to identify possible solutions should be undertaken, including where this has hindered the use of municipal recycled water and where barriers have been overcome. This review should include investor-owned utilities, which should be encouraged to build or participate in reuse projects and adopt appropriate recycled water rate structures, as allowed by the CPUC.

Implementers: WateReuse California, DWR, ACWA, and CPUC

Solution 2: Provide Agency Partnering Case Studies

Develop case studies where partnering between water, waste water, and other utilities has been effective in providing recycled water to CII businesses. Disseminate these case studies to agencies to educate them on techniques for effective partnerships.

Implementers: WateReuse California, DWR

Example: East Bay Municipal Utilities District

The EBMUD Board of Directors adopted a resolution authorizing work with other sanitation districts to allow those districts to provide recycled water supply within the service area and receive a waiver on "service duplication act" protections.

Appendix A: CII Task Force Recommended Best Management Practices

Intro text needed?

A.7.1 Commercial and Institutional Sectors

A.7.1.1 Commercial Food Service BMPs

A.7.1.1.1 Garbage Disposal BMPs

Operation, Maintenance, and User Education

For optimum garbage grinder water efficiency, consider the following BMPs:

- Turn off the water during idle periods when the unit is not in use and when the facility is closed.
- Scrape larger food scraps into a trash receptacle prior to rinsing food waste into the disposal unit. Consider composting food waste if appropriate.
- Never pour grease into the garbage grinder unit, as this will lead to clogged drain lines.
- Do not place any hard objects into the unit. This can dull the blades, reducing the unit's efficiency.
- Always run cold water through the garbage grinder unit during its use. Hot water may damage the unit. Cold water helps to keep the unit cool.
- Regularly inspect and clean the unit to make sure the blades are sharp and the unit is not clogged with debris.

Retrofit Options

- Consider installing a device that can sense the grinder motor's load and regulate the amount of water necessary to complete the disposal task.
- Consider installing a timer to stop the flow of water to the grinder after 15 minutes, requiring the user to periodically reactivate the system.

Replacement Options

When purchasing a new garbage grinder unit or looking to replace an existing unit, consider these options:

- Purchase a garbage grinder with a load sensor that regulates the amount of water conveyed through the unit based upon its use.
- Install a food pulper or food pulper/strainer combination system, which can recirculate 75 percent of the water used for the food disposal process.
- Replace mechanical food disposal systems with food strainers, which use little to no water.

A.7.1.1.2 Pre-Rinse Spray Valve BMPs

Operation, Maintenance, and User Education

For optimum pre-rinse spray valve (PRSV) efficiency, consider the following BMPs:

- Ensure that the PRSV unit's hose height is appropriate for the user (neither too high nor too low).
- To decrease water use, train users to manually scrape as much food waste from dishes as possible before using the PRSV.
- If possible, pre-soak heavily soiled dishes in a basin of water to loosen food residue.
- Train users how to properly use the spray handle clip ('always-on' clamp), if available on the PRSV. If a constant stream of water is not necessary, train users to manually depress the PRSV handle only when water is needed.
- Periodically inspect PRSVs for scale buildup on the faceplate orifices to ensure flow is not being restricted. Use cleaning products designed to dissolve scale. Do not attempt to bore or otherwise enlarge holes in the PRSV faceplate, as this may lead to increased water and energy use or cause cleaning performance problems. If scale cannot be removed, consider replacing the PRSV with a new model.
- Periodically inspect PRSVs for leaks and broken or loose parts. If necessary and possible, tighten screws and fittings to stop leakage. If the product cannot be manually adjusted to perform properly, consider replacing the entire unit.
- Conduct routine inspections for leaks and train appropriate custodial and cleaning personnel and users to identify and report leaks.

Retrofit Options

- Avoid retrofitting existing, inefficient PRSVs with flow control inserts (which restrict water flow) to reduce the flow rate.

Replacement Options

When installing new PRSVs or replacing existing equipment, consider the following:

- Choose models with flow rates of 1.3 gpm or less, considering the building's pressure.

A.7.1.1.3 Commercial Dishwasher (Warewasher) BMPs

Operation, Maintenance, and User Education

For optimum commercial dishwasher efficiency, follow these operating tips:

- Only run dishwashers when they are full. Each dishwasher rack should be filled to maximum capacity.
- Educate staff to scrape dishes prior to loading the dishwasher.

- Replace any damaged dishwasher racks.
- Ensure that the final rinse pressure and water temperature are within the manufacturer's recommendations.
- Operate the dishwasher close to or at the minimum flow rate recommended by the manufacturer. Set the rinse cycle time to the manufacturer's minimum recommended setting and periodically verify that the machine continues to operate with that rinse cycle time.
- Turn off machines at night when not in use.
- Install steam doors to reduce evaporation.
- Ensure that manual fill valves close completely after the wash tank is filled.
- Fix and repair any leaks. Inspect valves and rinse nozzles for proper operation and repair worn nozzles.

For conveyor-type machines, further steps can be taken to ensure optimum efficiency:

- Install and/or maintain wash curtains.
- Ensure the rinse bypass drain is properly adjusted so that the wash tank is adequately replenished during operation.
- Operate conveyor-type machines in auto-mode to save energy by running the conveyor motor only when needed.

Retrofit Options

- Consider installing rack sensors that allow water flow only when racks or dishes are present, saving water by initiating the cleaning cycle less frequently.

Replacement Options

When installing new dishwashers or replacing existing equipment, consider the following:

- Look for Energy Star qualified models.
- Avoid fill-and-dump machines, which use the most water.
- For flight-type dishwashers, choose equipment with a flow rate of less than 170 gallons per hour.
- Choose an appropriately sized dishwasher for typical kitchen throughput.

A.7.1.1.4 Washing and Sanitation BMPs

Operation, Maintenance, and User Education

For optimum wash-down sprayer efficiency, consider the following:

- Only use wash-down sprayers to clean floors, countertops, and other surfaces. Do not use wash-down sprayers to clean dishware, which should be cleaned with pre-rinse spray valves.

- Any conventional floor cleaning system with a hot-water hose should, at a minimum, have a self-closing valve. If the wash-down sprayer does not have such a valve, shut off the water supply when the sprayer is not in use.
- For floor washing applications, consider using a broom and dust pan to clean up solid waste and/or using a mop and squeegee instead of a wash-down sprayer.
- Use floor-cleaning machines that are equipped with a water tank.

Retrofit Options

- Consider installing a self-closing nozzle if a high-flowing wash-down sprayer hose is used without a nozzle

Replacement Options

- For certain applications, wash down sprayers may be replaced with mopping or sweeping.
- Choose pressure washers for facilities that rely on the washing capability of wash-down sprayers.
- Replace existing wash-down sprayers with water brooms for surface cleaning applications.

A.7.1.1.5 Commercial Ice Machine BMPs

Operation, Maintenance, and User Education

Consider the following tips to ensure energy- and water-efficient ice machine use:

- Periodically clean the ice machine to remove lime and scale; sanitize it to kill bacteria and fungi. For self-cleaning/sanitizing machines, run the self-cleaning option. For machines without a self-cleaning mode, shut down the machine, empty the bin of ice, add cleaning/sanitizing solution to the machine, switch it to cleaning mode, and finally switch it to ice production mode. Although water is wasted in the process, it is very important to create and discard several batches of ice to remove residual cleaning solution for health and safety considerations.
- Keep the ice machine’s coils clean to ensure the heat exchange process is running as efficiently as possible.
- Keep the lid closed to trap cool air inside the ice machine.
- Install a timer to shift ice production to nighttime or off-peak hours.
- Work with the machine’s manufacturer to ensure that the machine’s rinse cycle is set to the lowest possible frequency that still provides sufficient ice quality considering local water quality and site requirements. If available, use the ice machine’s ability to initiate rinse cycles based on sensor readings of minerals.
- Follow the manufacturer-provided use and care instructions for the specific model ice machine used at the facility.

- Train users to report leaking or otherwise improperly operating ice machines to the appropriate personnel.

Retrofit Options

- If the machine is cooled using single-pass water, modify the machine to operate on a closed loop that recirculates the cooling water through a cooling tower or heat exchanger, if possible. If eliminating single-pass cooling is not feasible, consider reusing the cooling water for another application within the facility.

Replacement Options

When installing new ice machines or replacing existing equipment, consider the following:

- Choose new machines appropriately-sized to fit the facility's need.
- Choose new machines that produce the quality of ice required; do not choose machines that produce higher ice quality than necessary.
- Consider selecting flake or nugget ice machines instead of cube ice machines.
- Choose only Energy Star qualified models.
- Consider using only air-cooled machines that meet the energy specifications outlined by the Consortium for Energy Efficiency.

A.7.1.1.6 Dipper Well BMPs

Operation, Maintenance, and User Education

For optimum dipper well efficiency, consider the following:

- Turn off water when service periods are slow and the dipper well is not in use. Turn off the water to the well at the end of each day as well. Clean the dipper well prior to restarting the water in order to remove any bacterial build up.
- Keep the flow rate of the dipper well valve at its minimum level.
- Consider rinsing utensils with an existing faucet only as needed rather than using a dipper well.
- Use cold or warm water instead of hot water in dipper wells where appropriate for rinsing utensils.

Retrofit Options

- Consider installing an in-line flow restrictor to reduce the flow rate from 0.5 or 1.0 gpm to 0.3 gpm.

Replacement Options

- Install a metering faucet for utensil rinsing.
- If the facility has a large volume of utensils, sufficient to run full dishwasher loads, consider installing an Energy Star®-qualified commercial under-counter dishwasher[247] instead of using a dipper well.

A.7.1.1.7 Combination Oven BMPs

Operation, Maintenance, and User Education

For optimum combination oven efficiency, consider the following:

- Use the oven's programming capabilities to control the use of the different cooking modes in order to minimize water and energy use. Where feasible, use the steam and combi-modes sparingly because these modes consume more water and significantly increase energy use. Maximize the use of the circulated hot air mode.
- Turn the oven off or down during non-peak periods or when not in use.
- Keep the oven doors completely closed.
- Maximize the amount of food cooked per use by ensuring that the oven is loaded to its full capacity.
- Replace door gaskets when necessary and keep door hinges tight, to provide a firm seal to retain heat or steam.

Retrofit Options

- If a boiler-based combination oven is used, install a condensate return system to direct the condensate back into the central boiler system for reuse.
- Insulate condensate return lines to further improve efficiency.
- There are currently no retrofit options available on the market to increase the efficiency of connectionless combination ovens.

Replacement Options

When installing new combination ovens or replacing existing equipment, consider the following:

- Choose models that are boilerless or connectionless and that use no more than 15 gallons of water per hour or 3.5 gallons per pan per hour.
- Consult the manufacturer to choose a combination oven that is appropriately sized for the cooking needs of the food service operation.
- Choose combination ovens listed among the qualified products on the Fisher Nickel list for energy rebates in California.[248]

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[247] www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COH
[248] www.fishnick.com/saveenergy/rebates/combis.pdf

A.7.1.1.8 Steam Cooker BMPs

Operation, Maintenance, and User Education

For optimum steam cooker efficiency, consider the following:

- Use batch production as opposed to staged loading of food pans (i.e., do not repeatedly open the door to load and unload food pans).
- Where possible, fill the steam cooker to capacity instead of cooking one pan in a multi-pan steamer.
- Keep the doors closed while the steamer is operating.
- Use only as many steamer compartments as needed.
- Use a timer to ensure that the steam cooker returns to standby mode after use.
- Turn the steam cooker off during long periods of non-use.
- Repair any leaks and remove any deposit buildup from the boiler on boiler-based models.

Retrofit Options

- If a boiler-type steam cooker is used, install a condensate return system to direct the condensate back into the central boiler system for reuse.
- Insulate condensate return lines to further improve efficiency.
- There are currently no retrofit options available on the market to increase the water efficiency of boilerless steam cookers.

Replacement Options

When installing new steam cookers or replacing existing equipment, consider the following:

- Choose a steam cooker that is of the appropriate size for the food service needs of the facility.
- Choose models that are Energy Star qualified.[249]

A.7.1.1.9 Steam Kettle BMPs

Operation, Maintenance, and User Education

For optimum steam kettle efficiency, consider the following:

- Regularly monitor self-contained steam kettle water levels and maintain control components to ensure efficient operation.
- Turn the steam kettle down or off between uses.
- Secure the steam kettle lid whenever possible to reduce the amount of energy required for simmering and boiling.

[249] www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COC

- If using a boiler-based steam kettle, ensure that the central boiler system is maintained properly in accordance with A.7.3.3.2 Heating System BMPs.

Retrofit Options

- For boiler-based steam kettles, a condensate return system can be installed to direct the condensate back into the central boiler system for reuse.
- There are currently no retrofit options available on the market to increase the efficiency of self-contained steam kettles.

Replacement Options

When installing new steam kettles or replacing existing equipment, consider the following:

- For smaller steaming needs, consider self-contained steam kettles without an external boiler, which use less water and energy than boiler-based steam kettles.
- If daily operations require a boiler-based steam kettle, consider a model with a condensate return system.
- Choose a steam kettle with a properly sized steam trap to prevent inadvertent dumping of condensate.

A.7.1.1.10 Wok Stove BMPs

Operation, Maintenance, and User Education

For optimum wok stove efficiency, consider the following:

- Encourage cooking staff to turn off rinse and reservoir spouts when not in use.
- Inspect and ensure that the shutoff valves for the rinse and reservoir spouts are in working order.
- Shut off the cooling water when the wok stove is not in use, especially at the end of each day.
- Routinely check cooling water lines for leaks and corrosion.

Retrofit Options

- Check to see if rinse spouts can be replaced with spouts that automatically shut off or that can switch off when pushed back away from the wok.

Replacement Options

When installing new wok stoves or replacing existing equipment, consider the following:

- Look for models that are considered waterless, which will be air-cooled instead of water-cooled.
- Look for waterless models that have automatic shutoff rinse and reservoir spouts and/or knee-operated timer taps to limit both the flow rate and duration of the flow.

A.7.1.2 Fabric Cleaning and Washing Equipment BMPs

Operation, Maintenance, and User Education

For optimum fabric cleaning and washing efficiency, consider the following:

- Operate washers only with full loads. For washer extractor and tunnel washer applications, use a laundry scale to weigh loads to ensure the machine is filled to capacity.
- Separate and wash laundry based upon the extent to which materials are soiled. Also consider separating laundry by the number of cycles needed.
- In consumer applications (laundromats), install only front loading high efficiency machines (single load and multi-load) and set those machines to maintain the manufacturer-rated Water Factor (WF).
- 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.
- Use detergents specially formulated for high-efficiency clothes washers.
- Avoid excessive backflushing of filters or softeners; backflush only when necessary.

Retrofit Options

- Add water reuse/recirculation systems to existing machines; simple or complex recirculation systems can be added to coin- or card-operated, multi-load washers, and washer extractors to recirculate a portion or all of the water for reuse in the next wash.
  - Evaluate space constraints when considering water reuse/recycling options; space may not be available to accommodate additional recycling equipment or storage tanks.
  - Recycling may also require adjustments in chemicals and detergents. Therefore, contact the chemical supply vendor during the planning process.
- All types of laundry washing machines can be retrofitted with an ozone system.

Replacement Options

When installing new laundry equipment or replacing existing equipment, consider the following:

- Select new coin- or card-operated, single-load clothes washer models that are Energy Star-qualified.
- When installing new multi-load washers, choose models that use no more than 6.0 gallons per cycle per cubic foot of capacity.
- Choose machines with built-in water recycling capabilities that can store the rinse water from the previous load for use in the next load when installing new or replacing old washer extractors.

- For very large industrial or commercial laundries, consider replacing old washer extractors or multi-load washers with tunnel washers if large volumes of laundry will be processed.
- Ensure that large commercial laundry equipment is easily programmable so it uses no more water than required for the degree of soiling of the items being washed.
- Choose new machines that support remote diagnosis by the manufacturer to minimize maintenance costs and time associated with troubleshooting equipment problems.

A.7.1.3 Hospitality and Lodging – Hotels and Motels BMPs

Common BMPs

For common operations and systems, the table below provides a cross-reference to the appropriate section listing BMPs.

Operation/System	Section Addressing BMPs
Restrooms and Plumbing	A.7.3.6 General Building Sanitary and Safety Applications BMPs
Cooling and Heating Systems	A.7.3.3 Thermodynamic Processes BMPs
On-Premise Laundries	A.7.1.2 Fabric Cleaning and Washing Equipment BMPs
Floor Cleaning	A.7.1.1.4 Washing and Sanitation BMPs
Ice Machines	A.7.1.1.5 Commercial Ice Machine BMPs
Kitchen Operations	A.7.1.1 Commercial Food Service BMPs
Submetering	A.7.3.2 Building Meters, Submeters, and Management Systems BMPs
Landscaping	A.7.3.5 Commercial Landscaping BMPs

Additional Hospitality and Lodging-Specific BMPs:

Additional BMPs to be considered in guest rooms include:

- Prohibit multiple showerhead installations in a shower stall.
- Substitute showers for bathtubs. Where bathtubs are necessary, use low-volume tubs.

- Use low flow showerheads.
- Encourage guests to engage in “green” practices for bed linens and towels to avoid unnecessary laundry use.

BMPs for floor cleaning include:

- Discourage the use of open hoses for cleaning. While wet methods may be used, install self-closing nozzles, limiting flow to 5 gpm.
- Install drains close to areas where liquid discharges are expected.
- Arrange equipment for easy use of a mop and squeegee system or floor-cleaning machine.

For ice machines installed on guest room floors as well as in the central kitchen:

- Select ENERGY STAR qualified ice-making machines that are air-cooled, using remote heads to expel warm air outside the workspace and customer areas. Air-cooled machines are preferred over cooling-tower loops.
- Select energy-efficient flake or nugget machines rather than cube-ice machines. If cube-ice machines are used, those that meet CEE Tier 2 or 3 efficiency standards are preferred.

Other recommended BMPs for lodging facilities include:

- Separate metering of water-using systems and building areas is recommended, where possible, in order to ensure that the costs of water use and wastewater disposal are accurately tracked.
- Install automatic shutoff and solenoid valves on all hoses and water-using equipment.
- Conspicuously mark fire-protection plumbing so no connections will be made other than those for fire protection.
- Install flow-detection meters on fire services to reveal unauthorized water flows.
- For landscaping, ensure the use of climate-appropriate plant materials and an efficient irrigation system that apply only the amount of water necessary is installed and monitored.

A.7.1.4 Medical and Laboratory Equipment & Processes

A.7.1.4.1 Sterilizer BMPs

Operation, Maintenance, and User Education

For optimum sterilizer efficiency, consider the following:

- If possible, choose something other than a free-standing steam sterilizer, such as a chemical, radiation, or dry heat sterilizer or even a table-top steam sterilizer.
- Ensure that free-standing steam sterilizers are equipped with water tempering devices, that the steam is returned to the boiler, or that it is condensed using a chilled water condenser.
- Where not cost prohibitive, consider stand-alone boilers on each autoclave.

- Prohibit the use of venturi vacuum systems on vacuum sterilizers.
- Use dry vacuum systems wherever allowed by the FDA 510K regulations.

Retrofit Options

- Replace standard tempering water valves with temperature actuated valves.
- Divert steam condensate to a small holding tank to allow natural cooling prior to discharge.
- Capture and reuse steam.
- Where allowed by the FDA 510K pre-market regulations, install a dry vacuum system.

Replacement Options

When purchasing a new sterilizer unit or looking to replace an existing unit, consider these options:

- Replace free-standing sterilizers with another kind including chemical, radiation, dry-heat or table-top steam sterilizers, where feasible.
- Replace inefficient steam sterilizers with a more current one equipped with a tempering kit or connected to the building's chilled water system.

A.7.1.4.2 Vacuum System BMPs

- Use dry vacuum systems for all medical and dental processes.
- Eliminate pass through cooled equipment.
- Use only air-cooled pumps of those connected to a cooling tower loop or chilled water system, especially for central vacuum systems that serve an entire facility. (Also refer to A.7.3.3 Thermodynamic Processes BMPs)
- Only use liquid ring pumps for conditions where acid fumes and other very corrosive materials are being handled.
- If a liquid ring vacuum pump must be used, consider a non-potable source of water such as an onsite source or recirculated water.

A.7.1.4.3 Laboratory Fume Hood BMPs

- Use dry hoods to the maximum extent possible.
- Choose scrubber systems only if necessary.
- If a hood scrubber system must be used, select a type that recirculates water.
- Control scrubber blowdown with a conductivity controller or other appropriate control device.
- Use an alternate, non-potable source of water for the scrubber wherever possible.
- In all cases, the hood should be operated according to the instructions for that hood.

A.7.1.4.4 Instrument, Glassware, Cage, Rack, and Bottle Washer BMPs

Operation, Maintenance, and User Education

For optimum glassware washer efficiency:

- Only run glassware washers when they are full. Fill each glassware washer rack to maximum capacity.
- Operate the glassware washer near or at the minimum flow rate recommended by the manufacturer.
- Use detergents that clean most effectively so rinsing is simpler.
- If the number of rinse cycles can be chosen, select as few rinse cycles as possible, considering the cleanliness requirements of the glassware.

For optimum washer-disinfector efficiency:

- Operate only when needed.
- Review literature for water and energy efficiency when purchasing new equipment.

For optimum cage, rack, and bottle washer efficiency in vivariums:

- Sterilize and recirculate water used in automatic animal watering systems instead of discharging down the drain.
- Consider using animal watering system water in other non-potable applications such as cooling tower make-up water or for cleaning animal facilities.

Retrofit Options

- For glassware washers, consider installing a water recycling system that reuses rinse cycle wastewater as wash water in the next load.
- For cage, rack, and bottle washers in vivariums, retrofit to make use of counter-current flow to reuse final rinse water from one washing cycle in earlier rinses in the next washing cycle.

Replacement Options

When purchasing a new glassware washer or replacing an existing one, look for models with these features:

- Cycle selection that allows users to optimize rinse cycles for both effective and efficient cleaning.
- Reuse of final rinse water as wash water for the next load.
- Water intake monitoring to adjust the amount of water used based on load size.

When purchasing new or replacing existing cage, rack, or bottle washers in vivariums:

- Consider models that recirculate water through four cleaning stages using a counter-current rinsing process.

- Use tunnel washers for small cage cleaning operations.

A.7.1.4.5 Vivarium and Aquarium BMPs

Vivarium Cleaning BMPs

Consider the following for optimum vivarium cleaning efficiency:

- Use squeegees and brooms to first clean an area to substantially reduce the amount of water needed for floor washing.
- Choosing hose nozzles with the minimum flow rates that accomplish the cleaning, increasing pressure to reduce water use, and use of floor cleaning equipment can all help reduce water use.
- Design floors and walls to be easily cleanable.

Animal Watering System BMPs

Consider the following for optimum animal watering system efficiency:

- For animal watering systems that use flushing, minimize the number of flushing cycles while ensuring sufficient control of bacterial growth.
- Consider using a recirculating animal watering system instead of a flushing system.
- Consider collecting and reusing wastewater from animal watering systems for other purposes within the facility, matching an end use with the level of water quality that exists or that can be achieved through water treatment.
- Before choosing an automatic watering system, consider the following issues: automatic watering systems require regular observation of the systems and the animals; if not properly maintained, they pose the risk of cage flooding or clogged valves; they do not allow for monitoring of animal water intake.

Aquarium System BMPs

Consider the following for optimum aquarium system efficiency:

- Include the proper use of filtration equipment, use water treatment systems to remove specific contaminants that may be unique to the situation, and institute proper care and cleaning of aquarium surfaces.

A.7.1.4.6 Photographic and X-Ray Equipment BMPs

Consider the following for optimum photographic and X-ray equipment efficiency:

- If old film type equipment is being used, install a WaterSaver kit.
- Encourage the switch to digital equipment.

A.7.1.5 Office Buildings

Common BMPs

For common operations and systems, the table below provides a cross-reference to the appropriate section listing BMPs.

Operation/System	Section Addressing BMPs
Restrooms and Plumbing	A.7.3.6 General Building Sanitary and Safety Applications BMPs
Cooling and Heating Systems	A.7.3.3 Thermodynamic Processes BMPs
Water Treatment	A.7.3.8 Water Treatment BMPs
Kitchen Operations	A.7.1.1 Commercial Food Service BMPs
Ice Machines	A.7.1.1.5 Commercial Ice Machines BMPs
Floor Cleaning	A.7.1.1.4 Washing and Sanitation BMPs
Submetering	A.7.3.2 Building Meters, Submeters, and Management Systems BMPs
Landscaping	A.7.3.5 Commercial Landscaping BMPs

Key Heating and Cooling System BMPs

Although heating and cooling system BMPs are addressed in the section referenced above, key BMPs include:

- Conserve energy and reduce the amount of heat generated.
- Maintain equipment and train operators to ensure correct and efficient equipment operation.
- Use non-water based cooling equipment and processes, if possible
- Minimize system losses
- Maximum recirculation/cycles of concentration before discharge of blowdown water.

Key Water Treatment BMPs

Although water treatment BMPs are addressed in the section referenced above, key BMPs include:

The most important measures to improve the efficiency of water treatment include the following:

- For all filtration processes, install pressure gauges to determine when to backwash or change cartridges, followed by backwash based upon pressure differential.
- Set recharge cycles by volume of water treated or by using conductivity controllers for all ion-exchange and softening processes.
- Avoid the use of clock timers for softener-recharge systems.
- Use water treatment only when necessary.

Key Ice Machine BMPs

Although ice machine BMPs are addressed in the section referenced above, key BMPs include:

- Select Energy Star qualified ice-making machines that are air-cooled, using remote heads to expel warm air outside the work space and customer areas. Air-cooled machines are preferred over cooling-tower loops.
- Select energy-efficient flake or nugget machines rather than cube-ice machines. If cube-ice machines are used, those that meet Consortium for Energy Efficiency (CEE) Tier 2 or 3 efficiency standards[250] are preferred; avoid products that are water cooled.

Key Floor Cleaning BMPs

Although floor cleaning BMPs are addressed in the section referenced above, key BMPs include:

- Discourage the use of open hoses for cleaning. While wet methods may be used, install self-closing nozzles, limiting flow to 5 gpm.
- Install drains close to areas where liquid discharges are expected.

Key Submetering BMPs

- Wherever possible, meter indoor water use separately from outdoor water use.

Other BMPs

Other recommendations include:

- Installing automatic shutoff and solenoid valves on all hoses and water-using equipment.

[250] CEE, 2011. http://www.cee1.org/com/com-kit/files/IceSpecification01Jul2011.pdf

A.7.1.6 Prisons and Correctional Facilities

Common BMPs

For common operations and systems, the table below provides a cross-reference to the appropriate section listing BMPs.

Operation/System	Section Addressing BMPs
Employee restroom facilities	A.7.3.6 General Building Sanitary and Safety Applications BMPs
Medical/dental facilities	A.7.1.4 Medical and Laboratory Equipment and Processes BMPs
Food service	A.7.1.1 Commercial Food Service BMPs
Inmate restroom facilities	A.7.3.6 General Building Sanitary and Safety Applications BMPs
Inmate showering facilities	A.7.1.3 Hospitality: Lodging – Hotels and Motels BMPs
Laundries and clothes washers	A.7.1.2 Fabric Cleaning and Washing Equipment BMPs
Cooling towers and boilers	A.7.3.3 Thermodynamic Processes BMPs
Water treatment: filtration and other processes	A.7.3.8 Water Treatment BMPs
Cogeneration and energy facilities	A.7.2.2.6 Power Plants BMPs
Wastewater treatment	A.7.3.8 Water Treatment BMPs
Prison industries	A.7.2 Industrial Sector BMPs. A.7.3.4 Cleaning Industrial Vessels, Pipes and Equipment BMPs
Prison farms, greenhouses, and gardens	A.7.3.5 Commercial Landscape BMPs
Pools and recreational facilities	A.7.3.7 Pools, Fountains, and Spas BMPs

Operation/System	Section Addressing BMPs
Landscape irrigation	A.7.3.5 Commercial Landscape BMPs
Vehicle washing	A.7.1.9 Vehicle Washing BMPs
Educational facilities	A.7.1.8 Schools and Educational Facilities BMPs
Leaks, metering, and unaccounted for water	A.7.3.2 Building Meters, Submeters, and Management Systems BMPs
Reclaimed water	9.0 Public Infrastructure Needs for Recycled Water
Alternate onsite sources of water	A.7.3.1 Alternate Onsite Sources of Non-Potable Water BMPs

Additional Prisons and Correctional Facilities BMP

Unique to this entity:

- Install flush valves that limit the number of flushes that a can occur in a given amount of time to eliminate excessive flushing.

A 7.1.7 Retail, Grocery Stores and Food Market BMPs

Common BMPs

For common operations and systems, the table below provides a cross-reference to the appropriate section listing BMPs.

Operation/System	Section Addressing BMPs
Cooling and Heating Systems	A.7.3.3 Thermodynamic Processes BMPs
Kitchen Operations	A.7.1.1 Commercial Food Service BMPs
Ice Machines	A.7.1.1.5 Commercial Ice Machines BMPs
Restrooms and Plumbing	A.7.3.6 General Building Sanitary and Safety Applications BMPs

Floor Cleaning	A.7.1.1.4 Washing and Sanitation BMPs
Submetering	A.7.3.2 Building Meters, Submeters, and Management Systems BMPs

Additional Kitchen Operation BMPs

Although kitchen operations BMPs are addressed in the section referenced above, additional BMPs for grocery and retail facilities include:

- Use only efficient pre-rinse spray valves (1.6 gpm maximum) for dish rinsing.
- Use strainer (scrapper) baskets in place of garbage disposals (grinders).
- Install ENERGY STAR automatic dishwashers meeting efficiency standards set by the Consortium for Energy Efficiency (CEE).
- Install steam doors on dishwashers.

For food preparation, several additional BMPs offer opportunities for improved water efficiency:

- Instead of steam tables, install dry heating tables.
- Thaw food in refrigerators. Avoid thawing food under running water.
- Use pasta cookers with a simmer mode and automatic over-flow-control valves. Restrict flow to 0.5 gpm.
- Use connectionless or boilerless steamers consuming no more than 3 gallons per hour.
- Install in-line restrictors that reduce “dipper well” flows to under 0.3 gpm where permitted.

Key Ice Machine BMPs

Although ice machine BMPs are addressed in the section referenced above, key BMPs for grocery and retail facilities include:

- Select ENERGY STAR® qualified ice-making machines that are air-cooled, using remote heads to expel warm air outside the workspace and customer areas. Air-cooled machines are preferred over cooling-tower loops.
- Select energy-efficient flake or nugget machines rather than cube-ice machines. If cube-ice machines are used, those that meet CEE Tier 2 or 3 efficiency standards are preferred.

Key Submetering BMPs

Although submetering BMPs are addressed in the section referenced above, key BMPs for grocery and retail facilities include:

- Separate metering of water-using systems and building areas is recommended in multi-tenant commercial applications where tenancy is divided among disparate users with widely different water use demands.
- Tracking actual water use through a building management system connected to a series of submeters to rapidly disclose operating issues such as leaks and equipment malfunctions that might have remained undiscovered for a period of time.

Additional Floor Cleaning BMPs

Although floor cleaning BMPs are addressed in the section referenced above, additional floor cleaning BMPs for grocery and retail facilities include:

- Discourage the use of open hoses for cleaning. While wet methods may be used, install self-closing nozzles and limit flow to 5 gpm.
- Install drains close to areas where liquid discharges are expected.
- Arrange equipment for easy use of a mop and squeegee system or floor-cleaning machine.

Other Additional Grocery and Retail Facilities BMPs

- Use self-contained “mini labs” that require no plumbing or washing for onsite photo processing.
- Install automatic shutoff and solenoid valves on all hoses and water-using equipment.
- Conspicuously mark fire-protection plumbing so no connections will be made other than those for fire protection.
- Install flow-detection meters on fire services to reveal unauthorized water flows.
- If available, and where codes and health departments permit, use non-potable, treated water for fixture flushing (toilets and urinals only) and landscape irrigation applications.

A.7.1.8 Schools and Educational Facilities

Common BMPs

For common operations and systems, the table below provides a cross-reference to the appropriate section listing BMPs.

Operation/System	Section Addressing BMPs
Restrooms and Plumbing	A.7.3.6 General Building Sanitary and Safety Applications BMPs
Cooling and Heating Systems	A.7.3.3 Thermodynamic Processes BMPs
On-Premise Laundries	A.7.1.2 Fabric Cleaning and Washing Equipment BMPs
Water Treatment	A.7.3.8 Water Treatment BMPs
Special Facilities	A.7.1.4 Medical and Laboratory Equipment and Processes BMPs
Floor Cleaning	A.7.1.1.4 Washing and Sanitation BMPs
Submetering	A.7.3.2 Building Meters, Submeters, and Management Systems BMPs
Residence Halls (colleges and universities)	A.7.1.3 Hospitality and Lodging – Hotels and Motels BMPs; A.7.3.6 General Building Sanitary and Safety Applications BMPs
Other	A.7.1.1 Commercial Food Service BMPs; A.7.3.5 Commercial Landscaping BMPs; A 7.3.1 Alternate Onsite Sources of Non-Potable Water

Key Restroom and Plumbing BMPs

Although restroom and plumbing system BMPs are addressed in the section referenced above, key BMPs include:

- Use water saving fixtures.
- Use non-potable treated water for toilet flushing, urinals, and landscape applications where available and allowed.

Key Heating and Cooling System BMPs

Although heating and cooling system BMPs are addressed in the section referenced above, key BMPs include:

- Conserve energy and reduce the amount of heat generated.
- Maintain equipment and train operators to ensure correct and efficient equipment operation.
- Use non-water based cooling equipment and processes, if possible
- Minimize system losses
- Maximum recirculation/cycles of concentration before discharge of blowdown water.

Key Special Facilities BMPs

Although special facilities BMPs are addressed in the section referenced above, key BMPs include:

- Choose dry-vacuum systems rather than liquid-ring pumps for laboratories.
- For vacuum and compressor systems, use air-cooled, radiator-cooled, chilled-loop, or cooling-tower systems.
- Sterilizers in laboratories should be equipped with water tempering devices.
- For photography and medical and other imaging, try to use digital technologies that allow images to be displayed on electronic video screens and stored in computer files.
- Where film imaging is required, use self-contained “mini-lab” developing units that require no special plumbing or washing to develop the film.
- For paper or film image copies use laser or ink-jet printing.

Key Floor Cleaning BMPs

Although floor cleaning BMPs are addressed in the section referenced above, key BMPs include:

- Discourage the use of open hoses for cleaning. While wet methods may be used, install self-closing nozzles, limiting flow to 5 gpm.
- Install drains close to areas where liquid discharges are expected.
- Arrange equipment for easy use of a mop and squeegee system or floor-cleaning machine.

Key Submetering BMP

- Wherever possible, separate metering of water-using systems and building areas is recommended.

A.7.1.9 Vehicle Washing

A.7.1.9.1 Self-Service Carwash BMPs

- The customer has a direct monetary incentive to move as quickly as possible, thus conserving water, because of the fixed pricing structure and requirement for purchase of additional time.
- As with in-bay automatics, reject water from the reverse osmosis (RO) unit may be used in landscape watering if landscape exists and spot-free rinse is offered.
- Use/reused of reclaimed water is limited by dumping of chemicals.

A.7.1.9.2 In-Bay Automatic BMPs

- Optimize nozzle size, number and alignment, flow rates, and timing.
- Consider using laser sensors to identify the length of the vehicle, thus limiting the gantry movement and timing of wash based upon the sensor signals.
- Consider using brushes or cloth equipment instead of frictionless or “touch-free” vehicle washes.
- Refer to A.7.3.8 Water Treatment Systems BMPs for BMPs related to use of RO and deionization equipment typically used in spot-free rinse operations.
- Use/reuse of reclaimed water can be difficult because all of the water flows to one pit, and all of the chemicals mix together.

A.7.1.9.3 Conveyor BMPs

- Consider using brushes or cloth equipment instead of frictionless or “touch-free” vehicle washes.
- Properly calibrate conveyor nozzles to turn on as the vehicle passes under the arch and to shut off as the vehicle exits each arch.
- Maintain proper nozzle alignment and pressure.
- Orient blowers after the final rinse to push water back into the tunnel after the final rinse arch, where it can be reused in carwashes with reclaim systems.
- If towel drying is included, install a float ball valve to stop the flow of water when it reaches an optimum level in towel washing sinks.
- If towel drying is included, replace older flow-through sinks or top loading washing machines with front loading machines.

A.7.1.9.4 Truck, Bus, and Fleet Washes BMPs

The type of equipment used to wash trucks, buses, utility vehicles, and heavy equipment is similar to that described above except larger in scale. Refer to the above sections for applicable BMPs.

A.7.1.9.5 Reclaim as a BMP

Self-Serve Carwash

Reclaim systems are not usually used by self-service carwashes due to the relatively few gallons per vehicle used by self-service customers. However:

- A closed-loop reclaim system can be used in self-service carwashes where there is no discharge to the sanitary sewer and all discharge is restricted.
- In these situations, the self-service should be staffed onsite to prevent customers from dumping oil or other materials.

In Bay Automatics

- Expensive since all chemical products, from cleaning to finish, as well as oil and grease and contaminants from the road winds up in the same separator tank.
- The water needs to be treated to remove all constituents that would interfere with its eventual reuse in the wash.

Conveyors

- The length of the tunnels can provide opportunities to reclaim rinse water separately from wash water, necessitating different levels of treatment.
- This flexibility can create more cost-effective reclaim opportunities.

Large Vehicles and Reclaim

- Controlled access to such facilities allows for more innovative treatment of the water.
- Rainfall can be captured to replenish systems, so closed-loop systems can approach 100 percent nonpotable water use.

Other Considerations

- Reclaim equipment has added value because it helps reduce the volume of discharge per vehicle.
- Recycled water from municipal sources is not typically delivered to commercial car washes.
- Use of municipal recycled water may be inhibited by pathogens and spotting on cars due to total dissolved solids (TDS).
    - Ozonation systems are commercially available to address pathogens.
    - Spotting can be managed with ion exchange and/or surfactants.

A.7.2. Industrial Sectors

A.7.2.1 BMPs for Industrial Operations

- One size does not fit all – For any given industry, there may be a dozen potential BMPs. Not all will be applicable. In many cases, establishing one BMP will make another one inapplicable because they will "be saving the same water."
- Every facility is unique - Analyzing potential payback is unique to each plant and situation. Unlike many commercial situations, manufacturing plants vary in manufacturing techniques and design, even within the same industry. As a result, what may work at one vegetable processing plant may not be applicable at another.
- The list should be used only as a guide - The intent of the industrial operations BMPs is to provide a list of possible measures that facilities can adopt for their specific situation.

<u>Common BMPs</u>

For common operations and systems, the table below provides a cross-reference to the appropriate section listing BMPs.

Operation/System	Section Addressing BMPs
Restrooms and Plumbing	A.7.3.6 General Building Sanitary and Safety Applications BMPs; Section 9.0 Public Infrastructure Needs for Recycled Water
Cooling and Heating Systems	A.7.3.3 Thermodynamic Processes BMPs
On-premise laundries	A.7.1.2 Fabric Cleaning and Washing Equipment BMPs
Floor Cleaning	A.7.1.1.4 Washing and Sanitation BMPs
Kitchen Operations	A.7.1.1 Commercial Food Service BMPs
Ice Machines	A.7.1.1.5 Commercial Ice Machines BMPs
Pools	A.7.3.7 Pools, Fountains, and Spas BMPs
Landscaping	A.7.3.5 Commercial Landscape BMPs
Equipment Cleaning	A.7.3.4. Cleaning Industrial Vessels, Pipes and Equipment BMPs

Water treatment: filtration and other processes	A.7.3.8 Water Treatment BMPs
Vehicle washing	A.7.1.9 Vehicle Washing BMPs
Medical and laboratory: pumps, sterilization, and air scrubbing processes	A.7.1.4 Medical and Laboratory Equipment and Processes BMPs
Water use accounting, leak detection and management	A.7.3.2 Building Meters, Submeters, and Management Systems BMPs

A.7.2.2 Industry-Specific Information

A.7.2.2.1 Aerospace Industries in California BMPs

Refer to A.7.2.2.2, Plating, Printed Circuit Board, and Metal Finishing for metal finishing and plating BMPs. Refer to A.7.2.1 for cross-references to BMP sections addressing cooling towers, boilers, sanitation, food service, laundry, vehicle washing, laboratory operations, filtering and water treatment BMPs.

Molding and casting BMPs

- Considering using resins in sand casting, where applicable.
- In all cases of investment casting where water is used, alternative methods are available.
- Mold cooling should only be done with either air or a closed cooling loop system.

Milling and Cutting BMPs

- For electric discharge machining, use kerosene instead of water where feasible.
- For water jet cutting and milling, recirculate water and abrasives.
- For cutting and milling fluids, use air, CO2, nitrogen, oils, and gels in place of oil-water mixtures, where feasible.

Welding BMPs

- Where possible, use welding techniques that do not require cooling water or brine.
- Spot welding and tungsten arc welding tips should be air cooled where feasible.

Quenching of Metals BMPs

- Once-through cooling water should be eliminated and replaced with a properly operated cooling tower or chilled water loop that recirculates the cooling water.
- Where feasible, air cooling should be used.

Aircraft Parts Stripping and Cleaning BMPs

- Dry paint removal methods, including the use of walnut shells, plastic pellets, sodium bicarbonate, and even carbon dioxide pellets, should be used where feasible. Intense light and heat sources are applicable for certain types of surfaces and offer water savings, but can use energy.
- Where caustic strippers or softening agents are used that require water to remove the residue, the resulting water should be filtered and recirculated.
- Very high pressure water systems should also be equipped with water filtration and recirculation devices.

Air Scrubbing BMPs

- Air scrubbers that use a water solution should be of the reticulating type and equipped with conductivity controllers or other devices to control the amount of makeup water.
- Scrubbers are excellent candidates for the use of alternate sources of water.
- Where feasible, a dry absorptive media should be used.

Painting BMPs

- Dry paint systems should be used where feasible, but for large surfaces, spray painting is still the most commonly applied method.
- Systems that filter and recirculate cleaning water are available. Where water curtains are used to capture paint particles in spray booths, the water should be filtered and recirculated.

A.7.2.2.2 Plating, Printed Circuit Boards, and Metal Finishing BMPs

Refer to A.7.2.1 for cross-references to BMP sections addressing cooling towers, boilers, sanitation, food service, laundry, vehicle washing, laboratory operations, cleaning industrial equipment, filtering and water treatment BMPs.

- Implement Dragout Controls. Minimize carryover from process and rinse tanks by:
    - Designing racks, barrels and processes, so that liquids captured in bends and curves of the pieces being processes are minimized, allowing time for parts to drain (dwell) over tank
    - Using sprays in place of dipping parts
    - Using air knifes, fogs or misting to remove solution
    - Vibrating or " bumping" parts to knock liquid off
    - Ensuring parts are pointed down so that they drain most efficiently
    - Using wetting agents
    - Hanging bars above tanks to allow parts to drain
    - Installing drip guards between tanks

  - Using drain boards

- Implement Chemical Concentration Control. Use of conductivity meters, chemical analysis equipment, optical sensors and similar methods to control the timing of draining, rinse baths, or adding chemicals only if they are necessary.
- Use multiple tank and countercurrent rinsing.
  - Reactive rinsing, where the rinse water from the final tank is used for the pickle-rinse tank, can also be used in some applications.
  - Dual purpose rinsing is an option where the same rinse tanks or spray rinses can be used for multiple purposes when water quality is not critical.
- Use mechanical mixing, agitation, and air blowing agitation in plating and rinsing operations to maximize solution contact with the parts being processed allowing lower concentrations of the chemicals in a bath.
- Select cleaning methods that reduce the need for rinsing. New zirconium compounds and methods, such as the patented Piclex process, exemplify new strategies that eliminating one or more rinses.
- Pretreat makeup water to achieve the maximum use of chemicals and reduce the need to dump tanks and replace water and solution.
- Implement Evaporation Control such as foams or floating balls specially designed to retard evaporation.
- Maximize air scrubber water recirculation and reuse.
  - Install recirculation systems with conductivity controllers, temperature probes, and fill and dump controls similar to conductivity blowdown controls on cooling towers.
  - Reuse of spent rinse water and other sources of water is an alternate source of makeup water where feasible.
- Rinse and process water recovery and reuse.
  - Use rinse water as makeup water to the process tank containing the chemicals being rinsed.
  - Use filtration and reverse osmosis to recover chemicals and produce a very clean stream of water for reuse.
- Plating Tank Cooling.
  - Recover this heat for use in other operations within the facility is optimum.
  - Where cooling is needed, use air cooling where bath temperatures can operate at 140oF or above.
  - If cooling coils are used in the tank, some form of agitation will help ensure good heat exchange. Tank fluids can be circulated through heat exchangers with pumps, thus providing for good heat transfer and helping to agitate the tank fluids.
  - Use a cooling tower or chilled water system if other non-water options are not feasible.

- Rectifier selection and cooling.
    - Use air cooled rectifiers where corrosive fumes from plating operations are not present, if feasible, which usually means they are outside the plating line building.
    - Where water cooling is necessary, use a cooling tower or chilled water loop.
    - Waste heat produced by the rectifiers should be recovered where possible. Many plating operations operate boilers, and the waste heat from rectifiers and tank cooling operations can be used to pre-heat boiler makeup water. Preheating water for the RO system improves the productivity and efficiency of these systems.
- Metering, flow control, and data acquisition. Meter makeup water to the RO system, tank filling, cooling towers, and other major water using areas.

A.7.2.2.2 Food Processing and Beverage Manufacturing BMPs

General BMPs that apply commonly to the food industry can also be found in A.7.3.4 Cleaning Industrial Vessels, Pipes, and Equipment BMPs and A.7.3.3 Thermodynamic Processes BMPs. BMPs specific to Food Processing and Beverage Manufacturing Industries are presented below:

Fruit and Vegetable Processing BMPs

Washing Operations

- Use vibration and air to help clear fruit and vegetables of debris and dirt before fluming or washing
- Use brushes to clean produce
- Spray wash instead of submerging fruits and vegetables to wash them
- Use countercurrent washing
- Reduce overflow
- Use can cooling water for first flush water

Fluming for Transport of Raw, Peeled, or Blanched Products:

- Where the fruit or vegetable will not be damaged by mechanical handling, use conveyor belts, use pneumatic systems and totes to move product instead of water.
- Use flumes with a minimum cross section to reduce water volume.
- Recirculate flume water where allowed by code.
- Use flumes with parabolic cross-sections rather than flat-bottom troughs.
- Eliminate fluming water and use dry removal of dirt.
- Sorting, culling, and grading should occur before fluming or washing. This will also reduce wastewater and save energy.

Processing Preparation, Use:

- Dry peeling and blanching
- Mechanical peeling
- Chemical peeling
- Steam blanching

Equipment and Facility Cleaning

- Reuse pump seal waste water for washing crates and pallets
- For rinsing and cleaning cans and beverage bottles (including wine bottles):
  - Use self-closing valves and/or automatic shutoffs or sensors that only allow timed sprays run to rinse bottles and cans when they are passing the spray nozzle
  - Clean bottles with air
- For cleaning sweep-and-use squeegees to remove solid waste, in place of using a hose
- For clean-in-place processes, the list below articulates methods for reducing water use:
  - Dry recovery of refuse
  - Eliminate wet transport of wastes where possible
  - Installing drip and catch equipment to keep floor clean
  - Use squeegees to remove bulk waste from floor before cleaning
  - Use floor scrubbing and vacuum systems
  - Hand clean larger parts from equipment
  - Place level indicators on tanks and overflow alarms on vessels

Concentrating

When concentrating food and juices, use filtration and membrane processes as an alternative to thermal/steam operations. The following summarizes some applications of membrane processes:

- Micro-filtration for:
  - Cold sterilization of beverages
  - Clarification of fruit juices, beers, and wines
  - Continuous fermentation
  - Separation of oil-water emulsions
  - Wastewater treatment
- Use Ultra-filtration for:
  - Concentration of milk
  - Recovery of whey proteins

    - Recovery of potato starch and proteins
    - Concentration of eggs
    - Clarification of fruit juices and alcoholic beverages
- Use Nano-filtration for:
    - Removal of micro-pollutants
    - Water softening
    - Wastewater treatment
- Reverse osmosis for:
    - Desalination
    - Concentration of food juice and sugars
    - Concentration of milk

General

- When coring, pitting and dicing use dry transport and conveyor belts as an alternative to transporting product by water
- For conveyor belt operations, investigate use of dry lubrication systems. Early attempts at dry lubrication systems were not always successful, but dry lubrication is now becoming commonplace.

Meat and Poultry Operations BMPs

The principal opportunities for reducing water use in meat and poultry processing by moving from wet to dry cleaning include:

- Dry recovery of manure, drippings, intestines, and other product waste.
- Eliminate wet transport of waste where possible.
- Install drip and catch equipment to keep floor clean.
- Use squeegees to remove bulk waste from floor before cleaning.
- Use floor scrubbing and vacuum systems.
- Hand clean larger parts of equipment.

If the meat or poultry is breaded or cooked, the following water efficiency measures can be employed:

- Use drip pans and splash guards to catch breading or parts.
- Practice manual cleaning procedures before washing.
- Only wash equipment once dry waste has been removed.
- Capture and return steam condensate for cooking, autoclaving, drying, and similar operations that require steam.

General - Alternate Sources of Water and Recirculated Water Use

Use of alternative sources and recirculated water is a best management practice for all industries. Issues and uses specific to Food Processing and Beverage Manufacturing are discussed in this section. These BMPs may include:

- Recycling water within the plant
- Use of alternate sources for non-food processing areas
- Reuse of plant effluent for irrigation

Land Application Reuse Regulations

Regulations specific to land application of wastewater from food processors include:

- Porter Cologne Act - Reuse cannot impact beneficial uses of groundwater
- Basin plans - Defines the beneficial use of water for each region
- Anti-degradation policy
  - Protects groundwater
  - Requires the use of Best Practicable Treatment and Control

Limitations on Water Reuse

- The U.S. Federal Food and Drug Administration and the U.S. Department of Agriculture's strict guidelines for food safety often means that much of the water used in meat and poultry processing, as well as other food processing operations, may only be used once.
- Use of ozone and membrane treatment of wastewaters are techniques now being tested within the poultry industry, and the use of recovered water for non-contact uses such as cage cleaning, dust control are feasible for many operations.

A.7.2.2.3 The High-Tech Industry in California BMPs

BMPs for the plating operations are discussed in A.7.2.2.2 Plating, Printed Circuit Board, and Metal Finishing BMPs

Reduction of Water Use for Wafer Processing BMPs

- Use programmable tool features
- Install control equipment to only use the exact amount of water needed throughout the specific operation.
- Use spray rinsing in place of emersion rinsing.
- Use process timers instead of dump rinser cycles.
- Countercurrent rinsing.
- Optimize ion-exchange regeneration cycles.

Water Reuse BMPs

- Ultra Pure Water (UPW) Production Water Recirculation and Reuse
  - Recover part of the fresh water processed through the ultrapure water system.
  - Employ treatment systems such as nanofiltration to recover water from the reject stream
  - Use RO reject water for cooling tower water.
- Reuse of Water for Non-UPW Purposes
  - Use water from the UPW waste streams, reject water from the RO unit, and other alternate onsite sources can be used in places that do not require UPW including:
    - Cooling tower makeup, though it is often necessary to supplement with water with dissolved solids content.
    - Scrubber water, though it is often necessary to supplement with water with dissolved solids content.
    - Toilet and urinal flushing.
    - Ornamental fountains and features.
  - Use other sources of non-potable water such as stormwater runoff, air conditioning condensate, foundation drain water, rainwater, and other sources, where feasible.

Other General BMPs

- Recover process and air conditioning waste heat to pre-heat incoming water making RO units operate more efficiently and reduce heat load on the cooling tower, where feasible.
- Use closed-loop and "dry cleaning" methods. Some of these methods include:
  - Pinpoint cleaning
  - Supercritical fluid cleaning
  - Cryogenic aerosol cleaning
  - HF vapor cleaning
  - Closed-loop
  - Dry manufacturing
- Use alternative manufacturing methods, where feasible.

Populating Circuit Boards BMPs

For deflux operations,

- Use non-UPW water of acceptable quality for deflux operation.
- Counter cleaning operations (freshest water last).
- Precise aim and pressure of hot water spray.

- Addition of cleaning compounds that will better remove the flux while reducing the total amount of fresh water required. The recovery and reuse of up to 90 percent of this water is possible.

Solar Energy System Manufacturing BMPs

- Use filters to produce pure water – Optimize pre-treatment upstream for RO by minimizing the reject water through the use of activated carbon filtration to produce high-quality DI water and increasing water recovery.
- Employ more efficient manufacturing systems –faster cutting systems means less water for lubrication as process time is decreased.
- Segregate and treat to facilitate water recovery; if wastewater is segregated, it is possible to reuse waste streams in other process areas.
- Employ re-use paths for process chemicals and water; chemical spiking or dosing can minimize bath dump, which includes water. Whenever possible, manufacturers should eliminate single-pass rinse steps.
- Employ water reduction strategies for wet scrubbers and chemical abatement systems.
  - Point-of-use abatement systems use an "on demand" water flow, meaning that the system is scrubbing when process gas is being abated rather than maintaining a constant flow of water through the system. This mode of operation needs to be verified on an individual basis taking into account other potential issues related to safety, environmental emission considerations (i.e. ensure this does not decrease the efficiency of the abatement system), biological growth, fouling, etc.
  - Use potable city supply water for point-of-use abatement systems rather than RO/DI, minimizing the use of RO and associated generation and disposal of the reject stream.
  - Use alternate methods for packed bed wet scrubbers to regulate the delivery of makeup water, such as conductivity or pH, rather than using a constant makeup flow. This needs to be verified on an individual basis accounting for potential issues related to safety, environmental emission considerations (i.e. ensure this does not decrease the efficiency of the scrubber), concentration of prohibited materials (i.e. metals/fluorides) that could cause violation of discharge limits, biological growth, fouling, and others.

A.7.2.2.4. The Petroleum Refining and Chemical Industries in California BMPs

Alternative Water Sources BMPs

- Segregate and reuse water within the refinery.
- Use stormwater and other onsite sources (e.g., condensate from refrigeration, steam and heating systems, and air conditioning processes; treated wastewater from restrooms and showers; and, similar sources), where feasible.
- Municipal recycled water is another source of freshwater supplies that could substitute for potable water. Recycled water can be used for cooling tower makeup, boiler feed, and all

other uses except potable use. Additional treatment may be needed and its availability may be limited due to lack of infrastructure to produce and deliver recycled water to industrial users.

Other General BMPs

- Meter, sub meter, and install automated data recording systems to follow water use at all major use points;
- Converting pumps to mechanical seals;
- Where packing glands are required, using alternate sources of water for seal water;
- Using dry vacuum pumps;
- Where liquid ring pumps are required, either installing a water recirculation system or use wastewater for the seal;
- Installing automatic cutoffs and solenoids on all water using equipment to ensure that water flow is stopped when the equipment is not working;
- Instituting training programs for employees;
- Installing water efficient plumbing fixtures and appliances; and
- Following vessel washing and pipe cleaning procedures. (See A.7.3.4 Cleaning Industrial Vessels, Pipes and Equipment BMPs.)

Chemical Industry-Specific BMPs

- Communication - Make sure your staff understands the most effective washing methods.
- Batch formulation - Processing the same types of chemical in batches can reduce the frequency of vessel washing.
- Mixing outside the vessel - This practice may reduce the need for vessel washing.
- Dedicated equipment - Using specific vessels for specific products can reduce cleaning requirements.
- Production scheduling - Batching compatible products together will minimize the washing needed between them.
- High-pressure cleaning - Systems that direct dense sprays and jets of wash liquor can help reduce the amount of water used, while improving wash efficiency by 90 percent.
- Automated vessel washing - You can use this process to control water use more precisely and reduce emissions, especially in enclosed vessels.
- Optimizing cleaning levels - Ensure that you use only the required level of cleaning for particular products. You may not need to wash at all, or you might be able to reuse wash liquor.
- Optimizing cleaning agents and solvents - Using different cleaning agents and solvents may reduce washing.
- Using wash liquor in product - Look into using wash liquor to dilute subsequent product batches where required.

- Material recovery – In areas where you cannot reuse wash liquors, look at ways of recovering materials from the effluent.

A.7.2.2.5. The Pharmaceutical and Biotech Industry BMPs

General BMPs

- Reuse RO reject water in production cycles, cooling tower makeup water, boiler feed water, and irrigation
- Meter, sub-meter, and install automated data recording systems to follow water use at all major use points
- Convert pumps to mechanical seals
- Where packing glands are required, using alternate sources of water for seal water
- Using dry vacuum pumps
- Where liquid ring pumps are required, either installing a water recirculation system or using wastewater for the seal
- Follow vessel washing and pipe cleaning procedures (see Section 7.3.4, Cleaning Industrial Vessels, Pipes and Equipment
- Install automatic cutoffs and solenoids on all water using equipment to ensure that water flow is stopped when the equipment is not working
- Institute training programs for employees
- Install water efficient plumbing fixtures and appliances
- Where bioreactors are used, consider smaller reactors with disposable liners.

Use of Alternative Water Sources

- Use stormwater and other onsite sources for firewater, pump seal water, cooling tower makeup, and boiler and utility water after proper treatment, where feasible.
- Condensate from refrigeration and air conditioning processes, treated wastewater from restrooms and showers, and similar sources may also provide small quantities of water for the refinery operation.
- Municipal recycled water can be used for cooling tower makeup, boiler feed, and all other uses except potable use although it may need additional treatment.
- Seawater can be used for cooling purposes for plants located along the coast, entirely eliminating the use of fresh water for cooling. However, power plants using seawater for cooling are now being required to eliminate once-through or pass-through cooling, which will further require them to install recirculating systems to reduce the volumes of water they withdraw.

A.7.2.2.6 Power Plant BMPs

To optimize power plant efficient, consider the following in addition to general cooling and heating system BMPs identified in A.7.3.3 Thermodynamic Processes BMPs.

- Use of municipal recycled water for power plant cooling.
- Adaptation of innovative water use and water recovery, water reuse and water recycling measures.
- Implementation of advanced cooling technologies.
- Adoption of energy efficiency measures and less water-intensive renewable energy sources, such as solar PV and wind, and others.
- Increase electricity generation efficiency.
- Install solar PV and wind power generation facilities.
- Use dry/hybrid cooling systems.
- Recirculate or reuse water within plant.
    - Increase closed cooling cycles.
    - Use blowdown.
    - Capture vapor produced in wet cooling tower.
- Use of alternative water sources:
    - Waste water treatment plant discharge.
    - Water produced in oil/gas extraction
    - Storm water flow.
    - Mine drainage.
    - Agricultural runoff.
    - Saline aquifers.

A.7.3 BMPs for Common Devices, Processes, and Practices Applicable to the CII Sectors

A.7.3.1 Alternate Onsite Sources of Non-Potable Water as a BMP

7.3.1.2 Potential Sources of Onsite Non-Potable Water

- Rainwater Harvesting - catching of water from roofs and other elevated structures and stored in cisterns for future use. Approximately 0.62 gallons of water can be collected per square foot of collection surface per inch of rainfall. The inability of the system to capture all water during heavy storms also affects practicable efficiency. In California, since most regions don’t receive precipitation during the summer, early fall, or late spring, cisterns are far less practical than in other parts of the country.

- Stormwater Harvesting - catching runoff from parking lots, roofs, and landscape. This water can either be captured in storage structures such as holding ponds or storage tanks for future use after proper treatment, or runoff can be slowed and allowed to infiltrate to the local aquifer. If storage structures are used, economics and design considerations are similar to that for rainwater, except that stormwater generally contains higher levels of contaminants than rainwater.
- Air Conditioner Condensate - the water formed inside air conditioning coils from dehumidification. Since the condensate is from the atmosphere, it lacks minerals and salts, but it does collect bacteria and particulates from air being passed through. The best time to incorporate condensate collection systems is in the design phase of a facility.
- Swimming Pool Filter Backwash Water - filter backwash water from the backwash of sand filters can be used for landscape irrigation and other uses if properly treated. Backwash water can contain high levels of suspended solids and bacteria and may also contain fairly high dissolved solids levels. Chlorine may be a factor if it is too high for the plants being irrigated. Algaecides can also damage plants, but in most cases, it can be used for irrigation with minimal treatment.
- Cooling Tower Blowdown - the water discharged to keep minerals from building up in cooling towers. It is usually high in TDS, but can be used to irrigate salt tolerant plants. Blowdown can also be used for other purposes such as toilet flushing, but special attention would need to be given to TDS levels and the type of treatment needed to bring it to the level needed for those uses.
- Reverse Osmosis (RO) and Nanofiltration (NF) - purge water rejected from this type of treatment equipment. This water has typically been treated and disinfected. RO One constituent of concern with RO or NF reject water is TDS. Where nanofiltration is used for softening, the reject water can also be very hard.
- Graywater - water from laundries, bathing, and hand washing fixtures. See the NSF 350 and NSF 350-1 standards for this type of water. If the IAPMO Green Plumbing and Mechanical Code is followed, gray water refers to untreated water from graywater sources that are only used for subsurface irrigation.
- Onsite Treated Wastewater - sewage treatment plants located on the premise where the wastewater is generated. When treated properly, this effluent can be a viable source of fresh water from municipal facilities.
- Foundation Drain Water - water pumped from under foundations, French drain systems, basement sumps, and from under slabs to prevent flooding of basements or buildings below the land surface. This water can vary significantly depending on the soil type and ground it comes in contact with. This water should have a major cation and anion analysis performed on it prior to use to determine its makeup. Normally, this type of water is an excellent candidate for landscape irrigation and cooling tower makeup.
- Boiler Blowdown - the quality of blowdown from boilers varies considerably depending on the quality of steam needed. Most commercial low-pressure boilers produce a blowdown that is high in TDS, but high pressure boiler blowdown is often low in TDS and can be used for non-potable purposes.

A.7.3.1.3 Potential Uses of Alternate Onsite Sources for Non-Potable Purposes

The most important factor when evaluating the possible uses is what the minimum water quality needed to meet the needs of the user and to ensure the safety of the water for the intended use.

Some potential uses include:

- Irrigation
- Green roofs
- Cooling tower makeup water
- Toilet and urinal flushing
- Makeup for an ornamental pond/fountain
- Swimming pools
- Laundry
- Industrial process use
- Any other use not requiring potable water
- These onsite sources can even be used for non-industry practices such as aquifer recharge and meeting environmental needs for in-stream flow and wetlands maintenance.

Water Quality Considerations - Making these sources usable often requires treatment; however, these sources do not need to be treated to more than the quality required for the intended use.

- Treatment technologies can be used to treat any onsite source to the quality necessary
- Treatment levels will depend on the ultimate use of the alternate water source.

A.7.3.1.4 Other Considerations

- Plumbing of rainwater, gray water, drain water, and blowdown from various sources to common end uses, like landscape irrigation, or non-potable indoor uses, such as toilet flushing, is not common, but it is recommended.
- Water treatment should be designed to treat the poorest water quality collected from the multiple sources.
- An effective way to use an alternate source of onsite water is to "backup" that alternate water source with a connection to a potable or recycled water source. This will allow the facility using the alternate onsite source of water to maximize its use of the alternate water source while having a backup water source when onsite sources are low due to operational or climatic conditions. In all cases, proper backflow prevention is necessary, which would typically be an air gap separation between the potable and non-potable supply.
- With the significant opportunities to reuse water in the CII sector, the CBSC should adopt updates to the plumbing code based on the IAPMO 2010 Green Plumbing Code supplement and the NSF 350 standard. This will provide clear direction to local jurisdictions for the oversight of these types of system, ensure protection of public health and advance the ability to reuse water.

A.7.3.2 Building Meters, Submeters, and Management Systems BMPs

Consider the following best practices for metering water use:

Determine What to Meter and Submeter

The following recommendations are based on the U.S. Green Building Council's proposed 2012 Leadership in Energy and Environmental Design (LEED) rating system:

Source Meters

- Meter all water conveyed to the facility, regardless of source. For example, even if a building's water is solely supplied by an alternative source (e.g., municipally supplied reclaimed water), a source meter should be installed.[251]
- If multiple sources of water are provided to a facility, each source should be metered and tracked separately.

Submeters

- Consider installing separate submeters to measure the following uses if they are permanently plumbed:[252]
    - Freestanding building with projected annual water use of 100,000 gallons or more.
    - Tenant space with projected annual water use of 100,000 gallons or more.
- Cooling tower with projected annual makeup water use of 100,000 gallons or more. Makeup water added to the system and blowdown water discarded from the system should be separately metered. A single makeup meter and a single blowdown meter may record flows for multiple cooling towers if they are controlled with the same system. Separately controlled cooling towers should have separate makeup and blowdown water meters.
- HVAC systems with aggregate annual water use of 100,000 gallons or more. If the facility has 50,000 square feet or more of climate controlled space, the following systems should be submetered individually or collectively: (1) evaporative coolers, humidifiers, and mist cooling devices; and (2) recirculating water systems with a fill water connection, such as chilled water, hot water, and dual temperature systems.
- Any boiler with aggregate projected annual water use of 100,000 gallons or more, or a boiler of more than 500,000 British thermal units per hour (BtuH). A single makeup meter may record flows for multiple boilers.
- Landscape irrigation that is automated and permanent.
- Water use from alternative water sources such as rainwater, air handler or boiler condensate, or other sources.
- Makeup water used to supplement rainwater, graywater, and other onsite water collection and treatment systems plumbed to receive supplemental water (reclaimed, raw, or potable) from municipal supply, onsite treatment systems, or a groundwater well.

[251] U.S. Green Building Council. 2010. Leadership in Energy and Environmental Design—November 2010. *Draft Rating System for Building Design & Construction* www.usgbc.org/ShowFile.aspx?DocumentID=8182.
[252] ibid

- Manmade ornamental and recreational bodies of water including pools, spas, and ornamental water features. Makeup water provided to such water bodies with a combined surface area of 500 square feet or more should be metered, regardless of the projected amount of water use. Do not meter individual features of less than 50 square feet that cannot be reasonably metered collectively.
- Any other process with a projected annual water use of 100,000 gallons or more.

In addition, also recommended for submetering consideration are the following:

- Other nonpotable water uses (process water) from sterilizers, air compressors, water filtration systems, laundry, and vehicle wash systems.
- Commercial food service water heaters with another meter for all food service water.

Meter Selection

- First, determine the meter's use and select the appropriate meter from the meter types listed below.
  - Positive **Displacement Meters.** Positive displacement meters are best suited for small commercial or institutional applications because they have higher accuracy at low flows and can precisely measure peak flows.
  - **Compound Meters.** Compound meters are good for large commercial or institutional facilities because they accurately measure low flows and high flows with their multiple-measuring chamber design.
  - **Turbine and Propeller Meters.** Turbine and propeller meters are most appropriate for continuous, high flow applications and are inaccurate at low flows. These types of meters are not usually recommended for commercial, institutional, or residential buildings because water flows are in constant fluctuation with very low minimum flow rates.
  - **Electromagnetic Flow Meters.** Electromagnetic flow meters have no moving parts and do not obstruct flow. They have electronic outputs that are easy to connect to automated systems and data management systems.
  - **Ultrasonic and Time-Flight Meters.** Ultrasonic and time-flight meters can be attached to the outside of the pipe and are excellent for temporary flow measurement such as a water conservation audit.
- Next, select the appropriate meter size.
  - It is important to understand the building's size, function, fixture types, usage occupancy, and peak population in order to select the appropriately sized meter. These statistics determine the minimum and maximum flow rates and should result in the selection of a properly sized water meter.
  - AWWA Standard M22, *Sizing Water Service Lines and Meters*, provides additional guidelines for selecting and sizing utility-owned and installed water meters.

Meter Installation and Maintenance

- When installing a meter, follow the manufacturer's instructions. Improper installation can lead to metering inaccuracies.
- Meters should be installed in an accessible location to allow for repair and calibration. In addition, the meter location should be protected from potential damage from surrounding equipment.
- To ensure uniform flow entering the meter, do not install the meter near pipe bends. In general, place the meter with a distance of at least 10 pipe diameters downstream and five pipe diameters upstream.
- Create a map indicating the location of all source meters and submeters.
- Include a strainer on all meters and submeters. It is possible that debris and sediment will enter a meter with the flow of water that can have an adverse effect on accurate measurement. An in-line strainer on the meter's inlet will collect debris and sediment and prevent these from entering the meter body.
- Meters deteriorate with age and should be tested for accuracy and calibrated on a regular basis. Sub-meters, however, may be subjected to more frequent inspection and calibration, depending upon the type and size of the meter and its application.

Water Use Tracking and Integration Into a Water Management Plan

- Use meters to provide the data that can be monitored to aid in the efficient operation of a facility: discovering and correcting water use anomalies and to helping the organization allocate the cost of water to the appropriate tasks or processes.
- Staff the facility with motivated, aware, and trained monitoring personnel.
- Consider installing a "real time" centralized building management system with remote communication capabilities to the meters and submeters.
- If not integrating metering data into a centralized system, consider the following:
    - Assign responsibility to track water use on a monthly or more frequent basis.
    - Train staff on meter reading and data recording.
    - Plot total water use and submetered data monthly, and examine data for unexplained fluctuations.
    - Evaluate trends and investigate and resolve any unexpected deviations in water use.

A.7.3.3 Thermodynamic Processes BMPs

7.3.3.1 Cooling Systems BMPs

General BMP Options

- Reducing Energy Input. Any action that can reduce the amount of energy to be eliminated will reduce heat rejected to a cooling system. Ways to reduce the load on a water-based cooling system include:
    - Energy Conservation. Evaluate the processes in the plant for maximum energy efficiency and waste-heat recovery since a more efficient building will reject less heat to the cooling tower. Energy conservation reduces the amount of waste heat generated and thus the cooling load regardless of the type of cooling system used. Recovery of energy for water or space heating, operation of a desiccant drying operation as part of a desiccant cooling system, and preheating of material in an industrial operation are all examples of this strategy.
    - Use Non-Water Based Equipment/Processes. Replacing processes or equipment with systems that do not require water cooling is the most obvious and one of the best ways to eliminate water use and save energy.
- Choice of Heat Sink. Discharge waste heat to the air or ground instead of water, where feasible.

Water Cooled System

If air-cooled or ground-cooled systems are not used, and cooling with water is the only option, it is important to choose the correct system.

- Single-Pass Systems - elimination of this process. The only possible exceptions should be for medical emergencies. Where elimination is not feasible:
    - Connect to a chilled water or cooling tower loop or a standalone reticulating refrigeration system.
    - Cool with non-potable water where feasible.
- Evaporative Coolers - WaterSense recommendations are as follows:
    - Use up to 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 eight hours).
    - Blowdown shall be mediated by conductivity or basin water temperature-based controllers.
    - Once-through or single-pass cooling systems, systems with continuous blowdown/bleedoff, and systems with timer-only mediated blowdown management shall not be used.

- In addition to the WaterSense BMPs, for large evaporative cooler systems of more than 50,000 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.
    - Automatic water and power shutoff systems for freezing.
- Use alternate sources of water, where feasible. Air conditioning condensate is of specific interest since it is produced as part of the air conditioning process.

Operation, Maintenance, and User Education

Operational processes are the first consideration in the efficient operation of a tower.

- For towers larger than 500 tons, a continuous electrical record of operations should be available for downloading. If that record is not available, the operator should maintain a written shift log. A logbook also provides a written shift log. At a minimum, the shift log should contain:
    - Details of makeup 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, and appearance
    - A description of potential problems
- Above all, ensure that the employee responsible for the cooling tower operations is knowledgeable of what to look for when examining records and what to look for when visually examining the cooling tower.
- Operate towers at a minimum of five CCs using potable water, depending upon the chemistry of the makeup water used. In certain cases, where source water quality is high, CCs of as much as 15 may be achieved.
- Use municipal recycled water or an onsite source of suitable water quality for cooling towers.
- Perform a life cycle cost analysis, including all operating, capital, and maintenance costs, to determine the cost effectiveness of a cooling tower vs. air cooling.

Water Treatment Vendor Considerations

- Choose a water treatment vendor that will work with your facility.
- Select a water treatment vendor that focuses on water efficiency. Request an estimate of the quantities and costs of treatment chemicals, volumes of makeup 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 in the contract. Increasing cycles from three to six reduces cooling tower makeup 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 Options

Cooling Tower design and retrofit BMPs include proper instrumentation and tower design and operation.

- Install a conductivity controller that can continuously measure the conductivity of the cooling tower water and that 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 (µS/cm) necessary to achieve that number of cycles.
- Install flow meters on makeup and blowdown lines. Manually read meters can be used for smaller towers, but if the tower is 500 tons or more, meter readings should be automated and connected to an electronic data management system.
- Install automated chemical feed systems on large cooling tower systems of 100 tons or more to monitor conductivity, control blowdown, and add chemicals based on makeup water flow. These systems minimize water and chemical use while protecting against scale, corrosion, and biological growth.
- Install overflow alarms on cooling tower overflow lines, and connect the overflow alarm to the central location so that an operator can determine if overflows are occurring. This alarm can be as simple as a flashing light in the control area. More sophisticated systems may include a computer alert.
- Consider contacting the water service provider to determine if the facility can receive a sanitary sewer charge deduction from the potable water lost to evaporation. If the utility agrees to provide this deduction, calculate the difference between the city-supplied potable water makeup and the blowdown water that is discharged to the sanitary sewer.
- Use high-efficiency drift eliminators that reduce drift loss to less than 0.002 percent of circulating water volume for cross-flow towers and 0.001 percent for counter-flow towers.

Replacement Options

When looking to replace an existing unit, consider these options:

- Cooling towers can be replaced with direct expansion (DX) air conditioning, which is technologically similar to home air conditioning. For large facilities, multiple units can be used. Because there are multiple units, only the units needed to achieve comfort in the building would be operated so the units that are operating would be working at their optimal level and if one unit needs repair, the other units can continue to operate.
- Replace water heat sinks with ground source heat exchangers (geothermal heat exchange). For office, school, and similar commercial operations, these systems offer energy efficiencies similar to cooling towers in many cases, but they do not have the maintenance and liability

issues associated with cooling towers and no evaporative water use. These systems can be operated in reverse in the winter for heating, thus eliminating the need for a dual cooling tower and boiler system.

- Replace inefficient systems with refrigerant-cooled systems. These systems use a working fluid such as Freon in place of the chilled water loop. They can be air cooled, ground cooled or water cooled, and they offer larger capacity and more application in commercial settings. These systems can also be used with ground source heat exchange systems making their energy efficiency levels similar to that of cooling tower systems without the use of water.

7.3.3.2 Heating Systems: Boilers BMPs

This section describes BMPs for steam-producing boilers.

Operation, Maintenance, and User Education

To improve water efficiency of boiler and steam systems, consider the following:

- Choose a water treatment vendor
    - Select a water treatment vendor that that focuses on water efficiency.
    - Request an estimate of the quantities and costs of treatment chemicals and the volumes of makeup and blowdown water expected per year. Choose a vendor that can minimize water use, chemical use, and cost while maintaining appropriate water chemistry for efficient scale and corrosion control.
- Read water chemistry reports
    - Ensure the water treatment vendor produces a report every time he or she evaluates the water chemistry in the boiler. Upon receiving these reports, read them to ensure that monitoring characteristics such as conductivity and cycles of concentration are within the target range. Problems within the system can be identified quickly if proper attention is paid to the water chemistry reports.
- Maintain boilers, steam lines, and steam traps
    - Regularly check steam lines for leaks and make repairs promptly.
    - Regularly clean and inspect boiler water and fire tubes.
    - Develop and implement an annual boiler tune-up program.
    - Provide proper insulation on piping and the central storage tank to conserve heat.
    - Implement a steam trap inspection program for boiler systems with condensate recovery. When steam traps exceed condensate temperature, this program can indicate that the trap is leaking. Temperature can be monitored using an infrared temperature device. Repair leaking traps as soon as possible.
    - Minimize Blowdown
    - Calculate and understand the boiler's cycles of concentration. Check the ratio of conductivity of blowdown water and the makeup water. Use a handheld conductivity

meter if the boiler is not equipped with permanent meters. This ratio should match the target cycles of concentration.

- Work with the water treatment vendor to prevent scaling and corrosion and to optimize cycles of concentration.
- Improve makeup water quality
    - Consider pre-treating boiler makeup water to remove impurities, which can increase the cycles of concentration the boiler can achieve. Water softeners, reverse osmosis systems, or demineralization are potential pre-treatment technology options.
    - Boiler water must be treated before use for all but the very low pressure-type boilers. Table 7.39 summarizes recommended boiler water concentrations from the ABMA.

Retrofit and Replacement Options

BMPs for boilers comprise of two main components. The first is reducing water through energy and water use efficiency, including: minimization of system water losses, controlling cycles of concentration, and using condensate return. The second involves water efficiency with blowdown and sampler tempering water.

- Energy efficiency is the first BMP for consideration. Heat is used to provide energy. Any reduction in energy use will reduce water use.
    - For maximizing boiler water efficiency, energy and water conservation for equipment, appliances, and fixtures that use hot water is the first major component to reducing hot water use.
    - Install recirculating hot-water systems for large buildings.
- Minimizing System Losses. Fixing leaks and reducing other losses is the second most important factor. With the exception of hot water used for space heating and equipment heat transfer, most hot water is consumptively used and not returned to the boiler.
    - Where a recirculating loop is used for space or equipment heating, it is also important to meter the makeup line to determine if that line is leaking.
    - Install code-compliant steam-distribution lines and equipment with steam traps.
    - Ensure that discharge pipes are easy to inspect for flow. Provide visible indicators that will show whether the valve has activated, thereby reducing plumbing leaks due to repeated openings of water-temperature- and pressure-relief valves (TPRVs).
- Maximize Cycles of Concentration.
    - Install an automatic blowdown control system to minimize blowdown and maximize cycles of concentration.
    - Proper control of boiler blowdown water is also critical to ensure efficient boiler operation and minimize makeup water use. The optimum blowdown rate is influenced by several factors, including boiler type, operating pressure, water treatment, and quality of makeup water. Maximize Condensate Return

- From a water-efficiency standpoint, installing and maintaining a condensate recovery system to capture and return condensate to the boiler for reuse is the most effective way to reduce water use.

Metering, Measurement, and Control

Metering, measurement, and control are critical to good boiler operations and to minimizing water use. The following are BMPs recommended for boilers:

- Install an automatic blowdown control system, particularly on boilers greater than 200 horsepower, to control the amount and frequency of blowdown rather than relying on continuous blowdown. Control systems with a conductivity controller will initiate blowdown only when the TDS concentrations in the boiler have built up to a certain concentration.
- Install a flow meter on makeup water line to monitor the amount of makeup water added to the boiler.
  - To steam boilers and water boilers of more than 100,000 BTUs per hour.
  - To closed-loop hot-water systems for heating.
- Refer to A.7.3.2 Building Meters, Submeters, and Management Systems BMPs for recommendations on how to use the meter once it is installed.
- Install condensate return meters for all boilers of 200 horsepower or more in closed loop systems.
- Install automated chemical feed systems to monitor conductivity, control blowdown, and add chemicals based on makeup water flow. These systems minimize water and chemical use while protecting against scale and corrosion. Equip steam boilers of 200 boiler horsepower (hp) or greater with conductivity controllers to regulate top blowdown.
- Ensure that boiler-temperature and makeup meters are clearly visible to operators.

Tempering of Sampler and Blowdown Water

- To properly control blowdown, measure the conductivity of the water in the boiler with a conductivity probe, bearing in mind that the boiler water is very hot and can damage the probe. Use a sampler cooler to cool the water to a temperature that is suitable for the probe.
- Most samplers are simple single-pass cooling systems. This water should be captured and used as boiler feed water, which may require constructing a collection tank to hold the cooling water until the system needs to send makeup water to the deaerator tank.
- For smaller boilers, it is the author’s experience that large holding tanks that allow the blowdown to cool to below 140oF may be used instead of tempering water. For larger systems, heat recovery systems are commercially available that capture the heat and thus eliminate the single pass cooling entirely.

A.7.3.4 Cleaning Industrial Vessels, Pipes and Equipment BMPs

7.3.4.1 Clean In Place BMPs

Operation, Maintenance, and User Education

- Train employees in proper CIP operations
- Maintain CIP equipment according to manufacturer's specifications and/or a regular inspection and maintenance program
- Allow adequate drain time for product recovery in vessels and tanks (including transport trucks).
- Use only a small amount of water or solvent to quickly spray the vessel to encourage better drainage of product adhering to the vessel. If the amount is small enough, the product recovered can often be incorporated into the final product.
- In pipe systems, optimize turbulence, time, temperature, and chemical cleaning agents to minimize water and energy use.
- Test water regularly and discharge only when its useful life is over.

Design Options

Good design in the first step in water efficient CIP systems. Type of materials used and configuration of the system will make CIP operations more efficient. Consider the following design factors to make CIP systems more efficient:

- Ensure that piping systems do not have sharp curves, joints, bolts and protrusions, or any areas where materials being processed can accumulate. Butt and flange welding, ball valves, and long radius elbows are examples of good piping systems.
- Tanks and vessels should be easy to clean.
- Eliminate "low places" in systems where material can accumulate.
- Use only easy-to-clean materials.
- Provide good access to all areas of equipment so it can be inspected and hand cleaned where necessary.
- Install automated cleaning procedures to ensure constant operation.

Equipment Options

- Single and two-tank systems are not considered to be as water efficient as multiple-tank systems and are therefore not recommended as a BMP.
- Consider multi-tank systems, instead of single and two-tank systems, that carefully control water use, capture and reuse water, and treat and filter water to be recirculated within the cycle.
    - Membranes and other treatments may be used to maximize recirculation of water.
    - The reuse of filtered detergent water is common.

- Choose new or replacement equipment with modern control technology and real-time analytical equipment to help control temperature and determine optimal detergent and chemical concentrations, as well as the amount of waste products in rinse water.

Maximize Product Recovery

- In large vessels and tanks in the chemical industry and similar non-food industries, solvent used for washing can be recovered and product separated to increase water efficiency.
- Where the solvent is used to carry the product in large vessels and tanks, the tank purge solvent can be used for the next batch of product.
- In pipe systems, use efficient and effective pigging systems (launcher, sensor, and retrieve and return systems). Pigging both recovers marketable material and reduces the amount of water needed to flush the product out. Thick or semi-solid products, such as sour cream, are hard to rinse from pipes, so they can contaminate large volume of water.

Efficient Cleaning

While the overall process of efficient cleaning methods is similar for pipes, vessels, and tanks, there are some differences that need to be considered for tank and vessel systems compared to pipe systems.

Large Vessels and Tanks

- For vessels and tanks, the first step to efficient cleaning starts with good process control and, as mentioned above, good design. For process control, options to consider include optical devices to determine when rinse water is clear, level controls, and other methods ensure efficient operation.
- Maximize pressure in CIP systems for tanks and vessels that employ spray ball technology. These devices range from simple balls with holes in them to high-pressure devices with multiple high-pressure nozzles that actuate turning devices that spray in multiple directions. The more pressure and directed force the ball has, the more efficiently it can clean. Some systems use booster pumps to increase pressure. Selection of the type of system to use depends on many factors, and many models are available. These systems are also useful for cleaning beer and wine casks, barrels, and vessels.
- Automate CIP systems. CIP can include use of manual spray hoses, including water jetting, or high-pressure sprays for hand cleaning of vessels such as tanks. These methods tend to be labor intensive, they often require entry into confined spaces, and they may consume large amounts of water, energy, and chemicals.

Pipe Systems

- For pipe systems, cleaning and rinsing fluids are pumped through the pipes; turbulence, time, temperature, and chemical cleaning agents are the factors that determine the optimum time required to clean pipe systems.

Ozone

- In some systems, ozone can be used as a sanitizer. It is powerful and it does not leave a residue, so rinse cycles may be eliminated, thus saving water and reducing wastewater strength. Since hot water use can often be reduced, hot water energy use may be reduced, but energy is also needed to produce ozone. Ozone applications require a benefit to cost analysis to determine their economic applicability on a case-by-case basis.

A.7.3.4.2 Clean Out of Place BMPs

Operation, Maintenance, and User Education

- As with CIP, It is important to test the water regularly so it is not discharged until its useful life is over. It is also important to minimize the vat size.
- Employee training and awareness helps workers pay attention to small details.

Equipment BMP Options

- Automated systems with verification-of-cleaning software that are used in the pharmaceutical industry may be applicable in other industries as well.
- Analyzing the water in sanitizing baths is important so sanitizer strength can be maintained instead of dumping.
- Sanitizer water can also be reused as first flush rinse water or even as wash water for the parts to be cleaned or for floor and area washing.
- The use of whitewater or ozone for cleaning and sanitizing offers opportunities to reduce the amount of rinse water needed in cleaning operations. Since hot water use can often be reduced, hot water energy use may be reduced, but energy is also needed to produce ozone. Ozone applications require a benefit to cost analysis to determine their economic applicability on a case-by-case basis.

A.7.3.4.3 Bottle/Can/Container Cleaning BMPs

- Consider caustic water recovery, recirculation of final rinse water for caustic makeup, and reuse of water for the pre-rinse and label removal stages.
- For bottle washing systems, the water used for first flushing can often be recovered and reused.
- Membrane technology can also be used in some instances to recover water and chemicals used in the bottle washing process.
- Consider air blowing to clean new bottles to save water while ensuring that particles are removed before the bottles are filled.

A.7.3.4.4 Crate and Pallet Washers BMPs

- Water efficiency standards for crate and pallet washers have not been established. The company purchasing this equipment should compare equipment and consider using the most water efficient for to meet their needs.

- Crate washers and pallet washers should be designed to recirculate water within the individual wash phases and to capture and reuse final rinse water for wash water use.
- Consider using tunnel washers, which offer both water and energy saving potential. High-volume efficient models use five stages of cleaning. Water efficient machines also recirculate the hot detergent water through strainer and filter systems at high volumes. Some efficient models have a two-stage rinse process in which the final rinse is done with clean water that is then captured and used in a first rinse stage. Following the first rinse, that water may then be reused as makeup for the detergent wash.

A.7.3.4.5 Equipment and Floor Cleaning BMPs

Operation, Maintenance, and User Education

- Physical removal of waste product before washing saves water, chemicals, energy, and reduces pollution loading and pre-treatment costs. Floors should be dry cleaned with vacuum systems, brooms, or squeegees depending on the type of material being removed.
- For mixers, extrusion and molding equipment, conveyor belts, and other open equipment to which one can gain direct access, cleaning should start with physical removal of residual materials and then be followed by wet washing.

Design Options

- Good layout and design of such areas as floors, exteriors of tanks and pipes, conveyor systems, and flumes are keys to having facilities that are easy to clean.
- Four principles should be incorporated into the design and layout of floors and walls:
  - Proper sealing of floors and walls so that soil is easily removed and water does not penetrate.
  - Sloping floors to floor drains so water can be removed easily.
  - Minimizing floor joints and joints between floor and walls.
  - Designing easily cleanable, well-sealed troughs and grates.

Equipment Options

- Equipment design and layout are also critical for good cleaning. As with CIP and COP systems, crevices, sharp turns, and "nooks and crannies" where dirt and materials can accumulate should be avoided.
- Where water is used for cleaning, it is better to use a number of smaller volumes of water to clean than one very large volume. Four principles of wet cleaning are:
  - Use high-pressure, low-volume sprays.
  - Install shutoffs on all cleaning equipment.
  - Use detergents and sanitizing chemicals that are easily removed with minimum water.

- Install and locate drains and sumps so water and wastes enter quickly to prevent the need for extensive use of a hose as a broom to move the waste to the drain.

A.7.3.5 Commercial Landscape BMPs

General Options

- The use of municipal recycled water is also considered a BMP and is discussed in Section 9. Municipal recycled water used in the landscape needs to meet certain water quality standards that address human and plant health concerns.
- Many of the landscape BMP recommendations come from the Model Water Efficient Landscape Ordinance (MWELO) found in the California Code of Regulations, Title 23, Division 2, Chapter 2.7, which became effective in January 2010.
- Since the MWELO standards do not apply to existing landscapes or to rehabilitated landscapes of less than 2,500 square feet, the BMPs recommended in this report would also apply to similar existing categories of CII landscapes.

A.7.3.5.1 Onsite Water Sources BMPs

- Reusing onsite water can represent a significant water source available for landscape use. . However high TDS may require further treatment or blending with other water sources before they may be used on the landscape. Potential onsite CII water sources include:
  - Rainwater harvesting. Detailed information on rainwater harvesting may be found at www.arcsa.org. Use of catchment basins is referenced in MWELO, Section 492.15.
  - Retention basins. There are standards and codes that address the construction of retention basins to serve as a reservoir to collect rainwater and indoor water for multiple purposes. Information on storm water retention can be found at a website sponsored by the California Storm Water Quality Association at: https://www.casqa.org/store/products/tabid/154/p-171-fact-sheet-se-2.aspx.
  - Graywater. The use of graywater is allowed in the CII sector per Appendix G, Title 24, Part 5, of the California Administrative Code. Technically, since graywater is defined as "untreated wastewater" from bathroom sinks, showers and baths, and clothes washers, it is generally most practical for institutional use. Information on California graywater standards may be found at: www.water.ca.gov/wateruseefficiency/docs/Revised_Graywater_Standards.pdf
  - Cooling tower blowdown water. Keep in mind that cooling tower blowdown water may contain biocides as part of the treatment process, which could be harmful to plants if untreated.
  - Reverse osmosis (RO) reject water.
  - Others

A.7.3.5.2 Design Factors BMPs

- Consider the incorporation of permeable hardscapes into the landscape. Permeable hardscapes include the use of:
  - Decking
  - Gravel pathways or pervious pavers (used for driveways, walkways, patios, etc.)
- Refer to landscape design BMPs are in MWELO, Section 492.61.
- Landscape BMP elements not addressed in MWELO include the use of synthetic turf, alternative turf choices, and subsurface irrigation.
- Prior to beginning the design process, a physical site inspection will help designers understand and address such issues as underground utility lines, overhead structures, grading, solar orientation, wind direction, existing plant material, and others.
- Irrigation system design. Proper irrigation system design and understanding emerging water-efficient technology is critical to efficient water use and involves numerous components ranging from the use of weather-based controllers to drip irrigation.
  - System design information may be found in MWELO, Section 492.7.
  - Replace overhead irrigation systems with some type of low volume irrigation, where feasible.
- Subsurface irrigation is also recommended where practical. For ground cover and shrubs, consider a subsurface drip irrigation technique that involves placing the drip line on the surface and covering it with several inches of mulch. Placing filter fabric a few inches below the drip line will also help slow the percolation of water and help spread the water horizontally.
- A landscape should be designed to use low water-requiring plants best suited to the California climate.
  - Use of ornamental grasses, low-water use and deep rooted ground covers, and alternative turf types, such as warm season turfs and buffalo grass, may result in substantial water savings.
  - Warm season grasses are more typically found in southern California where the dormancy period, which results in a brown color, is much shorter than in northern California.
  - Removing turf where it is not needed and replacing it with drought-tolerant shrubs and trees, permeable walkways, and mulch can lead to substantial water savings in commercial landscapes. Consider removing turf from areas such as non-playable areas of golf courses and decorative turf in front of commercial buildings and other areas, where applicable. More information may be found at: http://usgatero.msu.edu/v05/n21.pdf. A list of plants and their water requirements may be found in a document titled "Water Using Classifications of Landscape Species" (WUCOLS), located at www.water.ca.gov/wateruseefficiency/docs/wucols00.pdf.

- Plants should be grouped based on similar water requirements and site characteristics (e.g., root depth, solar radiation, location, slope, etc.), called 'hydro-zones', to help with irrigation design and application. Refer to MWELO, Section 492.6.
- Microclimates need to be considered in the landscape and irrigation design process because a plant's water requirement can vary widely because of such influences as the amount of direct or indirect solar radiation (sun verses shade), wind, humidity, and temperature. Refer to MWELO, Section 492.6 for details.
- Appropriate grading should include a strategy to support plant health, reduce runoff, and retain more water on the site. Refer to MWELO, Section 492.8 for details.

A.7.3.5.3 Project Installation BMPs

Installation BMPs include:

- Communication between the designer, installers, and the end user.
- Installation per the approved specifications.
- Use of licensed contractors.
- Use of trained or certified workers.
- Installation of plants and irrigation system per BMPs.
- As-built documentation.
- Approved check-off list of installation, including controller maps, hydrozones, and station descriptions of plant type, irrigation method, and precipitation rate.

A.7.3.5.4 Operations and Maintenance BMPs

Because proper landscape maintenance is critical to capturing a site's potential water savings over time, consider the following for optimum landscape irrigation operation:

- Develop a work schedule that addresses the need for:
  - Use of trained or certified workers
  - Mulching
  - Irrigation system leak detection and repair
  - Review/fine tuning of the irrigation schedule
  - Winterization (if appropriate)
  - Inspection of the site's back flow prevention device and water pressure
- In addition to the regular review of a landscape's various components, sites should also develop a communication plan between site staff and management that includes an emergency action plan for water shutoff.
- Proper soil management can improve water use efficiency, plant health, and moisture retention. Information on soil management may be found in MWELO, Section 492.5.

- Keep proper records on design and as-built plans to detect irrigation system problems and assist in making repairs. Retain information on advances in irrigation technology that can lead to further water savings if incorporated into the landscape.
- Perform regular site monitoring and communication between site staff and management to ensure that the irrigation schedule is correct, the irrigation system is functioning properly, the necessary repairs are being made, and the site is meeting its water budget.

A.7.3.5.5 Water Use Identification BMPs

- A landscape water budget (maximum applied water allowance (MAWA) for a given site) should be defined between the site owner and manager, water service provider, and landscape maintenance staff.
  - Individuals responsible for irrigation programming, inspections, and audits to ensure experience and proficiency in water conservation techniques should be carefully selected.
  - The water budget formula may be found in Section B1 of the MWELO document. Other information on landscape budgets may be found in MWELO, Section 492.4 and at the sites referenced in A.7.3.5.2 Design Factors BMPs.
- Landscape water use needs to be metered or submetered to determine water use efficiency for site water management.
  - MWELO requires the installation of a dedicated water meter for new and rehabilitated landscapes 5,000 square feet or greater and recommends dedicated irrigation meters for landscapes less than 5,000 square feet.
  - In addition to MWELO, existing landscapes should also be submetered with meters read on a monthly basis.
- Irrigation audits represent an opportunity to review the system's water use efficiency and make the necessary repairs and adjustments. Information on irrigation audits may be found in MWELO, Section 492.12.
- Proper management of a site's irrigation schedule is a critical component of efficient landscape water use. Information on irrigation scheduling may be found in MWELO, Section 492.10 and at the sites referenced in A.7.3.5.2 Design Factors BMPs. Information on irrigation scheduling using weather data can be found at http://wwwcimis.water.gov/cimis/data.jsp.

A.7.3.6 General Building Sanitary and Safety Applications

A.7.3.6.1 Toilet Fixtures (Water Closets) BMPs

Operation, Maintenance, and Education

- Train users to report continuously flushing, leaking, or otherwise improperly operating toilets to the appropriate management or maintenance personnel.
- Educate and inform users with restroom signage and other means to discourage the flushing of inappropriate objects such as feminine products, wrappers, or other trash. Train custodial staff on how to handle the inappropriate disposal of such objects.

Tank-Type Toilets

For optimum tank-type toilet operation, consider the following:

- Periodically check to ensure the fill valve is working properly and the water level is set correctly.
    - o Check to see if water is flowing over the top of the overflow tube inside of the tank. Ensure that the refill water level is set approximately ¼-inch below the top of the overflow tube by adjusting the float to a lower position if the water level is too high.
    - o If the toilet continues to run (fill) after the float is adjusted, replace the fill valve.
    - o In order to prevent changes in tank water levels due to line water pressure fluctuations, only replace existing fill valves with pilot-type fill valves.
- Check annually to ensure the flapper is not worn, a condition that will allow water to seep from the tank into the bowl and down the sewer. To perform this check, drop a dye tablet or several drops of diluted food coloring in the tank. After 10 minutes, if the dye has leaked into the bowl, then check for a tangled chain in the tank or replace a worn flapper. If leaking does not subside after a flapper valve is replaced, consider replacing the flapper seat and overflow tube assembly, which could also be worn.

Flushometer Valve and Bowl Combinations

For optimum flushometer-valve-type toilet operation, consider the following:

- No less frequently than annually, inspect diaphragm or piston valves in flushometer-valve-type toilets, and replace any worn parts. To determine if the valve is in need of replacement, determine the time it takes to complete a flush cycle; a properly functioning flush valve should not have a flush cycle longer than four seconds.
    - o If replacing valve inserts, confirm that the replacements are consistent with the valve manufacturer's specifications, including the rated flush volume.
    - o If replacing the entire valve, ensure it has a rated flush volume consistent with manufacturer specifications for the existing bowl, including the rated flush volume.
- Periodically check to ensure the control stop (which regulates the flow of water from the inlet pipe to the flushometer valve and is necessary for shutting off the flow of water during

maintenance and replacement of the bowl or valve) is set to a fully open position during normal operation.

- Upon installation of a flushometer toilet, adjust the flush volume in accordance with manufacturer's instructions to ensure optimum operation for the facility's specific conditions.
- Periodically inspect the flush volume adjustment screw to ensure the flush volume setting has not been modified from the original settings; if it has, it could change the water use and performance of the product.
- Ensure that the line pressure serving the fixture meets the minimum requirements of the fixture manufacturer (minimums are commonly specified as 35 psi).
- If installed, check and adjust automatic sensors to ensure proper settings and operation to avoid double or phantom flushing.

Retrofit Options

Tank-Type Toilets

- Avoid retrofitting existing tank-type toilets with displacement dams or bags, early-closing toilet flappers, or valves with different flush volumes, as these devices could impede overall performance and could require increased operation and maintenance.
- Do not attempt to convert a single-flush 1.6 gpf toilet fixture to a dual-flush fixture with an after-market device. The installation and use of these devices and other retrofit products can seriously affect fixture performance and could void manufacturer warranties.

Flushometer Valve and Bowl Combinations

- It is best to avoid valve retrofit options, such as valve inserts, that reduce the flush volume of flushometer-valve-type toilets. These products might not provide the expected performance when the original bowl is not hydraulically designed to function on a reduced flush volume. In addition, the use of these devices could void valve manufacturer warranties.
- Dual-flush conversion devices are also available for flushometer toilets. These devices usually replace the existing flush valve handle with a handle that provides a reduced flush volume for liquids and a standard flush for solids. Before embarking on a full-scale retrofit, test the product on a select number of toilets to verify it achieves and maintains the desired performance. Select the type of dual flush valve (‘down’ position for full flush or ‘down’ position for reduced flush) that achieves the best benefit.
- If feasible, remove sensor systems and replace with manually activated flush valves, which are shown to significantly reduce water consumption at the toilet.

Replacement Options

Tank-Type Toilets

- Replace all toilets within the building to meet the California requirements as specified in CalGreen.

- Choose WaterSense-labeled models (www.epa.gov/watersense/products), which are independently certified to have an effective flush volume of 1.28 gpf or less, and pass a performance test to remove at least 350 grams or more of solid waste in a single flush.

Flushometer Valve and Bowl Combinations

- Replace all toilets within the building to meet the California requirements as specified in CalGreen.
- Choose models that are designed to use 1.28 gpf or less in accordance with the requirements of CalGreen.
- When considering 1.28 gpf or less flushometer toilets, carefully evaluate the physical conditions of existing drainlines and the availability of supplemental water flow upstream from the toilet fixtures to ensure that the conditions are appropriate for effective waste transport.
- For maximum water savings and performance, purchase the flushometer valve and bowl in hydraulically matched combinations that are compatible in terms of their designed flush volume. A listing of matched and tested combinations may be found at www.map-testing.com/about/maximumperformance/flushometer.html.

A.7.3.6.2 Urinal Fixture BMPs

Operation, Maintenance, and User Education

Flushing Urinals

For optimum flushing urinal performance, consider the following:

- Annually inspect the flushometer diaphragm or piston valves and replace any worn parts.
    - If replacing valve inserts, verify that the replacements are consistent with the valve manufacturer’s specifications, including the rated flush volume.
    - If replacing the entire valve, ensure it has a rated flush volume consistent with manufacturer specifications for the urinal fixture itself. That is, the urinal fixture should be designed to function at the lower flush volume of the high-efficiency valve.
- Annually check and adjust automatic sensors, if installed, to ensure they are operating properly in order to avoid double or phantom flushing.
- Train custodial and maintenance personnel on how to clean and maintain urinals with automatic flush sensors to ensure that the urinal is returned to its intended flush volume after maintenance operations are completed.
- Train users to report continuously flushing, leaking, or otherwise improperly operating urinals to the appropriate management or maintenance personnel.

Non-Water Urinals

- If non-water urinals are selected for the facility, regularly clean and replace the seal cartridges or other materials as specified by the manufacturer, and rigorously follow all other manufacturer-provided instructions.
- Consideration should also be given to the enzyme products currently available in the marketplace for non-water urinals; these tablets and pucks are specially formulated with the enzymes needed to forestall or prevent drainline buildup and, in some cases, the odors associated with non-water urinals.

Retrofit Options

- Avoid aftermarket parts for urinal retrofits that are designed to reduce the flush volume of valves unless those inserts are rated to provide a flush volume compatible with the existing urinal fixture.
  - Confirm compatibility with the urinal fixture manufacturer, as many new urinal fixture models are designed to function at several different flush volumes.
  - If the flush volume of the valve insert is not compatible with the urinal fixture, it may not provide the expected performance, potentially leading to double flushing.

Replacement Options

- If feasible, replace all urinals in the building to meet the California requirements as specified in CalGreen.
- Choose WaterSense-labeled models (www.epa.gov/watersense/products) when installing new flushing urinals or replacing older, inefficient flushing urinals. WaterSense-labeled flushing urinals have been independently tested and certified to function at no more than 0.5 gpf.
  - In addition, WaterSense-labeled flushing urinals must meet specific criteria for flush performance and drain trap functionality and they are designed to be non-adjustable above their rated flush volume. These features provide for the longevity of water savings.
  - The WaterSense specification is applicable to the: urinal fixtures; pressurized flushing devices that deliver water to urinal fixtures; and, flush tank (gravity-type) flushing devices that deliver water to urinal fixtures.
- To ensure high performance and water savings, choose a valve and fixture combination with matching rated flush volumes.
- Non-water urinals can also be considered during urinal installation or replacement.
  - It is critical that the condition and design of the existing plumbing system be evaluated and the expected usage patterns be assessed in order to ensure that these products will meet the expectations of the facility manager and users.

- As a good rule of practice, adhere to the guidelines outlined in the IAPMO Green Plumbing and Mechanical Code Supplement253, which requires at least one water supply fixture unit (i.e., a faucet or some other water using fixture) to be installed on the drainline upstream of the urinal fixture drain to facilitate drainline flow and rinsing.
- It is also important to carefully adhere to manufacturer-recommended cleaning and maintenance requirements to ensure products continue to perform as expected.
- Rapid build-up of struvite in the urinal drainline may lead to complete blockage of the drain. Preparation for such potential blockage issues must be accounted for making the decision to replace older water inefficient urinals with high-efficiency urinals (HEUs).

A.7.3.6.3 Shower Systems BMPs

Operation, Maintenance, and User Education

For optimum showerhead operation, consider the following:

- System pressure should be tested to ensure that it is within the operating parameters of the showerhead, usually between 20 and 80 psi, necessary to ensure that the showerhead will deliver the expected flow and performance.
- Verify that the hot and cold water plumbing lines to the showerhead are routed through a shower compensating valve that meets the temperature control performance requirements of the American Society of Sanitary Engineers (ASSE) 1016 or American Society of Mechanical Engineers (ASME) A112.18.1/Canadian Standards Association (CSA) B125.1 standards when tested at the flow rate of the showerhead installed.254 A plumber can verify the compatibility of the showerhead and shower valve and, if necessary, install a valve that meets the recommended standards for the flow rate of the showerhead.
- Periodically inspect showerheads for scale buildup to ensure flow is not being restricted; remove scale as needed.
- Train users to report leaking or malfunctioning showerheads to the appropriate maintenance or management personnel.

Retrofit and Replacement Options

- Replacement is often more economical and practical than a retrofit.
- Avoid retrofitting existing inefficient showerheads with flow control inserts (which restrict water flow) or flow control valves (which can be activated to temporarily shut off water flow) to reduce the flow rate and save water. These devices may not provide adequate performance or physical safety in some facilities and can lead to user dissatisfaction.

[253] International Association of Plumbing and Mechanical Officials, 2010. *Green Plumbing & Mechanical Code Supplement.* Page 9, February.

[254] For example, a 1.5 gpm showerhead must be accompanied by a compensating valve rated and certified to the standard at 1.5 gpm in order to safely protect the bather.

- Multiple showerhead systems can be retrofitted to operate showerheads individually rather than simultaneously, or so that total consumption is equal to or less than 2.5 gpm at any given time.
- When replacing old showerheads with new ones, choose WaterSense-labeled models (www.epa.gov/watersense/products), which are independently certified to meet or exceed minimum performance requirements for spray coverage and intensity (force) at three different building line pressures: 80, 45, and 20 psi (the upper, mid, and lower range of potential household pressures.
- While remodeling, avoid purchasing and installing multiple showerheads systems unless the heads can be operated separately or the total volume of water flowing from all showerheads is never greater than the 2.0 gpm maximum prescribed by CalGreen.

A.7.3.6.4 Faucets BMPs

Operation, Maintenance, and User Education

For optimum faucet operation, consider the following:

- Test the system water pressure to ensure that it is between 20 and 80 psi, necessary for the faucet to deliver the expected flow and performance.
- Periodically inspect faucet aerators for scale and sediment buildup to ensure flow is not being restricted. Inspection should occur every 6 to 12 months, depending upon local water quality. Clean or replace the aerator or other spout end device, if necessary.
- If installed, check and adjust automatic sensors to ensure that they are operating properly to avoid faucets from running longer or more frequently than necessary.
- Post materials in restrooms and kitchens to educate users of the facility’s water-efficiency goals. Remind users to turn off the tap when they complete their use.
- Train users to report continuously running, leaking, or otherwise malfunctioning faucets to the appropriate maintenance or management personnel.
- Do not use running water to thaw food products, and discourage this practice in food service operations.

Retrofit Options

To retrofit an existing faucet to increase water efficiency, consider the following:

- For lavatory faucet retrofits in public restrooms, install faucet aerators or laminar flow devices that function at no more than 0.4 gpm, the CalGreen maximum.
- For lavatory faucet retrofit in private restrooms, look for WaterSense labeled faucet accessories (aerators or laminar flow devices) (http://www.epa.gov/watersense/products), which have flow rates of 1.5 gpm or less at 60 psi and no less than 0.8 gpm at 20 psi, and are compliant with CalGreen.
- For kitchen faucet retrofits, install aerators or laminar flow devices that achieve a flow rate of no greater than 1.8 gpm in accordance with CalGreen.

- Install temporary shut-off or foot-operated valves for kitchen faucets and faucets in food service operations. These valves close during intermittent activities such as scrubbing or dishwashing.
- For all faucet retrofits in medical facilities (including medical research and patient care facilities), install laminar flow devices instead of faucet aerators. Since laminar flow faucets do not inject air into the water, there is a lower risk of bacterial contamination.
- For service sinks and specialized applications, install retrofit devices that reduce the water flow, but without inhibiting the function of the sink (i.e., if the sink's function is volume dependent, do not reduce faucet flow rate to the point that it has to be used significantly longer).

Replacement Option

- For lavatory faucet replacement in private restrooms, look for WaterSense labeled lavatory faucets and faucet accessories (aerators or laminar flow devices) (http://www.epa.gov/watersense/products), which have flow rates of 1.5 gpm or less at 60 psi, and no less than 0.8 gpm at 20 psi and are compliant with CalGreen.

A.3.7 Pools, Fountains and Spas BMPs

A.7.3.7.1 Evaporative Loss Reduction BMPs

Evaporation is the most significant component of water use and also drives the use of water for TDS control. To reduce water losses from evaporation, consider the following:

- Shade the pool and reduce wind movement across the pool with fences and walls, non-shedding hedges, or other barriers.
- Limit sprays, waterfalls, and other features that increase contact area to atmosphere to just those needed for aesthetic value or for aeration of the pool water.
- Use chemicals or pool covers to retard evaporation. In California, Title 24 requires that heated pools be covered when not in use.
    - Traditional pool covers also reduce the amount of debris falling into the pool, thus reducing backwash frequency, reduce chemical use, and they save water by extending the time between pool drain-and-fill events by reducing evaporation.
    - Liquid evaporation barriers are water-safe chemicals that form a thin layer at the water surface. They are non-toxic and do not interfere with pool operations. They offer both heat and evaporation loss, but they work best where there is little movement of the water surface.

A.7.3.7.2 Leak Reduction BMPs

All pools, hot tubs, fountains and water features are subject to leaks. Consider the following to reduce leak losses:

- Meter and inspect for leaks:

   - In commercial and public pools and for larger water fountains containing 10,000 gallons of more, a makeup meter is essential to efficient operation and is strongly recommended for in-ground residential pools. Installing a meter on the pool makeup line is the most effective way of monitoring pool or fountain water use as well as for checking for leaks.
   - If a pool is losing more than two inches of water per week, it may have a leak. For high evaporation areas, this threshold may be increased to three inches per week.
   - Air bubbles in either the pump strainer basket or the water in the return line where the water enters the pool (even after three or four minutes of the pump running) may indicate that a leak exists in the suction side of the piping.
   - The most obvious indicator of a pool leak is when wet spots appear around the pool, filter, or piping.
- Repair leaks as soon as detected. The most common locations for leaks are where the pool and pipes are joined, at separations along the pool top and the bond beam, in the piping either on the suction or return lines to the filtration system, and in the pool liner. Another leak area is found around the pump seals such as "O" rings.

A.7.3.7.3 Splash-Out and Drag-Out Reduction BMPs

- The design of the edge of the pool and the "freeboard" or level of the pool water below both the edge and the top of the pool overflow help reduce water loss. In addition to reducing the amount of water splashed-out, this practice also allows for the rainfall retention. Some pool officials recommend retaining at least four inches of freeboard
- Most commercial pools and many residential pools can incorporate gutter and grate systems around the edge of the pool to catch splashes. Troughs can be built into the wall of the pool and drain back into the pool or can be used as skimmer-type devices.
- Another helpful design feature is beveling the edge of the pool so it slightly overhangs the pool. Doing so helps redirect splashes into the pool. It is important to remember, however, that the area slightly back from the pool edge must be graded to prevent dirty rainwater from flowing into the pool.

A.7.3.7.4 Disinfection and Water Quality Control BMPs

- Maintain proper pH, alkalinity, and hardness levels. This saves water by:
   - Reduce corrosion and prevent damage to pool surfaces, which extends equipment and pool life and reduces the potential for leak and corrosion losses.
   - Delays the exchange of pool water needed, reducing the number of times a pool must be drained and refilled.
   - Reduces the number of filtration system backwashes needed
- Reverse Osmosis and Nanofiltration (RO and NF) may also be possible to reduce dissolved minerals buildup and reduce water lost through the necessary dumping of pool water.

A.7.3.7.5 Filtration BMPs

The choice of the type of filtration equipment is the second most significant way to reduce water use, but it is the most readily achievable. To reduce pool water losses from filtration operations, consider the following:

- Manage pool water quality, which reduces the need for filter backwashing and, therefore, saves water.
- Backwash only when necessary; when diminished performance indicated filters should be backwashed.
- Backwash with the minimum water necessary to restore function.
- Use a pool vacuum cleaner that does not rely on the pool filter systems to capture debris.
- Where feasible, choose a filtration system with a filter media that minimizes backwash requirements (for both total volume required as well as frequency of backwashing).
- For pre-coat filter systems, choose an air 'bumping' system, where feasible, to further reduce water use.
- Refer to Table 7.51 in Section 7.3.8 for a summary of selection factors to consider for new or replacement pool systems.

A.7.3.8 Water Treatment BMPs

A.7.3.8.1 Sediment Filtration and Removal Processes (Non-Membrane) BMPs

To optimize non-membrane sediment filtration and removal water efficiency, consider the following:

- Only use filters where needed.
- Choose sediment filters that require the least number of backwashes.
- Examine ways to reuse backwash water or purge water.
- When filters are used, install pressure gauges and use the gauges to determine when to backwash.
- Backwash based on pressure drop instead of by a timer or a schedule.
- Cartridge filters should be the only type of filter used in most applications since they only need to be washed off with a hose and returned to the filter housing.

A.7.3.8.2 Physical Sediment and Precipitate Removal BMPs

Coagulation - sedimentation and filter presses and filter belts are physical sediment and precipitate removal processes that are important BMPs themselves and when used in conjunction with onsite water recovery and reuse.

- Coagulation - sedimentation is used where large volumes of water need to be treated. This process involves the addition of a chemical that causes particles to "clump" together (coagulate) to form heavy “flocs” which then settle out (precipitate). A full technical discussion is beyond the scope of this document, but this type of treatment is often used to treat raw surface water or even wastewater streams that can be reused within the facility. Filtration often follows coagulation - sedimentation.

- Precipitate removal is often found in plating operations and other industrial/commercial operations where metal salts are used. Leaf or belt presses are often employed to remove the precipitate. Technical details are beyond the scope of this document, but these water treatment processes are important to internal water reuse operations.

A.7.3.8.3 Softening BMPs

To optimize water efficiency, consider the following:

- Do not recharge based on timers.
- Consider demand based softener regeneration. The best systems actually measure the hardness and only backwash when a preset percent of the resin bed is exhausted.
- Use water meters that actuate recharge with a predetermine amount of water based on the water chemistry of the source water.

A.7.3.8.4 Cation and Anion Exchange BMPs

To optimize water efficiency for ion exchange processes:

- Use cation and anion exchange only when needed for the required water quality.
- The resin bed should be instrumented to ensure that recharge is done only when a preset percent of the bed's resin has been exhausted.

A.7.3.8.5 Distillation BMPs

To optimize water efficiency for distillation processes, consider the following:

- Eliminate once-through cooling.
- Maximize product water recovery as a percent of total water input to 75 percent or better.
- Install automatic water and gas or electric cutoffs when the receiving reservoir is full.

A.7.3.8.6 Carbon Adsorption BMPs

None identified.

A.7.3.8.7 Membrane Processes BMPs

Micro and Ultrafiltration

For optimum micro and ultrafiltration membrane water use efficiency:

- Use pressure drop across the membrane to determine when to backwash so that backwashing is done only when necessary.
- Follow manufacturer's recommendation on membrane cleaning to minimize the number of cleanings needed.

- Pre filter water to remove larger sediment to minimize backwash and cleaning and follow the BMPs for filtration for the pre filters.
- Consider use of metal-oxide filtration technologies, where feasible.

Nanofiltration and Reverse Osmosis

For optimum NF and RO operation water efficiency:

- Choose systems with the maximum permeate recovery rates.
- Clean according to recommendations from the manufacturer.
- Investigate ways of reusing the retentate.
- Ensure good pretreatment to minimize cleaning of the membranes.

A.7.3.8.8 Other Treatment Methods BMPs

None identified.

Appendix B: Glossary

Activated Carbon: An activated carbon filter is used for the removal of dissolved organics, color and odor- causing compounds. Generally high-molecular-weight, non-polar compounds are adsorbed more effectively than low-molecular-weight, polar compounds.

Aggregate-level metric: A metric that does not apply to a specific set of conditions, such as system-wide or sector-wide measures.

Alternative turf: See synthetic turf.

Alternative water source: Any non-potable water source used for irrigation purposes.

Artificial turf: See synthetic turf.

As-built documentation: Set of reproducible drawings that show significant changes in the work made during construction and that are usually based on drawings marked up in the field and other data furnished by the contractor (MWELO, Section 491).

Back flow prevention device: A safety device used to prevent pollution or contamination of the water supply due to the reverse flow of water from the irrigation system (MWELO, Section 491).

Benchmark: (1) A particular (numerical) value of a metric that denotes a specific level of performance; (2) A current value or beginning value of a metric.

Best management practice (BMP): Best management practices**;** recommended methods or practices designed to increase irrigation efficiency and uniformity thereby reducing water consumption and runoff, protecting water quality.

Chemical of emerging concern: Constituents that may occur in wastewater and may be resistant to some treatment processes. These constituents include: personal care products, pharmaceuticals including antibiotics and antimicrobials; industrial, agricultural, and household chemicals; natural hormones; food additives (e.g., phytoestrogens, caffeine, sweeteners); transformation products, inorganic constituents (e.g., boron, chlorate, gadolinium); and nanomaterials. Research is ongoing in the scientific community to assess the impacts of chemicals of emerging concern on flora and fauna exposed to wastewater. The term is often used interchangeably with 'constituents of emerging concern' or 'compounds of emerging concern'. It is also frequently abbreviated CECs.

Commercial water user: A water user that provides or distributes a product or service. (CWC §10608.12(d)). Examples of commercial users include customers who provide or distribute a product or service, such as hotels, restaurants, office buildings, commercial businesses, or other places of commerce.

Confounding-factors: Factors affecting the numeric value of a metric that are not related to the purpose of a metric.

Definitional noise: The inaccuracies in both the numerator and denominator of a metric as a result of different, specific or general, definitions used for collecting data.

De-ionization: Ion exchange onto synthetic resins or activated alumina is considered for the removal of mineral ions or hardness in the water. Deionized water is used in the spot-free rinse by some professional car wash operators.

Direct potable reuse: The planned introduction of highly treated recycled water either directly into a potable water supply distribution system downstream of any water treatment plant or into a raw water supply immediately upstream of a water treatment plant. (Paraphrase of Water Code §13561(b)).

Direct reuse: The use of recycled water that has been transported from a wastewater treatment plant to a reuse site without passing through a natural body of either surface water or ground water.

Economic efficiency: An efficiency measure that incorporates the concept of value, such as including a monetary or resource factor.

Efficiency: The ratio of output to input or vice versa. Water use metrics and benchmarks are inextricably linked to the concepts of "water conservation" and "water-use efficiency." Therefore, it is also helpful to define these concepts in the context of evaluating water use. The term "efficiency" derives from engineering practice where it is typically used to describe technical efficiency, or the ratio of output to input.

Enterprise: A legal entity operating as a business, government, or other organization which may have one or more places of operation or activity.

Establishment: A specific water use site (e.g., land parcel or building) at which there may be one or more end-uses of water.

Evapotranspiration: A combination of water transpired from vegetation and evaporated from the soil and plant surfaces (ASABE, 1998).

Existing landscape: For the purposes of this BMP, an established landscape associated with a CII site.

Filtration: The process by which suspended solids are removed from the water in order to better utilize the water in a greater number of processes. Granular media filters such as sand, glass and olivine are all in use. Bag or sack filters, made of woven material such as cloth or paper, are also in use.

Flocculation: The process by which anionic and cationic materials in the reclaim water are removed through use of polymers and/or metal salts. The chemical interactions result in the coagulation and sedimentation of suspended solids smaller than five microns. Flocculation can be used to effectively remove turbidity, color and total suspended solids. It is dependent on the proper selection of flocculent, precise control of the dosage and proper design of the hardware.

Full-spectrum: A water use classification term denoting the complete range of water uses and users, such that a classification system will have utility across different water planning or management functions at various levels of government and water service providers.

Graywater: Untreated wastewater that has not been contaminated by any toilet discharge, has not been affected by infectious, contaminated, or unhealthy bodily wastes, and does not present a threat from contamination by unhealthful processing, manufacturing, or operating wastes. Graywater includes wastewater from bathtubs, showers, bathroom washbasins, clothes washing machines, and laundry tubs, but does not include wastewater from kitchen sinks or dishwashers. (Water Code §14876)

Groundwater recharge: The infiltration or injection of water into a groundwater aquifer.

Hardscape: Any durable material pervious and non-pervious (MWELO, Section 491).

Hydro-zones: Portion of the landscaped area having plants with similar water needs. A hydro-zone may be irrigated or non-irrigated (MWELO, Section 491).

Incidental water use: Water that is used by industry for purposes not related to producing a product or product content or research and development. This includes incidental cooling, air conditioning, heating, landscape irrigation, sanitation, bathrooms, cleaning, food preparation, kitchens, or other water uses not related to the manufacturing of a product or research and development (23 CCR §596.1a(6).

Indirect potable reuse: The planned incorporation of recycled water into a raw water supply such as in potable water storage reservoirs or a groundwater aquifer resulting in mixing and assimilation, thus providing an environmental buffer. (Metcalf & Eddy/AECOM textbook, consistent with definition of "indirect potable reuse for groundwater recharge" in Water Code §13561(c)). Note that as "surface water augmentation" has been defined in the Water Code, it has been distinguished from direct potable reuse and would be a form of indirect potable reuse.

Indirect reuse: The use of recycled water indirectly after it has passed through a natural body of water after discharge from a wastewater treatment plant.

Industrial water user: (1) A water user that is primarily a manufacturer or processor of materials as defined by the North American Industry Classification System (NAICS) code sectors 31 to 33, inclusive, or an entity that is a water user primarily engaged in research and development (CWC §10608.12(h)). (2) A water user that is primarily manufacturer or processor of materials. Examples of industrial customers are those who primarily manufacture or process materials as defined by NAICS.

In-line irrigation: See subsurface irrigation.

Institutional water user: A water user dedicated to public service. This type of user includes, among other users, higher education institutions, schools, courts, churches, hospitals, government facilities, and non-profit research institutions. (CWC§10608.12 (i)). Examples of institutional customers include schools, courts, churches, hospitals, and government institutions regardless of ownership

Irrigation scheduling: Determining when to irrigate and how much water to apply based on measurements or estimates of soil moisture or crop water used by a plant (NRCS, 1997).

Irrigation system design: Drawings and associated documents detailing irrigation system layout, and component installation and maintenance requirements (IA, 2010).

Landscape budget: A volume of water allocated to the entire landscape area for some period of time. This allowance is established by the water service provider for the purpose of ensuring adequate supply of water resources (IA, 2010).

Maximum Applied Water Allowance (MAWA): The upper limit of annual applied water for the established landscaped area as specified in MWELO Section 492.4 (MWELO, Section 491).

Metadata: The attributes or conditions associated with data that provide understanding of the data, such as how the data were collected, the purpose and defined conditions of the data, when and by whom the data were collected, or methods of calculation; often referred to as "data about data".

Metric: A unit of measure (or a parameter being measured) that can be used to assess the rate of water use during a given period of time and at a given level of data aggregation (e.g., system-wide, sector-wide, customer level, or end-use level). Another term for a *metric* is *performance indicator*.

Metric value: A numerical value either (1) calculated from the mathematical formula for any given metric or (2) assigned to a given metric. A metric is not a benchmark or target.

Microclimate: Climate of a small, specific area that may contrast with the climate of the overall landscape area due to factors such as wind, sun exposure, plant density, or proximity to reflective surfaces (MWELO, 491).

Mulch: Any organic material, such as leaves, bark, straw, and compost, or inorganic mineral material, such as rocks, gravel, and decomposed granite left loose and applied to the soil surface for the beneficial purposes of reducing evaporation, suppressing weeds, moderating soil temperature, and preventing soil erosion (MWELO, 491).

Model Water Efficient Landscape Ordinance (MWELO): Model ordinance prepared by the Department of Water Resources as guidance for local agencies in developing landscaping ordinances that promote water conservation, prevent water waste, and protect water quality. Local agencies were required to adopt either the MWELO or an alternative landscape ordinance no later than January 31, 2010 (California Government Code 65597).

North American Industry Classification System (NAICS): NAICS is the standard used by Federal statistical agencies in classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. business economy. NAICS is based on a production-oriented concept, meaning that it groups establishments into industries according to similarity in the processes used to produce goods or services.

New construction landscape: For the purposes of this BMP, a new building with a landscape or other new landscape associated with a CII site.

New landscape: See new construction landscape.

Ozonation: The process of treating reclaim water with ozone to remove odor producing hydrocarbons. Ozone is a powerful oxidizing agent and effective as a disinfectant. In water ozone is a powerful bleaching agent, acting more rapidly than chlorine, hydrogen peroxide or sulphur dioxide. Ozone has an additional advantage over chlorine since it does not leave undesirable odors nor produce trihalomethanes - both potential by-products of chlorine use. One common means of producing ozone for injection in reclaim water is corona discharge. Another method is to produce ozone using ultraviolet light.

Oxidation: Oxidation in simple chemical terms is the loss of electrons. The purpose of oxidation in water treatment is to convert undesirable chemicals to a form that is neither harmful, nor as objectionable as the original form. In the professional car wash reclaim system, oxidation is used to treat for odor, color or organisms such as bacteria and algae. Common oxidants include chlorine, ozone, and oxygen or air.

Performance indicator: The same meaning as “metric value”.

Permeable: Any surface or material that allows the passage of water through the material and into the underlying soil (MWELO, 491).

Planned reuse: The deliberate direct or indirect use of recycled water without relinquishing control over the water during its delivery.

Process water: (1) a water used for producing a product or product content or water used for research and development, including, but not limited to, continuous manufacturing processes, water used for testing and maintaining equipment used in producing a product or product content, and water used in combined heat and power facilities used in producing a product or product content. Process water does not mean incidental water uses not related to the production of a product or product content, including, but not limited to, water used for restrooms, landscaping, air conditioning, heating, kitchens, and laundry. (CWC§10608.12 (l)) (2) a water used by industrial water users for producing a product or product content, or water used for research and development. Process water includes, but is not limited to; the continuous manufacturing processes, water used for testing, cleaning and maintaining equipment. Water used to cool machinery or buildings used in the manufacturing process or necessary to maintain product quality or chemical characteristics for product manufacturing or control rooms, data centers, laboratories, clean rooms and other industrial facility units that are integral to the manufacturing or research and development process shall be considered process water. Water used in the manufacturing process that is necessary for complying with local, State, and federal health and safety laws, and is not incidental water, shall be considered process water. Process water does not include incidental, commercial or institutional water uses (23 CCR 596.1a(11).

Productivity: A measure of the efficiency of production. The ratio of production output to what is required to produce it (inputs), total output per one unit of a total input.

Rainwater harvesting: Rainwater collection and distribution systems used as an alternative water source for irrigation (AWE, 2010).

Reclaimed water: Same meaning as "recycled water." (Water Code §26)

Recycled water: Water [that], as a result of treatment of waste, is suitable for a direct beneficial use or a controlled use that would not otherwise occur and is therefore considered a valuable resource. (Water Code §13050(n))

Rehabilitated landscape: Any re-landscaping project that requires a permit, plan check, or design review, meets the requirements of MWELO Section 490.1, and the modified landscape area is equal to or greater than 2,500 square feet, is 50 percent of the total landscape area, and the modifications are completed within one year (MWELO, Section 491).

Reverse Osmosis: Osmosis is defined in terms of water in an ideal state as the transport from a reservoir of pure water through a semipermeable membrane to a reservoir of water containing dissolved solutes. Reverse osmosis (RO) occurs when pressure is increased on the side of the membrane containing the solutes above the osmotic pressure of the solution. In this case water flows from the osmotic side of the membrane to the pure water side.

Scaling variable: Variable that can be used to standardize or characterize per unit rates of water use. Also called "scaling factor."

Separation: The first stage in a reclaim operation. Separation uses a settling tank, usually divided into at least three compartments, to allow grit to settle and to separate grease and oils from the water prior to reclaim in the professional car wash or discharge to the sanitary sewer. The tank will typically be located in-ground with the sections designed for gravity sedimentation, grease and oil separation, and with the third section of the tank for final clarification and discharge to reuse in the professional car wash or to the sanitary sewer system. At this point usually particles of up a range of 50 to 100 microns in size are removed, depending upon the size of the settling tank, and resultant residence time of the water. A cyclonic separator may also be used to increase the total amount of suspended solids removed from the water.

Standard Industrial Classification (SIC): A classification system for commercial, industrial, and institutional activities that classifies establishments by their primary type of activity and organizes industries in an increasing level of detail ranging from general economic sectors (e.g., manufacturing, services) to specific industry segments (e.g., commercial sports, laundry businesses). This system organizes industries by their output. SIC was replaced NAICS in 1997.

Soil management: Utilizing a soil analysis report that includes soil properties such as soil type and infiltration rate when designing and scheduling irrigation systems.

Subsurface irrigation: Application of water below the soil surface through emitters, with discharge rates generally in the same range as drip irrigation. The method of water application is different from and not to be confused with sub-irrigation where the root zone is irrigated by water table control (ASABE, 1998).

Surface water augmentation: The planned placement of recycled water into a surface water reservoir used as a source of domestic drinking water supply (Water Code §13561(d)) or into any surface water when discharged for the purpose of aquatic habitat enhancement.

Synthetic turf: A product manufactured to look like natural turfgrass; a permeable ground cover made from synthetic fibers.

Target: A benchmark that indicates a state of achievement expected at some time in the future.

Tempering: The transfer the heat properly and easily from steam to a working medium, such as, water or oil heat carrier

Turf: A ground cover surface of mowed grass (MWELO, Section 491).

Ultrafiltration: The process of using a membrane to filter out dissolved solids as well as the finest of suspended solids. Unlike reverse osmosis, ultrafiltration is not dependent on overcoming osmotic pressure differential, and can be accomplished at low pressure differences of 5 - 100 psi. The primary mechanism is selective sieving through pores.

Unplanned reuse: Unplanned reuse of treated wastewater effluent after disposal. Also called "incidental reuse."

Warm season turf: Grasses that grow vigorously in warm summer months and then generally enter some state of dormancy in winter, thereby having a lower water need compared to cool season turf. Examples of warm season grasses include Bermuda, Zoysia and Buffalo grasses.

Water audit: Also known as an irrigation survey, a water audit is an in-depth evaluation of the performance of an irrigation system that includes, but is not limited to: inspection, system tune-up, system test with distribution uniformity or emission uniformity, reporting overspray or runoff that causes overland flow, and preparation of an irrigation schedule (MWELO, Section 491).

Water budget: Volume of irrigation water required to maintain a functional, healthy landscape with the minimum amount of water. A water budget is established through a method of water-efficiency standards for landscapes by providing the water necessary to meet the ET of the landscaped area.

Water-centric: A water use classification term meaning being designed around and central to water uses and users, in contrast to characterizing economic activity, water billing functions, or other factors.

Water conservation: A reduction in water use, water loss, or waste.

Water-efficient landscape: A landscape that minimizes water requirements and consumption through proper design, installation, and management (AWE, 2010).

Water reclamation: (1) Same meaning as definition 1 for "water recycling." (2) The treatment of water of impaired quality, including brackish water and seawater, to produce a water of suitable quality for the intended use.

Water recycling: (1) The process of treating wastewater for beneficial use, storing and distributing recycled water, and the actual use of recycled water. (2) The reuse of water through the same series of processes, pipes, or vessels more than once by one user, wherein the effluent from one use is captured and redirected back into the same use or directed to another use within the same facility of the user.

Water reuse: (1) The use of treated wastewater for a beneficial purpose, such as agricultural irrigation and industrial cooling. (2) The additional use of previously used water.

Water use efficiency: The relation of water-related tasks accomplished with an amount of water.

Water use productivity: The relation of specific or general product, outputs, or economic activity to amount of water associated with those products, outputs, or activities.

Winterization: The process of removing water from the irrigation system before the onset of freezing temperatures (IA, 2010).

Appendix C: Case Studies

Appendix C contains case studies (Table C.1) describing commercial, industrial, and institutional (CII) water savings efforts currently being implemented in California. Table C.1 also identifies major water saving best management practices (BMP) applied in each case study (some case studies include additional directed BMPs). These case studies are provided as examples only. In most cases, there are other similar case studies, but those included had readily available data and/or cost benefit information, and provide geographic or industry-type diversity.

Table C.1 - CII Task Force Report Case Studies

Sector	Case Study Name	Subsector	County	Page	BMP							
					Alternate Water Supply	Cooling Tower Modification	Demand Management	Dual Plumbing	Flow System Modification	Landscape Modification	Municipal Recycled Water	Process Modification
COMMERCIAL	Eagle Foods	Food Service	Los Angeles	540					✓			✓
	Restaurant Retrofit	Food Service	Orange	542			✓					
	City of Sunnyvale	Golf Course	Santa Clara	544							✓	
	Woodland Hills Country Club	Golf Course	Los Angeles	545						✓		
	Serrano Residential Development	Golf Course/ Residential	El Dorado	546							✓	
	Applied Materials	High Tech	Santa Clara	548		✓			✓	✓	✓	✓
	Car Washes	Hospitality & Service	Marin	550							✓	
	Parc55 Toilet Retrofit	Hospitality & Service	San Francisco	551			✓					
	Large Southern California Landscapes	Landscaping	Various	552					✓			
	Xeriscape Conversion Study	Landscaping	Various	553						✓		
	Dual Plumbed Office Buildings	Office Building	Orange	554				✓			✓	
INDUSTRIAL	Aerojet	Manufacturing	Sacramento	555	✓							
	Air Products	Manufacturing	Santa Clara	557							✓	✓
	BP Carson Refinery	Manufacturing	Los Angeles	559		✓					✓	✓
	Amylin Pharmaceuticals	Pharmacology	San Diego	561		✓					✓	✓
	Genentech	Pharmacology	San Diego	563		✓			✓	✓	✓	
	Sutter Energy Center	Power Plant	Sutter	565		✓	✓					
INSTITUTIONAL	California Hospital Medical Center	Medical	Los Angeles	566						✓		
	City of Riverside Potable Reuse Project	Muni Utilities & Facilities	Riverside	567								
	Contra Costa County Animal Shelter	Muni Utilities & Facilities	Contra Costa	568				✓			✓	✓
	Livermore Fire Fighting	Muni Utilities & Facilities	Alameda	570							✓	
	San Diego County Water Authority	Parks	San Diego	571						✓		
	Los Angeles County Department of Parks and Recreation	Parks	Los Angeles	572					✓			
	Crean Lutheran High School	Schools	Orange	573				✓			✓	
	San Jose State University	Schools	Santa Clara	574		✓					✓	✓
	UC Merced	Schools	Merced	575			✓					
	Brentwood School	Schools	Los Angeles	577						✓		

Commercial: Food Service
Eagle Foods

City: Sun Valley
County: Los Angeles
Supplier: Los Angeles Department of Water and Power
SIC Code: 7542

Project Goal
To reduce or eliminate second tier water charges and reduce sewer charges.

Key Project Benefits
Replacing hose bib connectors and installing flow control valves:
- Reduced water use
- Reduced sewer charges

Project Description
Eagle Foods is a commissary and service center for catering truck operators. Catering truck operators can purchase food and supplies, clean trucks, fill water tanks, and house the catering trucks at the facility. In 2009, as drought conditions worsened and the Los Angeles Department of Water and Power (LADWP) implemented shortage year water rates, Eagle Foods management began looking for ways to save water. LADWP representatives met with Eagle Foods management to discuss their objectives and conduct a water audit. The audit revealed an opportunity to save water at the hose stands. Eagle Foods has 110 hose stands with 2 hoses each for washing trucks and filling truck water tanks. Eagle Food was able to significantly reduce its water and sewer charges by installing flow control valves to reduce flow from 7.5 (measured with LADWP meter) to 3.5 gallons per minute, replacing the hose bib connectors used to connect the hoses to the water tanks to reducing leakage at the point of connection, and using water brooms for wash down.,.

Water Savings Results
One month of pre-modification metering indicated an average consumption of 228.3 gallons per day (gpd). After modifications were implemented, the same hose stand had a consumption of 74.6 gpd. Based on LADWP metering, the actual savings for the first year of operation was 2,651,660 gallons.

Cost Benefit
Eagle Foods received an incentive payment through LADWP's Technical Assistance Program (TAP). The incentive is $1.75 per 1000 gallons saved over two years, not to exceed the project cost. Other cost saving were realized by a reduction in sewer charges, since Eagle Foods pays sewer charges based on 68% of the water it uses.

Best Management Practices
- Restrict water flow at hose stands – Eagle Foods installed flow control valves to reduce water flow from 7.5 gallons per minute (gpm) to 3.5 gpm.

Commercial: Food Service
Eagle Foods
continued

- Use water brooms instead of hoses to for sanitary wash down
- Install hose bib connectors to reduce leakage at water tanks
- Replace cracked hoses as needed to reduce leakage
- Institute training and educational programs for employees – Eagle Foods employees were trained on the use of the hose bib connectors and water brooms. Eagle Foods posted signage to educate employees about the water shortage and the water conservation ordinance

Project Contact
Mark Gentili, LADWP, 213-367-8556, mark.gentili@ladwp.com

Flow control valves installed on hoses

Hose bib connector

Commercial: Food Service
Restaurant Retrofit

City: various
County: Orange
Supplier: Irvine Ranch Water District
SIC Codes: 7221, 7222, 7223

Project Goal
To maximize equipment rebate opportunities to promote water savings at existing restaurants.

Key Project Benefits
Using available funding opportunities, less-efficient appliances were able to be replaced at existing restaurants.

Project Description
Irvine Ranch Water District's (IRWD) Restaurant Retrofit Package Program innovatively used an Enhanced Conservation Program grant from the Metropolitan Water District, existing Southern California Edison (SCE) energy rebates, and IRWD funding based on estimated avoided cost for water and wastewater. The program targeted installation of connectionless food steamers and 1.6 gpm pre-rinse spray valves at up to 50 restaurants to replace older equipment. IRWD selected a product manufacturer that met the qualifications for both the water and energy rebates. The product vendor then retained the installation contractor. To promote the program, IRWD sent out press releases and letters to the Restaurant Association and developed marketing materials which were distributed during CII audits and on special canvassing trips to targeted areas.

IRWD staff inspected interested customers' existing equipment to determine program eligibility. The product cost was covered entirely by the funding from IRWD, MWD, and SCE. The eligible customers were invoiced only for the installation and disposal costs for their old inefficient steamer. The vendor invoiced IRWD for the total product cost. After the installation was verified, the program participant signed over release of the SCE rebate to IRWD. IRWD then submitted for reimbursement from the SCE rebate and the MWD grant for their portions of the product cost.

Water Savings Results
The estimated water savings was 0.247 AF per device, per year. Each device was expected to have a 10 year life.

Cost Benefit
By focusing the financial benefits of the MWD grant ($785), the SCE rebates ($750), IRWD cost savings ($3,622 versus an actual retrofit cost of $2,750), plus the identified vendor and its installation contractor, IRWD was able to develop a cost-effective program that enabled participants to upgrade to water-saving equipment with minimal out-of-pocket cost.

Commercial: Food Service
Restaurant Retrofit
continued

Best Management Practices

- Utilized multiple rebate and grant sources to make the program cost-effective.

Project Challenges

1. Fewer restaurants participated in the program than expected, in part because only electric devices were available and some restaurants use gas steamers. Having both options available would have enabled more participation.

2. The project was limited to the IRWD service territory and not every restaurant uses food steamers in their cooking process. Expanding the project to a larger area would have yielded a greater participation rate.

3. The contract should require a duration of use long enough to realize the water and energy savings used as the basis for program funding.

4. A refund mechanism should be included in the agreements with the customers and the vendors in the event the customer is not satisfied with the product.

Project Contact

Amy McNulty, IRWD, 949-453-5634, **mcnulty@irwd.com**

Commercial: Golf Course
City of Sunnyvale Golf Course Irrigation

City: Sunnyvale
County: Santa Clara
Supplier: Sunnyvale WPCP
NAICS Code: 713910

Project Goal
To utilize the recycled water previously disposed into San Francisco Bay.

Key Project Benefits
Additional local golf courses have been able to be added to the recycled water system, generating revenue from a previously discharged resource.

Project Description
Use of recycled water at the Sunnyvale Golf Course began in 2001. The project was initiated because of water quality issues associated with the discharge of the recycled water into San Francisco Bay.

Recycled water is used throughout the golf course, with the exception of the greens. No other significant modifications to the golf course irrigation system occurred with the switch to recycled water.

Water Savings Results and Other Benefits
The use of the recycled water at the golf course has reduced potable water use by about 350 acre/ft per year. The cost of recycled water is comparable to potable water.

An additional benefit to using recycled water is the savings in electricity because pump stations do not need to be run to water the golf course.

Project Challenges
Higher salt content in the recycled water resulted in the loss of most of the golf courses redwood trees. Soil flushing to reduce salts is more of a challenge in dry years when there is less natural precipitation to flush soils. Overall, turf quality is much better in the years following wet winters.

Vertical drains are used to help alleviate some drainage problem areas.

The golf course is also in the process of trying to identify areas on the golf course where irrigated turf can be reduced to go back to more naturalized areas.

Project Contact
Gary K. Carls, City of Sunnyvale, 408-730-7625, gcarls@ci.sunnyvale.ca.us

Commercial: Golf Course
Woodland Hills Country Club

City: Woodland Hills
County: Los Angeles
Supplier: Los Angeles Department of Water and Power
SIC Code: 7997

Project Goal
To remove turf in areas of non-play without disrupting play on the golf course.

Key Project Benefits
Turf replacement with drought resistant plants, mulch and ground cover:

- Reduced water use
- Lowered second tier water charges

Project Description
Woodland Hills Country Club is a private, member-owned 18-hole golf course and country club located in the San Fernando Valley. The Country Club met with Los Angeles Department of Water and Power's (LADWP) Water Conservation group to plan participation in LADWP's Commercial Turf Removal program. Key issues were to remove turf without disrupting play on the golf course and to maintain the golf course's aesthetic appeal for club members.

Overall, 7 acres of the 72 acres gold course were replaced in 2 phases. In the areas where turf was removed, the overhead irrigation sprinklers were also removed and/or replaced with low water drip irrigation.

Water Savings Results
Based on 1 full year of irrigation since the turf was removed (2011), when compared to the 2 years prior to turf removal, the annual water savings was 11.7 million gallons. This 22 percent reduction occurred with a reduction in 10 percent of the turf at the golf course.

Cost Benefit
In addition to the overall cost savings realized from water use, the project costs were supported by LADWP's Turf Removal Program. During the two phases of turf removal, project costs to the country club were $319,839. Incentive payments received from LADWP were $308,878, based on a rate of $1.00 per square foot of turf removed, not to exceed the project cost. There is a decrease in labor and maintenance for the converted areas

Best Management Practices

- Utilized a centralized weather based irrigation controller to manage and maintain efficient watering.

- Educated and trained the Golf Course Superintendent and employees to maintain the new plants and use the weather based irrigation controller to its full capacity.

Project Contact
Mark Gentili, LADWP, 213-367-8556, mark.gentili@ladwp.com

Commercial: Golf Course/Residential
Serrano Residential Development

City: El Dorado Hills
County: El Dorado
Supplier: El Dorado Irrigation District
NAICS Code: 221310

Project Goal
To supplement available water supplies with municipal recycled water to support full construction of the Serrano Development.

Key Project Benefits
- Largest residential development in California to irrigate front and backyards using recycled water
- Successful developer-water service provider coordination

Project Description
The Serrano project was originally approved in 1988 with secure water rights for only a portion of the planned development. Because of unintended delays in securing additional water rights, alternate water supplies were needed to enable the development to continue. The developer and El Dorado Irrigation District (EID) sought options to produce recycled water from two of the existing WWTP's. After extensive planning and coordination with State agencies, EID Board of Directors approved a plan that included allowing use of recycled water for front and backyard irrigation for 3,400 production homes, street medians and a golf course. The project was split into two phases. For Phase I, the developer upgraded EID's Deer Creek Wastewater Treatment Plant to provide recycled water for the backbone of the development: golf courses, parks, public landscaping and wetlands enhancement. The developer also constructed the distribution and storage facilities. For Phase II, EID upgraded the facilities at its El Dorado Hills WWTP to provide unrestricted use Title 22 recycled water and the developer constructed conveyance to the Serrano project and a two million gallon storage tank.

The Serrano project involved continuous interaction between the developer, EID and State regulatory agencies. All parties involved benefited from the project's outcomes. The developer paid for the design and construction costs of the recycled water facilities at the Deer Creek WWTP, plus the conveyance and storage systems. The developer also paid for all operation, maintenance and power costs for a period of 7 years. In return, the developer received recycled water facility connection credits and waiver of monthly use charges for the initial 7 years of system operation. This agreement enabled the project to proceed without impacting existing EID customers. Working closely with regulators enabled the project to meet State requirements for back flow prevention and other public health and welfare protection safeguards.

Commercial: Golf Course/Residential
Serrano Residential Development
continued

The Serrano project has been successfully integrating recycled water in a residential development for nearly 20 years. As a result of the project bringing the use of recycled water to the EID service area, EID has been able to expand recycled water use. EID now has nearly 4,000 recycled water connections for front and back yard irrigation of dual-plumbed homes, street medians, parks, golf courses, commercial landscaping, and WWTP industrial use.

Best Management Practices

- Use of recycled water as an integral part of the water supply for a major residential development.
- Instituted training and educational programs for employees and residential owners

Project Challenges

Because it was one of the first developments in the state to use recycled water for front and backyard residential irrigation, the project required extensive coordination with state agencies.

Project Contact

Elizabeth Wells, Engineering Manager - Wastewater and Recycled Water, ewells@eid.org

Commercial: High Tech
Applied Materials, Inc.

City: Santa Clara
County: Santa Clara County
Supplier: South Bay Water Recycling
SIC Code: 3344

Project Goal
To reduce water consumption by 10 percent at each world-wide facility by 2012.

Key Project Benefits
Award winning efforts achieved a 9 percent water savings by 2010, representing an annual water-use reduction of 24 million gallons.

SILICON VALLEY
WATER CONSERVATION
AWARDS

Project Description
Applied Materials, Inc. provides equipment, services and software to support the manufacture of advanced semiconductor, flat panel display and solar photovoltaic products for affordable consumer electronics. It operates two research and development facilities in Santa Clara County.

After an initial water use audit by South Bay Water Recycling, several water savings opportunities were identified, including:

- Re-landscaping the common areas of the campuses in-line with budget constraints by replacing some turf with native and drought tolerant plants, plus installing drip irrigation and smart controllers.
- Installing motion activated faucets and low flow fixtures in employee restrooms and break areas, and hand sanitizer stations throughout the buildings for a quick and easy way for employees to be germ free without the need for frequent hand washing.
- Revising engineering code for equipment (product) control software.
- Integrating the use of recycled water by sending Reverse Osmosis Unit reject water to cooling towers at one of Applied Materials' campuses.

Water Savings Results and Other Project Benefits
Water savings from replacement of more than 500 fixtures in restrooms and cafeterias represents approximately 5% of site gross water use and resulted in water savings in line with the estimates provided by the manufacturer. Rebates enabled payback within two to three years.
Consolidation of tools (i.e. the semiconductor fabrication systems or "tools" installed in the labs) and changes to software for tools that use deionized water resulted in water savings of approximately 10 million gallons per year.
Applied Materials received a Silicon Valley Water Conservation Award in 2009.

Commercial: High Tech
Applied Materials, Inc.
continued

Best Management Practices

- Water use audit with local water service provider participation
- Replace high water use landscape and install new area landscape with drought tolerant landscape and newer, programmable controls and sensors. The landscaping included a shaded pathway in the common area that employees use for breaks and say makes them more relaxed after spending time there.
- Process/Software revisions to controller code
- RO water reject reuse in cooling towers

Project Challenges
This practice was challenging to implement and required research and close cooperation and between Facilities and business units to enable development of better water use software recipes to meet technology requirements and customer demands for process quality.

Project Contact
Martin Gothberg, Applied Materials, 408-235-4570, Martin_Gothberg@amat.com

Commercial: Hospitality & Service
Car Washes

City: San Rafael
County: Marin
Supplier: Marin Municipal Water District
NAICS Code: 811192/7542

Project Goal
To incorporate recycled water into car wash operations.

Key Project Benefits
Integrating recycled water into car wash operations:

- Replaced a potable demand with recycled water
- Provided an innovative non-irrigation application for recycled water in a commercial setting

Project Description
In 1993, the retrofit of Betts Car Wash in San Rafael, a Marin Municipal Water District (MMWD) customer became the first car wash in the state to use recycled water. Initially, there were issues with spotting, which were alleviated with installation of a reverse osmosis unit to provide low TDS rinse water, and bacterial regrowth and Legionella, which was resolved by establishing a shock disinfection program in the basin that collected and recycled used washwater. Two other new car wash installations using recycled water have begun operating since Betts – at a Union76 in 1996 and a Shell station in 2001.

Best Management Practices
- Developed an innovative approach to using recycled water for a non-potable commercial demand

Project Contact
Dewey Sorensen, MMWD, 415-945-1558, dsorensen@marinwater.org

Commercial: Hospitality & Service
Parc55 Toilet Retrofit and Laundry Improvements

City: San Francisco
County: San Franciso
San Francisco Public Utilities Commission
NAICS Code: 721110

Project Goal
To reduce hotel water use

Key Project Benefits

- Replacing older hotel toilets reduced water use and decreased maintenance calls
- Onsite laundry machines retrofits enabled rinse water reuse

Project Description
The Parc55 Union Square Hotel in located in downtown San Francisco. Originally built in 1984, the hotel is actively involved in conserving environmental resources in its business practices. It maintains USEPA's Energy Star designation and two recent activities – toilet replacement and laundry facility retrofit – have significantly reduced water use at the hotel.
The Parc55 Union Square has 1,015 guest rooms and 1,030 guest room toilet fixtures. The toilets originally installed in the hotel were 3.5 gallons per flush, gravity-fed fixtures. The hotel conducted an 11-month retrofit of each of the hotel's toilets with a 1.0 gallon per flush, pressure-assisted fixture.

Onsite commercial laundry machines were retrofitted in 1997. The retrofit enables final rinse water to be reused as the first wash water of the following load.

Water Savings Results and Other Benefits
Toilet replacement resulted in a 26 percent decrease in monthly hotel water use, based on monthly meter records from before, during, and after the retrofit. This has resulted in an annual estimated water savings of 34 acre-feet, which saves about $100,000 per year in water billing. An additional benefit to the retrofit is fewer maintenance calls to address aging toilet issues. The number of service calls for fixture maintenance dropped by half in the months after the retrofit.

Washing machine retrofits reduced laundry water use by 35 percent.

Best Management Practices

- Replaced older high-volume toilets with new low-volume flush toilets.
- Retrofitted commercial washing facilities to reuse last cycle rinse water.

Project Contact
Shelly Harris, Wyndham Hotels, 415-403-6655, sharris@wyndham.com
Parc55 green practices are summarized at: http://www.parc55hotel.com/stay/guest-services/green-practices

Commercial: Landscaping
Large Southern California Landscapes

City: Various
Counties: Los Angeles, Riverside & San Bernardino
Supplier: Various
SIC/NAICS Code: various

Project Goal

To conduct irrigation evaluations and train professional landscapers, groundskeepers and golf course superintendants.

Key Project Benefits

30 sites were evaluated to identify and recommend opportunities to increase distribution uniformity and irrigation efficiency.

Project Description

Through a Prop 50 grant, thirty large, predominantly turf landscapes in southern California were surveyed and assessed by a subcontractor to the UC Cooperative Extension. The grant was awarded to perform onsite water audits with hands-on training of grounds keeping staff, provide incentives, and conduct follow-up.

Low values of irrigation distribution uniformity (how evenly irrigation water is applied over an area, expressed as a percent) and irrigation efficiency (how much irrigation water is beneficially used by the irrigated plants, expressed as a percent) result in wasted water and money. The distribution uniformity was determined for each of the 30 evaluated sites. In addition, the subcontractor assessed plant condition and adjusted, repaired, and replaced irrigation equipment as an education and training opportunity.

Water Savings Results and Other Benefits

The initial average (mean) distribution uniformity for the 30 evaluated sites was 58 percent and ranged from 41 to 86 percent. After repairs and recommendations were provided, the distribution uniformity improved to 69 percent. In some instances where spray heads were replaced with rotating nozzles, distribution uniformity improved as much as 24 percent.

Other project benefits realized from reducing irrigation demand included cost savings from reduced water usage, reduced energy demand for pumping and treat irrigation water, reduced dry season irrigation runoff, and improved plant health and appearance. Training and education of professional landscapers increased job skills.

Best Management Practices

- Implements water conservation BMP 5 (addresses outdoor irrigation at CII landscape sites

Project Contact

Janet Hartin, UC Cooperative Extension Advisor, San Bernardino and Los Angeles Counties, jshartin@ucdavis.edu

Commercial: Landscaping
Xeriscape Conversion Study

City: Las Vegas, Nevada
County: Clark
Supplier: various
SIC/NAICS Code: NA

Project Goal
To determine water savings for converting residential turf landscape to xeriscape.

Key Project Benefits
Replacing turf with xeriscape can provide significant water use and cost savings.

Project Description
Southern Nevada Water Authority (SNWA), the Las Vegas regional water wholesaler, conducted a multi-year project to quantify specific cost-savings associated with converting residential turf landscape to xeriscape. Submeters were installed at hundreds of residential sites in the Las Vegas area to collect data for discrete portions of residents' landscapes. This enabled quantification of water use changes and costs for converting residential landscape. Data also were collected for other factors, such as seasonality and neighborhood and resident attributes.

Once the landscape conversion was complete, data showed an initial drop in water consumption that quickly stabilized. Over the mufti-year study, household water use generally remained consistent.

A sub-study of other commercial properties with xeriscape landscaping found similar results to the residential xeriscape customers.

Water Savings Results
Converting from turf to xeric landscapes resulted in a 76.4% water savings (73.0 compared to 17.2 gallons per square foot annually).

Cost Benefits
Annual water bill savings varies depending on the water service provider and the rate tiering, but was estimated to be about $0.15 per square foot at the time of the 2005 study. The cost to convert the landscape using a contractor was $1.93 per square foot and $1.37 per square foot without a contractor.

In addition to cost benefits, the study identified indirect benefits. These included reducing yard maintenance by 2.2 hours per month and annual maintenance cost reduction of $206 per year.

Project Contact
Kent Sovocool, Southern Nevada Water Authority, 702-862-3738, kent.sovocool@snwa.com
This project was funded in part by the Bureau of Reclamation. The document is available at: http://www.snwa.com/assets/pdf/about_reports_xeriscape.pdf

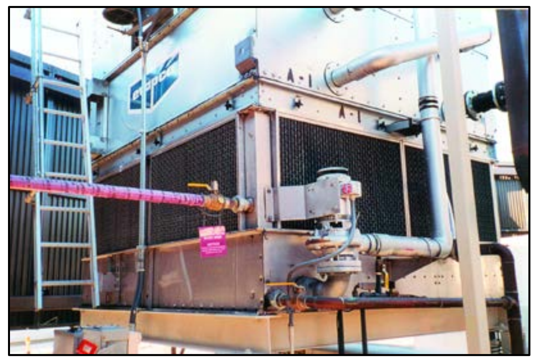
Commerical: Office Building
Dual Plumbed Office Buildings

City: various
County: Orange
Supplier: Irvine Ranch Water District
SIC Code: 6512-02

Project Goal
To reduce water use in office buildings.

Key Project Benefits
Recycled water at new office buildings can be used for:

- Toilet and urinal flushing
- Cooling towers
- Landscaping



Project Description
In 1991, the Irvine Ranch Water District (IRWD) began using reclaimed water for toilet flushing in high-rise office buildings. Office building use of recycled water has now expanded to include dozens of office buildings within its service area. Use of recycled water both inside and outside of the buildings has supported green initiatives and conserved water. . . .

Water Savings Results and Other Project Benefits
Potable water use savings of up to 75 percent can occur where recycled water use is incorporated into commercial office buildings. Each building can save approximately 15 AF per year, depending on size. With IRWD's recycled water rate approximately 60 percent of the potable water rate, this is a savings of over $3,000 per year.

Best Management Practices

- Use of recycled water for landscape irrigation and dual plumbing buildings

Project Contact
Gabriel Vargas, IRWD, 949-453-5588, vargas@irwd.com

Industrial: Manufacturing
Aerojet

City: Folsom
County: Sacramento
Supplier: City of Folsom
NAICS Codes: 334511, 336413
Project Goals:
To develop beneficial reuses of remediated water.

Key Project Benefits
Beneficial reuse of remediated water enables reduced demand on the City of Folsom potable water supplies.

Project Description
Aerojet is a world-recognized aerospace and defense contractor. Onsite groundwater remediation produces millions of gallons of high quality non-potable water every day that had previously been disposed into local surface creeks. Aerojet is located within the City of Folsom's place of use, so the City holds the rights for the water extracted for the remediation and also provided potable water to Aerojet. Developing this win-win project enables Aerojet to reuse its remediated water and the City of Folsom to reduce potable water deliveries. Aerojet's primary uses for its remediated water are testing and product manufacturing cooling, as well as fire protection.

Aerojet's Groundwater Extraction and Treatment (GET) system provides treatment to remove volatile organic compounds and other groundwater contaminants. The high-quality water produced by this process is suitable for irrigation and industrial uses. Currently, GET A and GET B (the two GET sites included in the City of Folsom agreement) produce more water than Aerojet uses. The City of Folsom is currently developing plans to provide this remediated water to other nearby CII customers, which will further reduce local CII potable water demands.

Water Savings Results
The City of Folsom provided Aerojet approximately 2,500 acre-feet of potable water per year, with a contract amount of up to 4,600 acre-feet/year. The GET A and B sites annually produce up to 8,600 acre-feet of remediated water. That water would then be delivered to Aerojet for industrial and possibly potable needs, with the remaining water supplied by the City of Folsom to other CII customers.

Beneficial reuse of the 8,600 acre-feet of remediated groundwater for non-potable industrial applications will reduce demands on the City of Folsom's existing surface water supplies. This use of remediated groundwater will produce not only environmental benefits but a regional use for an otherwise unusable water resource. These remediated uses allow conservation of the City's other existing water sources that are then protected under California Law. Moreover, these uses will result in a net percentage savings of surface water deliveries because of the new applications of the GET water supply.

Industrial: Manufacturing
Aerojet
continued

Cost Benefit
The expenses incurred by the United States EPA and Aerojet to design, construct and activate the facilities as well as the ongoing maintenance of those facilities is in the hundreds of millions of dollars. The City and Aerojet seek to develop the water derived from these facilities and apply those waters to beneficial uses that provide economic returns. The savings to the City will include the offset costs of developing and delivering the existing City's water supplies to Aerojet.

Project Challenges
The primary project challenges include developing the necessary infrastructure to deliver water to its designated uses throughout the City's service area. This development includes paying the capital costs and operation and maintenance costs associated with running these facilities. Moreover, identifying beneficial uses with the given infrastructure delivery system may also provide system challenges.

Best Management Practices
- Identified alternate water supplies – reuse of remediated water

Project Contact
Ken Payne, City of Folsom, 916-351-3573, kpayne@folsom.ca.us

Industrial: Manufacturing
Air Products

City: Santa Clara
County: Santa Clara
Supplier: South Bay Water Recycling
NAICS Code: 325120

Project Goal
To pursue green initiatives.

Key Project Benefits
Replacing potable process water with recycled water has reduced Air Products' water costs by half.

Project Description
The Santa Clara Air Separation Unit separates air into pure liquid and gaseous argon, oxygen, and nitrogen. The separated gases are then distributed through a gas pipeline and by a ground fleet. The site uses water to cool the components involved in the air separation process. After the water acquires heat from the equipment, it travels back to the water tower where it is cooled by evaporation. The cool water is then pumped back into the system to again remove heat. Water is added to the system to maintain water in the tower lost through evaporation. Second only to energy use, water is a critical part of the air separation process.

Replacing some facility potable water use with recycled water was considered after Air Products staff attended a City of Santa Clara business networking meeting for local businesses to share innovations and opportunities. This outreach initiated a partnership with South Bay Water Recycling (SBWR) and the City of Santa Clara, which constructed a 1,300 foot pipeline extension to deliver recycled water to Air Products. The pipeline was partially funded by stimulus funds obtained through the Bureau of Reclamation's Title XVI Program.

Water quality was Air Products' major concern about incorporating recycled water into its processes. Working with SBWR and its water treatment service provider, Air Products developed a suitable water treatment plan that included the use of additional microbiological control chemicals, as well as an additional feed of pH control agents to lower the operating pH band.

Water Savings Results and Other Benefits
Air Products estimates that 62 million gallons (190 acre feet) of annual potable water used at the plant has been replaced by recycled water. In addition to the cost savings, the project serves as a model for other companies to address water shortage issues. Extension of the recycled water pipeline provides a cost-effective opportunity for nearby companies to switch to recycled water. Air Products has been sharing their knowledge and best practices for incorporating a recycled water system at various conferences and events. This project also has spurred a similar recycled water effort at Air Products' plant in Santa Fe Springs.

Industrial: Manufacturing
Air Products
continued

Cost Benefit
SBWR water is half of the price of potable water, so Air Products saves nearly $100,000 per year on the cost of process water. Onsite construction costs needed to receive the recycled water were regained within 1 year of operation.

Best Management Practices
- Incorporated recycled water into facility operations, with minor process modifications

Project Contact
Luke Charpentier, Air Products, phone (408) 988-6263, email charpelj@airproducts.com.

Industrial: Manufacturing
BP Carson Refinery

City: Carson
County: Los Angeles County
Supplier: West Basin Municipal Water District
NAICS Code: 324110

Project Goal
To reduce potable water use.

Key Project Benefits
Recycled water is currently meeting 30 percent of the plant's water demands. The facility plans to increase the use of recycled water to meet 55 percent of demands.

Project Description
The BP Carson Refinery (BP Carson) is located on 630 acres in Los Angeles County near the Long Beach and Los Angeles Harbors. BP Carson is one of the largest refineries in California and is a major producer of clean fuels. It processes a variety of different crudes from all over the world and supplies 25% of the Los Angeles gasoline demand and 15% of the jet fuel to Los Angeles International Airport.

BP Carson receives two separate streams of recycled water from West Basin MWD: a reverse osmosis (RO) stream and a nitrified stream. The RO water is used both in the boilers and cooling towers. For use in the boilers, the RO water is sent to an onsite "second pass" RO unit for a final "polish," it is then de-aerated to help reduce the corrosive nature of the pure RO water. The waste water or "concentrate" that is produced from this onsite RO unit is reused as partial makeup water to one of the cooling towers (~ 125 gpm or 180,000 gpd). The RO water not used for boiler feed water production is blended with the nitrified water supplied from the Carson Facility. This blended stream is used for makeup water in the cooling towers. The overall cooling tower makeup is supplemented by city water as necessary. The potable supply also acts as a backup in case the supply of recycled water is interrupted.

The project goals have been incorporated in a staged approach, with Stages 1 and 2 completed in 2000 and 2007 respectively. The 3rd Stage is expected to be completed in 2014. Stage 1 kicked off the project with a goal to partially supply recycled water to the cooling towers. The goal of Stage 2 was to supply the refinery boilers with 100% recycled water. Stage 3 will continue to increase the use of recycled water to supply the majority of cooling tower makeup water with recycled water.

Industrial: Manufacturing
BP Carson Refinery
continued

Cost Benefit

The major costs of using recycled water include the meter charge and the capital costs for pipelines, post treatment systems (i.e. onsite RO system), and backup systems. The major economic benefit of using “designer” recycled water is reduced treatment costs at the refinery, especially for boiler feed water. When the “all-in” costs are considered it is only slightly more expensive to use recycled water.

Best Management Practices

- Incorporated recycled water into the facility operations
- Maintain backup water supply (potable water) for water supply reliability (operational adjustments are required for water quality changes)
- Onsite RO facility reject water is reused as partial cooling tower makeup water

Project Challenges

There are several challenges the facility must address in using recycled water. These include:

1. Air gaps are required by the Health Department to prevent a backflow situation if the potable system goes down. Check valves and/or block valves are not deemed sufficient. Other back flow prevention costs included instrumentation and controls systems, plus storage tanks to ensure an uninterrupted supply and to prevent backflow if there is an outage or reduction in pressure on the city water supply line.
2. Water that is treated with RO is corrosive by nature, so a separate non-carbon steel pipeline/distribution system was built inside the refinery to accommodate the use of this water.
3. The nitrified recycled water is high in iron and phosphates due to upstream water quality treatments and may limit the number of cycles the water can be used in the cooling towers. This effect is reduced by the blending of RO water into the nitrified supply.
4. Chemical treatment programs need to be adjusted when switching from the city water supply over to a predominantly recycled supply, especially in cooling towers. Water quality changes can also occur seasonally with City water or with recycled water source changes. Good communication between the recycled plant operator and the refinery operators minimize the impacts of these changes.

Project Contact

Ken Letwin, BP Carson, 310-847-5430, Ken.Letwin@bp.com

Industrial: Pharmacology
Amylin Pharmaceuticals

City: San Diego
County: San Diego
Supplier: City of San Diego
NAICS Codes: 873108/541711

Project Goals
To reduce water costs, implement an alternative “green” pretreatment technology, and support ISO 14000 recertification.

Key Project Benefits
Converting to recycled water:

- Reduced potable water use
- Reduced overall water use

Project Description
Amylin Pharmaceuticals maintains several San Diego facilities where it manufactures pharmaceutical products. Because of the success and savings from integrating recycled water at one facility, Amylin sought to retrofit two additional facilities located nearby. The retrofits at the first facility included conversion of the irrigation system and large decorative reflecting pond to recycled water use. The retrofits at the second facility included conversion of the irrigation system and cooling tower system makeup water to recycled water.

Replacing potable water for recycled water in a large decorative reflecting pond required algal growth control. The pond is a major architectural and aesthetic focal point of the exterior at that Amylin facility. Amylin uses an existing pond recirculation pump, filtration and disinfection system, coupled with regular monitoring, to maintain water quality in the pond.

Process modifications were required at the second facility to incorporate recycled water. These modifications involved implementing an alternative onsite “green” pretreatment technology to decrease makeup water consumption, minimize or eliminate traditional chemical use, and minimize scale and corrosion issues within the cooling tower. The pretreatment technology utilizes the natural water chemistry (silica, TDS, alkalinity), reducing the need for additive chemical treatment, removes existing scale buildup, and increases heat transfer efficiency. This process change enabled the cycles of concentration to be increased from 3 to greater than 50 times within the cooling tower, which also decreased overall water use and significantly reduced water demand.

Industrial: Pharmacology
Amylin Pharmaceuticals
continued

Water Savings Results and Other Project Benefits
The conversion to recycled water replaced almost 39 acre-feet of potable water use (10.5 acre-feet from landscape and irrigation, plus 28.1 acre-feet from cooling tower use), saving approximately $65,000 per year. Additionally, because of efficiencies gained by the use of an alternative treatment technology for the makeup water feed to the cooling towers, the overall use of makeup water is reduced by about 30 percent.

Best Management Practices

- Incorporated recycled water into the facility operations
- Reduced cooling tower water and chemical use by incorporating a “green” pretreatment technology

Project Challenges
The primary challenge to the completion of the recycled water retrofit project was the lead time necessary for regulatory reviews, site inspections, and installations of the recycled water meters. The regulatory agencies were great to work with but being short-staffed lengthened project review, approvals, and time necessary to schedule inspections.

Project Contact
Joel Bowdan III, RBF Consulting, 858-614-5000, jbowdan@rbf.com

Industrial: Pharmacology
Genentech

City: Oceanside
County: San Diego
Supplier: City of Oceanside
NAICS Code: 541711

Project Goal
To reduce water consumption in support of Genentech's role as a good environmental custodian for sustainable operation.

Key Project Benefits
Water savings was achieved by:

- Replacing 2/3 of facility grass with artificial turf
- Incorporating recycled water into makeup water for facility steam boilers

Project Description
Genentech's Oceanside facility is one of several in California that produces pharmaceuticals. Reducing water consumption would help Genentech to support local, regional, and statewide water conservation goals. Two areas of high water use were addressed – landscape irrigation and boiler makeup water.

Replacing 2/3 of the facility's grass (26,385 square feet) with artificial turf provided an overall reduction in water consumption, as well as reduced onsite pest populations. In addition to the grass removal, irrigation spray heads were replaced with rotators and drip lines and software was purchased to monitor/control the irrigation system for the remaining landscaping. Auto sensor faucets were replaced in campus restrooms with manual faucets, as a result of operational and maintenance issues.

Recycled water was incorporated into plant operations in 2010 by introducing it into the makeup water for operation of the steam boilers used to generate distilled water. The high quality of the recycled water benefited the system by improving water quality. Plant modifications included installation of a 500 gallon storage tank and transfer system to pump the recycled water to the boiler system as the recycled water became available to the facility. The building management system monitors and records recycled water system operation.

Water Savings Results and Other Project Benefits
Modifying the irrigation heads and replacing the lawn with artificial turf saved approximately 5 million gallons of water in 2010.

The use of recycled water in plant operations saves approximately 4,000 gallons per day because of decrease in process water demands. This reduction alone resulted in an 18-month pay-off of the $40,000 management system for the recycled water storage and operation. The energy penalty from the addition of the new recycled water pump and controls is factored into the estimate and proved to be negligible long term.

Industrial: Pharmacology
Genentech
continued

Unexpected benefits resulting from the use of recycled water included reduction in the amount of water needed to be added as makeup water, increase in the blow-down water cycles from 5 to 50 times, and reduction in natural gas consumption because the energy expended during blowdown was now retained by the system for distribution and use. Additionally, wear and tear on system equipment is reduced because of reduction in the violence in the blowdown activity and the higher quality steam introduced fewer contaminants and improved the steam traps and user performance.

Best Management Practices

- Reduced irrigated landscape
- Incorporated recycled water into the facilities makeup water

Project Contact

Jan Richcreek, Genentech, 760-231-2456, richcreek.jan@gene.com

Industrial: Power Plant
Sutter Energy Center


John Maulbetsch

City: Yuba City
County: Sutter County
Supplier: Self-supplied
NAICS Code: 231112

Project Goal
Install a gas-fired power plant in Sutter County.

Key Project Benefits
Modification of the project design from water-cooled to air-cooled reduced planned groundwater use by 95 percent

Project Description
Calpine Corporation's natural gas-fired, 578 megawatt Sutter Energy Center began operating in 2001. Located in rural Sutter County, the Sutter Energy Center's original plan was to use wet cooling towers. This would have used an average of about 4.3 million gallons of local groundwater per day or approximately 4,856 acre-feet per year. Factoring in peak operating conditions, the annual total could have reached 7,115 acre-feet per year. Cooling tower water was to come from a series of onsite wells. Cooling water blowdown and other grey water waste streams, totaling over 2 million gallons of water per day, were planned to be discharged to a local system of canals and drains which eventually flow into the Sacramento River. Because of the surface water discharge, the proposed project was to use less than 3 cycles of concentration for the cooling water to keep the concentrations of certain metals in the blowdown below applicable water quality standards.

To address concerns over using local groundwater in the agricultural region, the applicant changed the project design to use an air-cooled condenser for power plant cooling. This reduced planned water consumption for the project to an average daily flow of 60,000 gallons per day (67 acre-feet, annually), reducing average project water demand by nearly 99 percent, and 95 percent when considering peak rates. Although not as efficient from an energy-production perspective, converting to an air-cooled process plant enabled stronger community support for the project and better water use efficiency.
A second change to the project focused on effluent discharge. Instead of discharging cooling tower blowdown to local canals and drains, the project was redesigned to use an onsite crystallizer to treat process wastewater. Only storm water runoff is discharged off site.

Best Management Practices
Converting from water cooling towers to air cooling towers enabled more efficient overall plant water use.

Project Challenges
Concerns about the original project design impacting local water supply and the willingness of the applicant to address these concerns resulted in a project with strong local support.

Project Contact
Joe O'Hagan, California Energy Commission, johagan@energy.state.ca.us

Institutional: Medical
California Hospital Medical Center

City: Los Angeles
County: Los Angeles
Supplier: Los Angeles Department of Water and Power
SIC Code: 8062

Project Goal
To reduce water consumption and cost by reducing or eliminating second tier water charges and reduce sewer charges.

Key Project Benefits
Installation of laminar devices saved water without any process modifications to facility operations.

Project Description
California Hospital Medical Center is a short-term acute care facility with 302 staffed beds. A third-party company conducted a survey of domestic water usage at the facility, including staff interviews to understand key water uses. A key identified water use was the 507 sinks throughout the hospital, with an average weighted flow rate of 3.73 gpm. Installation of a simple laminar device at the end of each faucet reduced the sink flow rate to 1.5 gpm.

Water Savings Results
Prior to the installation of the laminar devices, the annual water use at the hospital sinks was estimated to be approximately 21.2 acre-feet. After the installation, the water use was estimated to be reduced between 12.7 and 14.6 acre-feet per year (based on calculated and multi-year water meter readings).

Cost Benefit
The full cost of the installation of the laminar devices was recovered by an incentive payment from LADWP ($1.75 per 1000 gallons saved over two years, not to exceed the project cost) and from the Southern California Gas Company. The incentive payment would have covered the entire cost of the project, based on the water volume savings, but only provided half because of the Gas Company payment. Additional savings were realized by the California Medical Center because decreasing its water bill, in turn decreased its sewer charges (69% of water use).

Best Management Practices
- Restrict water flow in faucets.

Project Contact
Mark Gentili, LADWP, 213-367-8556, mark.gentili@ladwp.com

Institutional: Municipal Utilities & Facilities
City Of Riverside Potable Reuse Project

City: Riverside
County: Riverside
Supplier: City of Riverside
NAICS Code: 221330

Project Goal
To increase local water supply through water supply portfolio diversification and increased use of recycled water.

Key Project Benefits
Directly compared costs for 'traditional' purple pipe delivery infrastructure to groundwater recharge

Project Description
Water demand in the City of Riverside's service area could exceed supply as soon as 2015. The City of Riverside evaluated two options for integrating 10,000 AF of recycled water into its water supply options as an alternative to importing water or developing other sources. The two recycled water options were:

1. Purple Pipe: Serve 740 customers through 172 miles of distribution pipeline at a capital cost of $550 million. The cost of this project is equivalent to $42/month for each customer, which is greater than the current average user cost of $35/month.
2. Potable Reuse: Convey recycled water 6 miles north to groundwater recharge basins at a capital cost of $95 million. The City can use existing infrastructure to extract groundwater and distribute it to customers. The cost of this project is equivalent to $9/month for each customer.

The purple pipe project was considered infeasible because of cost and community disruption. The City is implementing the potable reuse option based on its lower cost. The cost difference between these two types of recycling projects illustrates the importance of potable reuse to use recycled water most cost-effectively. It also avoided the impacts of constructing 172 miles of pipeline in City streets. Impacts of importing water also are avoided. Economic impact equivalent to an average of $33/month for every service area customer is avoided. The project is currently being designed and permitted.

Project Contact
Kevin Milligan, Utilities Assistant General Manager – Water, kmilligan@riversideca.gov

Institutional: Municipal Utilities & Facilities
Contra Costa County Animal Services Facility

City: Martinez
County: Contra Costa
Supplier: Central Contra Costa Sanitation District
NAICS Code: 812910

Project Goal
To provide recycled water for pet kennel wash down and for landscape irrigation.

Key Project Benefits
Implementing dual plumbing in the animal shelter
- Conserves potable water supplies
- Demonstrates green building principles
- Reduces water costs

Project Description
The Contra Costa County Animal Services Facility is a 37,000 square foot facility that can house over 300 dogs, cats, birds, and other animals. When it opened in 2005, it was the first dual plumbed building within the Central Contra Costa Sanitary District's service area. Recycled water is used for the facility's exterior landscaping and to wash down the pet kennels, and was the first facility in the country to use recycled water for this purpose. Because recycled water is heated in a closed loop system for the kennel wash down water, the potential growth of the bacteria *Legionella* needed to be addressed (this would also be an issue for potable water as well). Disinfectants added to the rinse water were also determined to be effective against *Legionella*. Several other additives are used in the kennel wash down water, including cleaning solutions, deodorizers, and granular absorbents.

Corrosion protection was the main issue for the heated recycled water because of small amounts of ammonia present. To prevent corrosion of copper pipes, sodium silicate is added to the kennel washing hot water system.

Water Savings Results and Other Project Benefits
The facility uses about 2 million gallons per year of recycled water, which directly reduces potable water demand. The annual cost of recycled water is about $6,000, which is approximately $2,000 per year less than potable water, because recycled water is priced about 25% less than potable supply.

Cost Benefit
There were additional costs to install dual plumbing in the building interior and install a corrosion protection system. However, it is expected these costs will be recovered early in the life of the facility (within 15 – 20 years). The costs to connect the facility were minimal since recycled water was already available in the street in front of the property.

Institutional: Municipal Utilities & Facilities
Contra Costa County Animal Services Facility
continued

Best Management Practices

- Innovative use of recycled water.
- Dual plumbing installation.

Project Challenges

There was concern that there would be increased potential for corrosion within the dual plumbed piping and the kennel wash down system. Working with the County and a consultant, it was determined that the system piping would be Type K copper instead of Type L. A corrosion inhibitor system (sodium silicate) was also installed, which was not reactive with the other chemical additives for the wash down area.

Project Contact

Don Berger, Central Contra Costa Water District, 925-229-7259, dberger@centralsan.dst.ca.us

Institutional: Municipal Utilities & Facilities
City of Livermore Fire Fighting

City: Livermore
County: Alameda
Supplier: Livermore Municipal Water
NAICS Code: 922160

Project Goal
To use recycled water for fighting fires in Livermore's commercial area to conserve potable water.

Key Project Benefits
Saves potable water for higher and better uses:
- Reduced potable water use.
- Provides an excellent replacement for firefighting water.

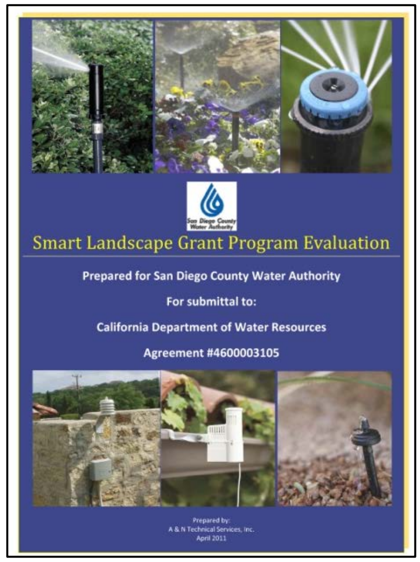
Project Description
Recycled water originally was integrated into the fire-fighting system in Livermore's commercial area because it was the only water system with adequate storage and elevation to provide required fire flows. It was used both in the hydrant system and the sprinkler systems of individual buildings. Both the potable and recycled water systems now have adequate elevated storage. Recycled water now is only used in the 65 fire hydrants scattered throughout this commercial area. Livermore will continue to use recycled water for all eligible uses in order to conserve potable water

Water Savings Results
The Fire Department doesn't measure the actual volume of water it uses for fire-fighting, so cannot quantify how much recycled water has actually been used. However, the recycled water system is an important component of the City's fire fighting system because it enables the city to maintain an essential function and reduce dependence on strained local potable water supplies.

Best Management Practices
- Recycled water was the right resource for this project.
- Utilizing an existing, available resource enabled the project to move forward.

Project Contact
Randy Werner, Livermore Municipal Water, 925-960-8100, rwerner@cityoflivermore.net

Institutional: Parks
San Diego County Water Authority



City: 24 member agencies
County: San Diego
Supplier: San Diego County Water Authority
NAICS Codes: 561730, 611110, 611310, and 531312

Project Goal
To upgrade the irrigation efficiency of large landscape areas.

Key Project Benefits
Hundreds of sites up to 2 acres were improved, resulting in a program-wide water savings of 13.7%.

Project Description
San Diego County Water Authority issued grants for upgrading large landscape areas to organizations such as community associations, commercial and industrial parks, and schools. Grants, typically $5,000 to $10,000, could be used for irrigation hardware repairs and upgrades to improve irrigation efficiency at sites up to 2 acres. Private sites were funded at up to $2,500 per acre and public sites at up to $5,000 per acre.

474 program participants received nearly $2.1 million in financial incentives to upgrade or replace irrigation hardware including smart controllers, sensors, rotary nozzles, valves, low-volume irrigation components, and other devices.

Water Savings Results
Multi Family sites (community associations) typically achieved a 10.8 % reduction in landscape water use while other participating CII accounts achieved on average a 20.5% savings. The program-wide savings average was 13.7%. Estimated water savings of 8,000 acre-feet were projected over the 10-year life. The cost of the saved water ($287/AF) compared favorably to the cost of imported water ($811/AF).

Best Management Practices
The following best practices are recommended for irrigation system management:

- Conduct a landscape water audit, including a water budget
- Upgrade distribution system first, then install a smart irrigation controller
- Monitor and manage water use for water budget compliance

Project Contact
Carlos Michelon, SDCWA, 858-522-6756, cmichelon@sdcwa.org

"Smart Landscape Grant Program Evaluation," prepared by A&N Technical Services, Inc. for the San Diego County Water Authority. http://www.sdcwa.org/sites/default/files/files/water-management/conservation/smart-landscape-grant-prog-report.pdf

Institutional: Parks
Los Angeles County Department of Parks and Recreation

City: Sylmar
County: Los Angeles
Supplier: Los Angeles Department of Water and Power
NAICS Codes: 712190, 713910

Project Goal
To reduce water use at two Los Angeles city parks.

Key Project Benefits
Installation of weather-based irrigation controllers surpassed the project target of saving 1 acre-foot of water per acre of irrigated parkland.

Project Description
Los Angeles County Department of Parks and Recreation (LACDPR) maintain over 100 acres of landscape at El Cariso Park and Veterans Park in the Sylmar area of the San Fernando Valley. Existing controllers did not have weather based smart irrigation technology. It was determined that upgrading to weather based technology would save significant amounts of water. Prior to the upgrade, existing irrigation systems were evaluated for proper operation and deficiencies were corrected. After installation by a contractor, park maintenance personnel were trained in the programming and operation of the new smart controller systems.

Water Savings Results and Other Benefits
The first year after installation, water savings exceeded the goal of 1 acre-foot per acre of irrigated parkland. El Cariso Park, 56.6 acres had saved 127 AF (meter is shared with a golf course that also did an irrigation project) and Veterans Park (46 acres) had saved 71 AF. Through implementation of these projects within Los Angeles Department of Water and Power's (LADWP) service area, LACDPR received rebate money and used the money for controller upgrades at other parks in LA County not serviced by LADWP.

Best Management Practices
- Weather-Based irrigation control using local CIMIS weather stations.
- Rain sensor irrigation control.
- Remote monitoring of irrigation systems and controllers operations and systems alert notifications

Project Contact
Mozaffar Bahrami, 213-738-4709 for the LACDPR and Enrique Silva 213-367-0893 for the LADWP.

Institutional: Schools
Crean Lutheran High School

City: Irvine
County: Orange
Supplier: Irvine Ranch Water District
NAICS Code: 611110

Project Goal
To incorporate a conservation principle by conserving potable water.

Key Project Benefits
Fully integrates recycled water into campus life:

- Landscape irrigated with recycled water
- Toilets and urinals flush with recycled water in the classroom building and gymnasium building

Project Description
Crean Lutheran, a private high school, uses recycled water for toilets, urinals and priming floor drains in its buildings. Crean Lutheran High School was the first high school in the Irvine Ranch Water District (IRWD) service area and the State of California to use recycled water for indoor plumbing. Its two dual-plumbed buildings serve more than 500 students and 30 staff members. The two dual plumbed buildings are its classroom building and the gym, which is a tensioned fabric membrane structure. In addition, the school uses recycled water to irrigate its nine acres of landscaped area.

The school's dual-plumbed, two-story modular classroom building was constructed differently than other dual-plumbed buildings. The modules were constructed in numerous sections in Perris, California and then brought to the Irvine location and assembled.

Water Savings Results and Other Project Benefits
The combined use of recycled water used in the dual-plumbed buildings and the school's landscaping saves more than 10 million gallons (31 acre feet) of drinking water per year. Crean Lutheran High School was honored by California WateReuse as a 2012 Recycled Water Customer of the Year.

Best Management Practices

- Use of recycled water for landscape irrigation and dual plumbing buildings

Project Contact
Gabriel Vargas, IRWD, 949-453-5588, vargas@irwd.com

Institutional: Schools
San Jose State University

City: San Jose
County: Santa Clara
Supplier: South Bay Water Recycling
NAICS Code: 611310

Project Goals
To reduce flows to the sanitary sewer and to improve cooling system efficiency

Key Project Benefits
Evaluation of water sources and installing new controls has:

- Reduced sewer charges
- Reduced chemical demands
- Supported campus 'good steward of the earth' goal

Project Description
The university's Central Plant (Plant) provides steam heating, chilled water cooling, and electrical distribution for approximately five million square feet of urban university building space. It has been using recycled water for its cooling tower make up water since 1999, but also has access to groundwater. The university evaluated the two possible water sources, which enabled it to realize cost benefits from both reduced chemical demands and the use of the less expensive recycled water. It also installed a new control unit to maintain chemical feeds (active polymer used in the process for scaling control) and sewer system discharges.

Water Savings Results
The new controller increased the number of cycles of concentration in the cooling tower from between two and three to up to between five and six, reducing the campus' industrial waste water discharge to the sanitary sewer by an average of 60%.

Cost Benefit
The return on investment of $11,545 for equipment purchase and installation was recovered in 135 days because of chemical, operational, water source, and sewer cost savings.

Best Management Practices
- Use of recycled water as a more cost-effective and environmentally-friendly water supply.
- Better automation reduced operational costs.
- Improved bio-control by measuring active biological growth in the tower basin with a color sensitive dye.

Project Contact
Chris Nordby, San Jose State University, 408-924-1950, chris.nordby@sjsu.edu

Institutional: Schools
UC Merced


YESENIA AMARO

City: Merced
County: Merced
Supplier: City of Merced
NAICS Code: 611310

Project Goal
To create a water-saving culture on campus.

Key Project Benefits
Created student-focused competition to raise water conservation awareness.

Project Description
UC Merced partnered with a Silicon Valley company to obtain recorders that monitor and track real-time water usage. The devices are hoped to have both short-term and long-term benefits. Initially, the devices have been used to support campus water conservation efforts, including the UC Merced Water Battle 2011, which monitored water use in nine campus residence halls to see which hall saves the most water per person. The winning residence hall won a pizza party and $1,000 nonprofit organization donation (which the dorm gave to the Boys & Girls Club of Merced). It is hoped that this effort will help create more water awareness among students and get them into a habit of saving water. In the long term, the technology will help the university comply the Water Conservation Act of 2009, which sets the goal of reducing the per-capita urban water use by 20 percent by 2020.

Water Savings Results and Other Project Benefits
The 600 students living in the residence halls reduced their water use by an average of 14 percent over the 31 days of the competition. They took shorter showers and did not run the faucet when brushing teeth and shaving. These particular residence halls don't have kitchens or washing machines in the units, so the options for saving water were in the bathroom sink, shower and toilet. Total water saving for the one month competition was 89,000 gallons (0.3 acre feet). The university uses about 64 million gallons (196 acre feet) of water every year.

Using the meters to monitor water use within individual buildings alerted facility maintenance workers seven leaky toilets. They were wasting about 150 gallons of water an hour.

Cost Benefit
Water saving from identification of malfunctioning toilets paid for the cost of the meters.

Institutional: Schools
UC Merced
continued

Best Management Practices

- Portable water metering devices were able to be effectively used to support campus competitions and identify facility maintenance issues.
- Social media, such as Facebook and YouTube, and online contest tracking were valuable tools in communicating with the students during the contest.

Project Challenges
Finding the best way to communicate water saving ideas and techniques to college students.

Project Contact
Jim Genes, UC Merced, 209-228-4368, jgenes@ucmerced.edu

Information on this case study first appeared in the Merced Sun-Star, in articles by Yesenia Amaro (yamaro@mercedsun-star.com).

The YouTube video produced for the competition can be viewed at: http://www.youtube.com/watch?v=3wL2-yWOmJE

Institutional: Schools
Brentwood School

City: Los Angeles
County: Los Angeles
Supplier: Los Angeles Department of Water and Power
SIC Code: 8211

Project Goal
To remove turf and create a school campus as an example of Mediterranean flora with plants from California, Australia, South Africa, and other Mediterranean climates.

Key Project Benefits
Turf replacement with drought resistant plants, mulch and ground cover:

- Reduced water use
- Replaced hillsides of tall fescue
- Create shade with trees to help reduce ET rate for the plants in the understory

Project Description
Brentwood School is a K through 12 school located in West Los Angeles. Landscape maintenance is done by a contractor. The landscape contractor proposed removal of 5.9 acres of turf to save water and money. Turf was removed by scalping and then covering the area with 6 to 8 inches of mulch. Herbicides were not used and the lack of sunlight prevented the turf from growing back. The irrigation system was removed. Plants and trees are being added to the project site and are being maintained by manual watering, as needed. The turf football field, two softball fields, and soccer fields are being traditionally maintained.

Water Savings Results and Other Benefits
The campus has reduced their water use by about 40% from the 8 year average prior to the project. The campus has become a drought tolerant garden which helps educate students and visitors on the benefits of being an environmental steward.

Best Management Practices

- Hand irrigation, when needed, reduces water loss.
- Drought tolerant plants require a lot less water than turf.
- Mulching decreases evaporation.

Project Contact
Jerry Budnick, Alternative Maintenance Services, 310-472-2919, jbudnick@alternativemaintenance.com

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Appendix D: Supplemental Materials for Water Use Metrics and Data Collection

Appendix D contains supplemental material referred to in Section 5: Water Use Metrics and Data Collection.

D.1 Criteria for Selecting a Metric

Criteria are established to evaluate the advantages and limitations of particular water-use metrics. Metadata (data about data) is composed of the multitude of factors defining and affecting the application of particular metrics. Establishing evaluation criteria provides a systematic approach for determining whether a particular metric is appropriate. The aspects for evaluating each proposed metric are described below.

Case

For the purpose of this report a proposed metric and the conditions of its use are called a "case." A case description contains the following: definition of a metric and its components, its intended purpose, and its intended application.

Technical Water-Use Merits

The technical merits of the metric used as a water-use efficiency or productivity performance indicator for the specific case are discussed below. For example, the scaling factor of a metric should have a relationship to water use. If studies have been conducted on the metric, the results of the effectiveness of the metric may be presented.

Metric Data

The specific data needed to calculate the metric are described. Also, the necessary parameters associated with the data are described.

Sources of Data

Provided in this section is a discussion on current or potential future sources of data, what or who the sources are, and the availability of the data. For a metric used as a general purpose indicator, the data for its calculation must be reasonably and consistently available.

Definitional Noise

A key factor in the applicability of a metric is the reliability of the data. As described earlier, definitional noise is a significant agent affecting the consistency and reliability of data. Provided in this section is discussion of the inaccuracies in metadata for the metric as a result of different, specific or general, definitions used for data collection or use of a data source.

Confounding Factors

A key aspect for proper application (appropriateness-in-use) of a water-use metric is identifying and understanding the agents contributing to plausible but erroneous conclusions. These misleading agents must be eliminated when possible and mitigated when necessary to provide methods for valid evaluations. Provided in this section is a discussion of the agents affecting the numeric value of a metric case unrelated to the purpose of a metric (e.g., social, economic, environmental, political factors or variability of manufacturing goods even within a subsector of like industries).

Evaluation

Provided in this section are rational judgments made from available information, including but not limited to the enumeration of limitations and advantages associated with the application of the metric, recommendations, and any caveats to prevent erroneous conclusions.

D.2 United Kingdom, Environment Agency, Best Practices Benchmarks Examples

The Environmental Agency of the United Kingdom has published the following water use benchmarks based on the metrics in the "unit" column of the table. The source for this document is cited at the end of the document.

Environment Agency

How much water should we be using?

Find out more about typical and best practice benchmarks

Your water use figure on its own doesn't tell you how much you could save. To do that, you need to compare your water use to the benchmarks in the table shown below.

Even if you are at or below the best practice benchmark, you may still be able to reduce your water use.

Table of typical and best practice benchmarks

	Typical	Best practice	Unit	Sample
Office	9.3	6.4	cu.m/person/yr	500
Prison with laundry	143	115.3	cu.m/prisoner/yr	144
Prisoner without laundry	116.6	9.4	cu.m/prisoner/yr	"
Primary school with pool	4.3	3.1	cu.m/pupil/yr	14,330
Primary school without pool	3.8	2.7	cu.m/pupil/yr	"
Secondary school with pool	5.1	3.6	cu.m/pupil/yr	"
Secondary school without pool	3.9	2.7	cu.m/pupil/yr	"
Defra laboratory	0.767	0.612	cu.m/m2 floor area/yr	14
Large acute or teaching hospital *1	1.66	1.38	cu.m/m2 floor area/yr	273
Small acute or long stay hospital *1 without personal laundry	1.17	0.90	cu.m/m2 floor area/yr	"
with personal laundry	1.56	1.24	cu.m/m2 floor area/yr	"
Court with catering facilities	0.54	0.35	cu.m/m2 floor area/yr	44
Court without catering facilities	0.25	0.20	cu.m/m2 floor area/yr	"
Museum and art gallery	0.332	0.181	cu.m/m2 floor area/yr	50
Nursing home	80.6	68.5	cu.m/resident/yr	70
College and university	0.62	0.40	cu.m/m2 floor area/yr	127
Public lavatory	10.7	6.0	cu.m/m2 floor area/yr	86
Police station	0.92	0.63	cu.m/m2 floor area/yr	141
Sports centre	0.0385	0.0305	cu.m/visitor/yr	65
Library	0.203	0.128	cu.m/m2 floor area/yr	89
Community centre	0.326	0.173	cu.m/m2 floor area/yr	62
Fire station	15.08	9.38	cu.m/person/yr	61
Coastguard station 2	12.62	no benchmark	cu.m/person/yr	116
Depots	no benchmark			23
Golf courses	no benchmark			45
Vehicle inspectorate depot 3	0.12	no benchmark	cu.m/m2 floor area/yr	71

1 For all hospitals with central laundry facilities add 8.2 litres per laundry article/yr
2 No benchmark recommended − figure should be used as a guideline only
3 Due to small sample size, good practice benchmarks were not calculated

Source: The Watermark project

Information from Environment Agency
http://www.environment-agency.gov.uk/business/topics/water/34866.aspx
Author: The Environment Agency | enquiries@environment-agency.gov.uk
Last updated: 12 December 2011

D.3 Metrics Used for Various Applications

CII Task Force members contributed examples of CII metrics shown in Table D.1.

Table D.1 - Metrics Used for Various Applications

Company	Water Tracked (units)	Water Metric (index or normalized)	Future Goal	Information Source
Chevron	Parts per million	Average oil concentration in discharges to water	1) Begin collecting total water-use data 2) Develop a corporate freshwater strategy	Chevron Corporate Responsibility Report 2009
Clorox	Million gallons	Ratio: Gallons of water per case	=	2011 Annual Report
Genentech	Cubic meters	Cubic Meters per unit of marketed product	Improve water efficiency by 10 percent by the year 2010, compared to 2004	2007 Corporate Sustainability Report
Hewlett-Packard	=	=	Reduce water consumption by 5% compared to 2007	HP's Environmental Goals and Policies
Johnson and Johnson	Cubic meters	Cubic Meters/$1000 sales	10% cumulative avoidance 2001-2005	2005 Sustainability Report
Northrop Grumman	"Water usage at Northrop Grumman is a minor component of our manufacturing and is not therefore a key element in our product lines"			2010 Corporate Responsibility Report
Pfizer	Million cubic meters	=	Continue to conserve water by setting internal targets at site level	2009 Corporate Responsibility Report/Key performance index
Qualcomm	Million gallons	=	Reduced our annual water and electricity usage	Qualcomm Social Responsibility Report
SEMPRA Energy	Billions of gallons per year	=	=	2010 Corporate Responsibility Report
Sony	Million cubic meters	=	Achieve absolute reduction of 20% or more in volume of water purchased or drawn from groundwater for manufacturing purposes at sites form the fiscal year 2000 level by fiscal year 2010.	Corporate Social Responsibility
UPS	Cubic meters	Cubic Meters per 1000 packages (normalized)	=	Sustainability at UPS 2010

D.4 Metric Cases

As discussed in Section 5.5.3, water use metrics take two basic forms: the basic quotient of volume per unit of time and an efficiency or productivity measure in the form of the basic quotient divided by a scaling or normalizing factor. The basic quotient is useful for monitoring overall water use for any defined situation and trends over time. It can be applied easily to monitor use for particular processes within an establishment, especially if there is submetering. This simple measure is also useful for utilities or the state to assess the portion of total water use devoted to CII sectors or subsectors, and whether there are any long-term trends of the water use. The basic quotient is not useful as an indicator of water use efficiency or changes in efficiency except under very controlled situations where confounding factors are minimal, such as for an individual industrial establishment where the quantity of products remains constant over time.

Where conditions are less controlled, measures of efficiency entail use of scaling factors, and the identification of appropriate metrics becomes much more challenging. It is essential to carefully define a metric and identify the controlling agents of its metadata to prevent misuse. A metric that is useful in one situation may be less useful in another.

Many water use metrics are used by businesses, government, industry associations, and others, as shown in Appendix D.3. Selecting an appropriate metric involves a systematic evaluation. Five metric context perspectives are identified in Figure 5.2. Most metrics are used within one or more of these perspectives. Some examples of metrics used in these context perspectives are given below. This is followed by an evaluation of three potential metrics as they might be used within a particular context. The evaluations are not thorough, but they do serve to illustrate the application of the selection criteria provided in the Section 5.5.7 and Appendix D.1.

1. **Specific Process or Application**
   Most of the BMPs in this report are applicable to specific processes or applications of water use, and appropriate metrics to assess the effectiveness of specific BMPs are included in sections of the report that address specific CII BMPs. Individual water users are encouraged to develop metrics that can be used for specific CII subsectors.

   Users should consider sub-metering to more accurately track disaggregated water use where appropriate. (See Section 7 for additional information.)

2. **Establishment**
   As an example of establishment level metrics, the Coca Cola Company has published data on the ratio of volume of water used to volume of beverage in units of liter per liter. It has used a time trend for its own facilities to monitor its objective of reducing its water use while growing its unit case volume. (The Coca Cola Company 2011.)

3. **Water Service Provider**
   At this time, water agencies use GPCD for evaluating water use efficiency goals.

4. **Specific CII Subsector**
   As an example of subsector metrics, the Beverage Industry Environmental Roundtable provides a guide for beverage companies to assess their water use and net consumption for producing beverages as well as the packaging and containers for beverages. It provides a framework to

document direct and indirect water use consumed in providing the raw materials and energy used in beverage and container production. The common metric is liters of water use per liter of beverage (Beverage Industry Environmental Roundtable 2011).

5. **Broad Aggregated CII Sectors**
Determining a single metric that represents one of the three CII sectors, such as commercial alone, or all three CII sectors combined is a challenge. Establishments within any CII sectors can have extremely dissimilar water use profiles with very different factors that drive water use. Applying GPCD based on population to the aggregated industrial sector, that is, all industries combined, is generally considered inappropriate. Two metrics are evaluated in Metrics Cases 2 and 3 below as potential metrics for aggregated CII sectors, one excluding the industrial sector.

Metrics Case Evaluations

Three metrics cases are evaluated. A "case" represents the metric and the defined conditions for use of the metric and the data incorporated into the metric. Metrics Case 1 applies only to a subsector, office buildings without cooling towers, while Metrics Cases 2 and 3 apply to aggregated CII sectors, either commercial and institutional sectors combined or to all three sectors.

Metrics Case 1 (Subsector): Office Buildings Without Cooling Towers

Metric: Gallons per square foot of building area per year (gal/ft^2/year)

Application: Office buildings without water-using cooling towers

This case represents a metric that applies to a subsector, office buildings, regardless of CII sector. Establishments with water use fitting a typical office building profile may be found in all three of the CII sectors. Significant differences are found between buildings with or without water-using cooling towers. For this example, metadata for this metric include that it is associated with buildings without cooling towers. This metric conceivably could be useful from the context perspective of Specific CII Subsectors shown in Figure 5.2. A company could compare efficiencies of its office buildings. If data were available to aggregate averages for office buildings within a geographic area, such as a county or state, a company could compare its building efficiency with the regional or statewide average to identify areas of potential improvement. The state could determine ranges for this subsector for water users to evaluate their water use.

Technical Water-Use Merits

A strong correlation between water use and heated-building area was found in a study by Morales et al. (2011).

Sydney Water has promoted this metric. Sydney Water is Australia's largest water utility and is a statutory state-owned corporation. Sydney Water has established several water use benchmarks for the CII sectors. Benchmarks using the building area metric are presented in the Table D.2.

Table D.2 - Benchmarks for Water Efficiency in Sydney Office Buildings

Benchmark	Office with cooling towers kL/m²/year (gal./ft²/year)	Office without cooling towers kL/m²/year (gal./ft²/year)
Median market practice with no leaks	1.01 (24.79)	0.64 (15.71)
Economic best practice	0.84 (20.62)	0.47 (11.54)
Very well managed	0.77 (18.90)	0.4 (9.82)

Adapted from Table 2 in Sydney Water (2012).

Sydney Water studied the office building water use in the area and established benchmarks, which act as performance indicators for water use. If a business can determine its water use for a year, it can compare its use to the benchmark to see how well it is doing.

Another example of presumed merit is using building area as a scaling factor as mandated by federal Executive Order 13514, which requires reductions for potable water consumption intensity. Potable water use intensity has been defined in federal guidance as annual potable water use divided by total gross square footage of facility space (gal/ft^2) (U.S. DOE, 2008).

Metric Data

The case metric is composed of a basic quotient and scaling factor (SF):

$$Basic\ quotient = \frac{Volume}{Time}, with\ units\ of\ \frac{gallons}{day}$$

SF = total building area in square feet (ft^2)

$$Case\ metric = \frac{Basic\ Quotient}{SF}, \text{with } units \text{ of } \frac{\frac{gallons}{day}}{ft^2} = \frac{gallons}{day{\sim}ft^2}$$

The required data are:

- Volume on one year averaged by 365 days per year to gal/day.
- Building Area, square feet for office buildings.

Sources of Data

Current: Annual volumes of water for office building users may be available from water service providers if their water customers and billing records identify office buildings as a customer category, perhaps by using a business classification system such as NAICS. In the case of Florida, where this metric was studied, the Florida Department of Revenue maintains a database of 8.8 million land parcels with associated data including building areas. For comparison, California building area data may be available from county assessors' offices. Because the typical office building water profile has a landscape component, there may be some geographical variation (a confounding factor) due to regional climatic differences. This would require adjustments to the data to account for regional representation of the data.

Future: Improvements in classification of customers in billing records and identification of assessor parcel numbers in billing records could improve availability of data for this metric.

Definitional Noise

If customers are classified using NAICS or another system based on business activity rather than water, office buildings may be placed in other classes, such as industrial.

Confounding Factors

A statistically valid sample of data for a statewide aggregate metric may not be possible if a significant number of water service providers cannot readily identify office buildings and its associated water use or if a significant number of counties cannot provide data on building areas on land parcels.

Weather conditions can affect water use, especially for landscaping irrigation, which can confound comparison of data over time. Weather normalization methodologies may be needed for this metric.

Evaluation

The availability of building area data from the county assessor and water delivered data to office buildings from water service providers was not investigated. Building area data would have to be correlated with office building water users, which would be difficult if water service providers do not record assessor parcel numbers in customer billing records. While studies have shown that this metric has technical merit, this metric may not be feasible for certain water service providers and counties for the use in the water service provider context.

Metrics Case 2 (Broad Aggregated Sectors): All Commercial and Institutional Establishments, Statewide

Metric: Gallons per day per capita (gpcd)

Application: All commercial and institutional establishments, statewide.

This case represents a statewide aggregated metric comprised of all establishments identified under the commercial and institutional sectors as shown in Figure 5.1, Water Use Sector Classification System. The purpose of this metric is to determine statewide trends in water use productivity.

Technical Water-Use Merits

The technical merit of this metric does not appear to have been evaluated in research studies. The merits are suggested based on the following suppositions that need further study. The commercial and institutional establishments primarily serve the population within the state. Unlike industrial establishments, it is presumed that the commercial and institutional services provided generally are not exported or serving populations outside the state. As such, commercial and Institutional services, as a statewide aggregate serving Californians, are somewhat proportional to statewide population. There are large institutions, such as military complexes, prisons, and universities, which serve the entire state as opposed to just the community where they are located. Based on these premises, changes over time in GPCD may be an indicator of changes in productivity, including efficiency, in the commercial and institutional sectors.

Ideally, all commercial and institutional establishments, including self-supplied water establishments or enterprises, would be included. Many large commercial and institutional establishments, military complexes, correctional facilities and universities, are self-supplied yet provide services to the entire state population. If all commercial and institutional water use were reported for the state, confounding factors resulting from incomplete data would be reduced.

Metric Data

The case metric is composed of a basic quotient and scaling factor (SF):

$$Basic\ quotient\ \frac{Volume}{Time}, \text{with units of } \frac{gallons}{day}$$

SF = general population served (capita).

$$Case\ metric = \frac{\text{Basic Quotient}}{\text{SF}}, \text{with } units \text{ of } \frac{\frac{gallons}{day}}{\text{capita}} = \frac{\text{gallons}}{\text{capita}{\sim}\text{day}}$$

The required data are:

- Volume on one year averaged by 365 days per year to gal/day for commercial and institutional establishments.
- Population served by the water agencies reporting the volume data in the state or the water agency service areas.
- Total population within each hydrologic region.

Sources of Data

Current: Water use and appropriate population measurements or estimates for the commercial and institutional sectors are required throughout the state such that a reproducible and statistically valid sample is feasible from which the statewide commercial and institutional sector GPCD may be calculated from year-to-year or at less frequent periods (e.g., every two or five years).

Yearly volumes of water for all commercial and institutional users are available from water service providers. There is no need in this case for a disaggregation of these sectors.

Because many commercial and institutional establishments have a landscape component in its water-use profile, there may be some geographical variation (i.e., a confounding factor) due to regional climatic differences. This would require adjustments to the data to account for regional representation of the data. The population served by the water agency can be provided by the water service provider using consistent methodologies as prescribed by DWR. The populations of hydrologic regions can be determined by DWR. The sources of population data are the U.S. Bureau of the Census and the California Department of Finance. A statewide aggregate can be composed of data from a sample of water service providers within the ten hydrologic regions defined by DWR, weighted by population served by the water service providers providing the data and total population within each hydrologic region.

Future: Improvements in classification of customers in billing records and identification of assessor parcel numbers in billing records could improve availability of data for this metric. Sub-metering to disaggregate large landscape and other main types of water use not defined as commercial or institutional would also improve data for this metric. Obtaining data from self-supplied water users would provide a more complete and accurate accounting and metric calculation.

Definitional Noise

The types of establishments which comprise the commercial, institutional, industrial sectors are not consistently defined.

As shown in Figure 5.1, large landscape is generally treated as its own water use sector. However, large landscapes are generally operated by enterprises serving a commercial or institutional, or even a multifamily purpose. A decision would have to be made whether the large landscape sector water use should be included in the commercial and institutional metric. For example, some utilities classify multifamily residential as commercial and large landscaping as commercial or institutional.

Differing methods for determining population served by water agencies could pose a problem, especially if the population estimating methods change over the course of trending.

Confounding Factors

A statistically valid sample of data for a statewide aggregate metric may not be possible due to insufficient data for self-supplied water establishments. If self-supplied water data are consistently excluded over time, the time trend of this case metric may still have meaning, even though the numeric value is not fully representative.

Weather conditions can affect water use, especially for landscape irrigation, which can confound the comparison of data over time. Weather normalization methodologies may be needed for this metric.

Economic fluctuations, such as recessions, can significantly affect business activity, and associated water use, independent of population served. This can make changes in the case metric over short time periods misleading as an indicator of efficiency or productivity.

Long-term changes in the composition of business in the state can affect the water use and resulting metric. This would confound the interpretation of this metric as an efficiency metric, but such long-term changes as they affect water use would still leave the metric as a water use productivity indicator.

Evaluation

GPCD may be the water use metric best known by the layperson. It is currently used to indicate relative water use efficiency at the utility level for urban water use. As discussed above, determination of values based on this metric does not provide an indicator of efficiency-in-use but rather provides a value which is better as an indicator of water use productivity in the aggregated commercial and institutional sectors. The omission of self-supplied water in current data reporting is a significant weakness.

Metrics Case 3 (Broad Aggregated Sectors): All Industrial Establishments, Statewide

Metric: Volume (gallons) of water used per unit of value (dollars) added to the economy for a given period (year).

Application: Statewide aggregated industrial sector.

This case represents a statewide aggregated metric comprised of all establishments identified in the industrial sector. The ability of this metric to indicate water use efficiency or productivity is evaluated. The statewide annual volume of water used in the industrial sector is divided by the gross domestic product (GDP) for the state "gross domestic product by state" or GDPS, formerly known as the Gross State Product or GSP). Value added is a measure of the contribution to the gross domestic product made by the economic activity in the defined industrial sector.

Technical Water-Use Merits

A decrease in the value of this metric may indicate: 1) improvements in technological efficiency, 2) structural changes in the economy with water use shifting to less water intensive industrial uses, 3) increase in reuse (recycling) of water in the industrial sector as a whole, and 4) use of alternative sources not accounted for in the volume of water used. (United Nations 2007).

The aggregated nature of the metric, i.e., statewide, provides identity protection to industrial establishments that are protective of their water-using techniques or quantities; no single industrial establishment or sector is singled out.

Metric Data

The case metric is composed of a basic quotient and scaling factor (SF):

$$Basic\ quotient\ \frac{Volume}{Time}, \text{with units of } \frac{gallons}{Year}$$

SF = Annual gross domestic product (GDPS) by state for California for the defined industrial establishments, dollars added per year.

$$Case\ metric = \frac{\text{Basic Quotient}}{\text{SF}}, \text{with } units \text{ of } \frac{\frac{gallons}{year}}{\text{GDPS}} = \frac{\text{gallons}}{\text{\$ GDPS}}, \text{a given year}$$

The required data are:

- Statewide industrial sector annual volume of water used as defined and determined by DWR. This includes municipal and self-supplied volumes within the industrial sector.
- GPDS as provided by the U.S. Bureau of Economic Analysis corresponding to California, the given year, and the defined industrial sectors.

Sources of Data

Current: Annual industrial water use volumes may be available from water service providers if their water customer billing records include adequate classifications or coding, perhaps using a business classification system such as NAICS. The population served by the water agency can be provided by the water service provider using consistent methodologies as prescribed by DWR. The populations of hydrologic regions can be determined by DWR using data from the U.S. Bureau of Census and the California Department of Finance. A statewide estimate of industrial water use can be derived from data from a sample of water agencies within the ten hydrologic regions defined by DWR, weighted by population served by the water service providers who provided the data and total population within each hydrologic region.

The annual gross domestic product by state is available though the Bureau of Economic Analysis (BEA), U.S. Department of Commerce. The data are available annually and disaggregation by NAICS coding is possible to a limited degree.

Future: Noting that DWR currently needs to use estimating techniques to derive the basic quotient for this case metric, it is expected that near future advancements in geospatial data sharing, large public domain datasets availability from regulatory agencies and industry associations may provide better data eliminating some of the estimation techniques currently employed to determine this metric.

It is likely that significant strides will be made to establish a unifying water use classification throughout the state, making the disaggregation of industrial sector water use from the total urban water use totals consistent from year to year.

Definitional Noise

The types of establishments which comprise the commercial, institutional, industrial sectors are not consistently defined.

Differing methods for determining population served by water agencies could pose a problem, especially if the population estimating methods change over the course of trending.

Confounding Factors

A statistically valid sample of data for a statewide aggregate metric may not be possible due to insufficient data for self-supplied water establishments. It may be inappropriate to use population as a basis for scaling sampled data to a statewide aggregated industrial water use. It may be more appropriate to use the number of industrial employees to derive statewide industrial water use than using general population. The data available through the Longitudinal Employer – Household Dynamics (LEHD) program may prove to be the best source of data to reduce effects of deriving self-supplied water estimates at the statewide level.

Weather conditions can affect water use, especially for landscape irrigation, which can confound comparison of data over time. As a rule, the fraction of water used for irrigating landscape is small for industrial establishments compared to product or process water use. However, some industrial process, most notably cooling tower, are affected significantly by weather. The overall extent to which weather affects industrial water use is not known. Water is utilized in a manufacturing process or product. Weather normalization methodologies may be needed for this metric because some industrial processes use more or less water depending on weather conditions.

Economic fluctuations, such as recessions, can significantly affect business activity, and associated water use, independent of population served. This can make changes in the case metric over short time periods misleading as an indicator of efficiency or productivity.

Long-term changes in the composition of business in the state can affect the water use and resulting metric. This would confound the interpretation of this metric as an efficiency, but such long-term changes as they affect water use would still leave the metric as a productivity indicator of water use.

Evaluation

This metric represents industrial water use normalized by productivity as value added in dollars on a statewide basis during a year-long period and will not capture regional temporal or spatial variability over any period of time. When values computed from the metric are trended over long time intervals, five or more years, these values may be so influenced by weather factors as to prevent meaningful evaluation or use of the metric as a water use efficiency or productivity indicator. Another approach using this metric might be to aggregate it from water use data collected and adjusted for separate subsectors with common water profiles. This may minimize certain confounding factors by allowing more accurate scaling factors to be used for extrapolating sampled data to statewide values.

Starting with better disaggregated data at the regional level with methodologies to track and correlate all major confounding factors affecting industrial water use may be essential in deriving an appropriate statewide level value for this metric. Such an approach would identify appropriate normalization methodology for weather and other confounding factors at the regional level. In conjunction with such an approach, the metric would likely need to be computed yearly, trended, and improvements in water use efficiency or productivity evaluated in accordance with any indentified constraints or parameters.

This metric may also give an indication of the intrinsic value being placed on water. Low values of this metrics occur when water is used for high dollar-value added activities. The metric's inverse, dollars per gallon, has low values when water is used for low dollar-value added activities and high values for high-dollar purposes. The intrinsic value associated or deemed with water use activities takes into account many tangible and intangible factors which are not addressed in this case study.

This metric would be computed by DWR and used appropriately along with other water use metrics to indicate increases in water use efficiency or productivity at the statewide level. DWR should work with all stakeholders to develop the record keeping techniques, data collecting, and data sharing methodologies necessary to render this metric a viable tool in assessing improvements in water use efficiency and productivity within the industrial sector.

D.5 Example Metric Analyses by the United Nations

The following is an example of a metric based on economic value added. The metric is the amount of water used per dollar of value added within a sector or subsector of the economy. This is a direct excerpt taken from "Indicators of Sustainable Development: Guidelines and Methodologies –Third edition Methodology sheets" published by the United Nations Division for Sustainable Development, Pages 203 to 206. This excerpt is available through the United Nations at http://www.un.org/esa/sustdev/natlinfo/indicators/methodology_sheets/freshwater/water_use_intensity.pdf.

WATER USE INTENSITY BY ECONOMIC ACTIVITY		
Freshwater	Water Quantity	Core indicator

1. INDICATOR

(a) **Name:** Water use intensity by economic activity

(b) **Brief Definition:** Cubic meters of water used per unit of value added (in US $) by economic activity.

(c) **Unit of Measurement:** m^3/ US $

(d) **Placement in the CSD Indicator Set:** Freshwater/Water Quantity

2. POLICY RELEVANCE

(a) **Purpose:** This indicator measures the intensity of water use in terms of volumes of water per unit of value added. It is an indicator of pressure of the economy on the water resources and therefore an indicator of sustainable development. It is an important indicator for policies of water allocation among different sectors of the economy since in water-scarce regions, where there is competition for water among various users, water is likely to be allocated to the less intensive use.

(b) **Relevance to Sustainable/Unsustainable Development (theme/sub-theme):** When this indicator is monitored over time, it shows whether the country manages its water resources to improve economic performance while simultaneously reducing the impact on the environment, that is, to decouple pattern of water use from economic growth. Water conservation policies aiming at improving water intensity (through, for example, recycling and better water-saving technologies) ultimately reduce pressure on the environment.

If the indicator is compiled for the whole economy without the breakdown by economic activity, it should be redefined as water abstraction divided by Gross Domestic Product (GDP). A decrease in the value of this indicator may indicate: (a) improvements in technological efficiency; (b) structural changes in the economy with water allocated to less intense activities; (c) increase reuse of water in the economy; and (d) use of alternative sources (e.g. desalinated water).

Water use intensity is defined in a similar way as the indicators on material and energy intensity. It could also be expressed as 'water use productivity' (the inverse of water intensity) (see points 3(c)).

(c) **International Conventions and Agreements:** None

(d) **International Targets/Recommended Standards:** None

(e) **Linkages to Other Indicators:** This indicator is linked to Annual Abstraction of Ground and Surface Water as Percent of Renewable Water. While the indicator of annual abstraction measures pressure on the water resources, the water intensity indicator measures the 'water requirements' of an economic activity (cubic meters of water per unit of value added generated) thus the pressure of the economy on the water resources. Together these two indicators form the basis for water allocation policies: in water-scarce countries, water is likely to be allocated to the less water intensive activity. This indicator can also be linked to social indicators, such as employment by economic activity, to evaluate the social impact of different allocation policies.

3. METHODOLOGICAL DESCRIPTION

(a) **Underlying Definitions and Concepts:** Water used by an economic activity consists of the sum of (i) water directly abstracted from the environment either permanently or temporarily for own use and (ii) water received from other industries including reused water. Value added (gross) by economic activity is defined as in the National Accounts as the value of output less the value of intermediate consumption; it is a measure of the contribution to GDP made by an economic activity. The industrial classification follows the International Standard Industrial Classification of all Economic Activities Rev.4 (ISIC) (UN, 2006a) used in the National Accounts. The following breakdown of the economic activities is recommended as minimum:

Agriculture, Forestry and Fishing (ISIC 01-03), Mining, Manufacturing and Electricity (ISIC 5-35) and Service industries (ISIC 37-99). Note that the activity that abstracts water for distribution – Water collection, treatment and supply, ISIC 36 – is excluded from the indicator as (i) the water abstracted and distributed to other activities is included in the use of the other activities and (ii) only a small part of the water abstracted by ISIC 36 is for its own uses. The indicator is computed at national level and its temporal scale is the calendar year.

(b) **Measurement Methods:** Value added is generally obtained from standard national accounts. Water abstracted for own use by an economic activity may be difficult to estimate especially for Agriculture. Water received from other economic units is often metered.

(c) **Limitations of the Indicator:** Since the indicator is computed at national level and for a year-long, it may hide spatial and temporal variability in water use. The industry breakdown distinguishes only three groups of industries to broadly distinguish Agriculture from Manufacturing and Service industries. A more detailed breakdown may be useful to compare productivity within these groups. For example, for countries which rely heavily to seasonal tourism, which often coincides with periods of high water scarcity, it may be particularly useful to identify explicitly the most relevant economic activities for tourism (such as, Accommodation and Food service activities).

(d) **Status of the Methodology:** This indicator can be derived from the standard hybrid tables of the System of Environmental-Economic Accounting for Water (UN, 2006b).

(e) **Alternative Definitions/Indicators:** In countries in which economic activities receive negligible amount of water from other units, the indicator could be calculated dividing the volumes of water directly abstracted by an economic activity for own use by value added. As mentioned in point 2(b), the inverse of water use intensity is 'water use productivity' which measures the value added generated by one unit of water used. Water productivity gives an indication of the intrinsic value being placed on water. It has low values when water is used for low value purposes, which is generally the case when water is abundant and/or undervalued. High values of the indicators are associated with water recycling and improved technology which reduce the amount of water used and therefore abstracted.

4. ASSESSMENT OF DATA

(a) **Data Needed to Compile the Indicator:** Direct water abstraction, water received from other economic units and value added (gross) by economic activity.

(b) **National and International Data Availability and Sources:** Economic data on value added by economic activity are generally available in countries. At the international level information on value added is part of the official national accounts statistics collected by UNSD and can be found in the UNSD publications *National Accounts Statistics: Main Aggregates and Detailed Tables* and *National Accounts Statistics: Analysis of Main Aggregates.* Data on water use by economic activities are collected at international level by two Questionnaires on water: the UNSD/UNEP Questionnaire which covers non-OECD countries and the Joint OECD/Eurostat Questionnaire which covers OECD countries.

(c) **Data References:**

Economic information is available at http://unstats.un.org/unsd/snaama/Introduction.asp

Water use information is available at http//unstat.un.org/unsd/ENVIRONMEN

5. AGENCIES INVOLVED IN THE DEVELOPMENT OF THE INDICATOR

(a) Lead Agency: United Nations Statistics Division. The contact point is the Chief of Environment Statistics Section, UNSD; fax no. 1 (212) 963 1374.

(b) Other Organizations: Not available.

6. REFERENCES

(a) Readings:

United Nations (2006a). International Standard Industrial Classification of all Economic Activities, ST/ESA/STAT/SER.M/4/Rev.4.

United Nations (2006b). System of Environmental-Economic Accounting for Water, (Published draft http://unstats.un.org/unsd/envaccounting/ceea/PImeetings/Handbook_Voorburg.pdf).

United Nations (2005). National Accounts Statistics: Analysis of Main Aggregates, 2004. ST/ESA/STAT/Ser.X/35. Sales No. E.06.XVII.8.

United Nations (2006). National Accounts Statistics: Analysis of Main Aggregates, 2003-2004. ST/ESA/STAT/Ser.X/34. Sales No. E.06.XVII.5.

United Nations (2008). International Recommendations for Water Statistics (forthcoming)

(b) Internet site:

http://unstats.un.org/unsd/environment
http://unstats.un.org/unsd/nationalaccount/nadefault.htm

D.6 East Bay Municipal Utility District Billing Classification Codes

East Bay Municipal Utility District (EBMUD) has a billing classification codes (BCC) system for water customers. There are 88 CII Codes and 3 residential codes. The codes are shown in Table D.3

Table D.3 - EBMUD Business Classification Code and Other Related Water Use Categories and Data for 2005.

Source: Data arranged by DWR from an Excel® workbook provided by EBMUD, file name “EBMUD_bcc_monthly_use_96_05”.

BCC	Category (CATG)	Brief Description (DESC1)	2005 (1000's of gallons)	2005 Accounts in BCC	Detail Description (DESC2)
100	COMMERCIAL	AGRICULTURE	82,135	113	farms, nurseries, vegetable gardens, dairy farms, poultry and eggs, other animal specialty farms, aviary, fishing and hunting, apiaries, forestry and ranches.
700	COMMERCIAL	VETERINARIAN SERVICES	23,684	95	kennels, animal hospitals, pet breeding and animal training.
1200	INDUSTRIAL	MINING AND QUARRYING	11,064	<10	sand and gravel washing.
1500	COMMERCIAL	CONSTRUCTION	33,172	702	Contractors, heavy construction, equipment yards.
2010	INDUSTRIAL	MEAT PRODUCTS - PROCESSING/PKG	38,650	31	cured, smoked, canned, frozen meat, sausage and pet food with meat.
2011	INDUSTRIAL	SLAUGHTERHOUSE	0	0	
2020	INDUSTRIAL	DAIRY PRODUCT PROCESSING	66,823	16	milk, butter, ice cream and cheese, bottled, condensed, dried, manufacturing/processing and packing.
2030	INDUSTRIAL	FRUIT AND VEGETABLE CANNING	536	<10	frozen foods, fruit drinks, preserves.
2040	INDUSTRIAL	GRAIN MILLS	12,264	<10	making cereals, blended and prepared flour and rice, grain-based breakfast food and pet food.
2050	INDUSTRIAL	BAKERIES	54,680	77	manufacturing bread and pastry products.
2051	INDUSTRIAL	BAKERIES - MFG BREAD ONLY	23,822	23	
2060	INDUSTRIAL	SUGAR PROCESSING	780,614	13	making confectionery, candy, cocoa, chewing gum and chocolate.
2070	INDUSTRIAL	FATS AND OILS	16,311	<10	refining, processing/packing cotton-seed oil, soy bean oil, vegetable oil, animal and marine fat, cooking oil and shortening.
2077	INDUSTRIAL	RENDERING TALLOW	0	0	animal and marine fat.
2080	INDUSTRIAL	BEVERAGE MANUFACTURE	398,505	17	bottling and canning soft drinks, flavoring and extract manufacturing, alcoholic beverages.
2090	INDUSTRIAL	SPECIALTY FOOD MANUFACTURING	28,891	31	yeast, vinegar, snack foods.
2091	INDUSTRIAL	SEAFOOD PROCESSING	1,335	<10	canning and freezing fish, processing fresh and smoked fish.
2300	INDUSTRIAL	TEXTILE GOODS MANUFACTURING	10,209	62	making apparel, finishing products from fabrics, fabric and carpet production.
2400	INDUSTRIAL	LUMBER AND WOOD	4,426	31	making plywood, forest products, sawdust, veneers, wood working, wood preserving.

BCC	Category (CATG)	Brief Description (DESC1)	2005 (1000's of gallons)	2005 Accounts in BCC	Detail Description (DESC2)
		PRODUCTS MFG			
2500	INDUSTRIAL	FURNITURE	9,838	87	wood and metal cabinets, mattresses and fixture manufacturing.
2600	INDUSTRIAL	PULP AND PAPER PRODUCTS MFG	27,139	23	making paper board, corrugated containers and boxes.
2700	INDUSTRIAL	PRINTING, PUBLISHING	17,782	146	printing plate engraving, typesetting and bookbinding.
2810	INDUSTRIAL	INORGANIC CHEMICALS MFG	85,689	20	making bulk inorganic pigments (excluding pesticides, drugs, medicines, cleaning agents, glycerin and cosmetics).
2820	INDUSTRIAL	SYNTHETIC MATERIALS MFG	23,803	41	plastic, synthetic rubber, man-made fibers, resins and cellulosic materials.
2830	INDUSTRIAL	DRUGS MANUFACTURING	139,573	35	medicinal chemicals and pharmaceutical products.
2840	INDUSTRIAL	CLEANING AND SANITATION PROD MFG	6,396	16	making soaps, detergents, cleaning solutions, disinfectants and cosmetics.
2850	INDUSTRIAL	PAINT MANUFACTURING	7,954	12	making water or oil soluble paints and varnishes.
2860	INDUSTRIAL	ORGANIC CHEMICALS MANUFACTURING	163,312	<10	making solvents, alcohols, plasticizers, synthetic oils, esters and amines (except plastics, drugs, agricultural chemicals, edible oils, and cleaning and sanitation preparations).
2870	INDUSTRIAL	AGRICULTURE AND CHEMICALS MFG	715	<10	making fertilizers, pesticides and herbicides.
2891	INDUSTRIAL	ADHESIVES AND GELATIN MFG	3,460	<10	
2893	INDUSTRIAL	INK AND PIGMENT MANUFACTURING	2,714	12	
2900	PETROLEUM	PETROLEUM PRODUCTS MANUFACTURING	4,937,509	36	petroleum refining, manufacturing paving and roofing materials, asphalt, lubrication oils, greases and waxes.
3000	INDUSTRIAL	RUBBER PRODUCTS	2,046	10	fabricated rubber products manufacturing.
3110	INDUSTRIAL	LEATHER TANNING	0	0	
3200	INDUSTRIAL	EARTHENWARE MANUFACTURING	150,400	64	making cement, glass, clay and stone products.
3300	INDUSTRIAL	PRIMARY METALS MANUFACTURING	61,803	65	furnaces and foundries, heat-treating, rolling and drawing of primary metals.
3400	INDUSTRIAL	METAL PRODUCTS FABRICATING	35,706	201	welding shops, forging, stamping, making cans, plate and fabricated metal products.
3410	INDUSTRIAL	DRUMS AND BARRELS MFG	626	<10	recycling, reconditioning.
3470	INDUSTRIAL	METAL FINISHING	14,288	40	electroplating, galvanizing, ferro-enameling, and allied services.
3500	INDUSTRIAL	MACHINERY MANUFACTURING	5,120	41	engines, farm, construction and other machinery (excluding foundries, transportation and electrical machinery, and fabricated metal).
3590	INDUSTRIAL	MACHINE SHOP	15,841	132	including knife and saw sharpening.

BCC	Category (CATG)	Brief Description (DESC1)	2005 (1000's of gallons)	2005 Accounts in BCC	Detail Description (DESC2)
		JOBBING/REPAIR			
3600	INDUSTRIAL	ELECTRICAL MACHINERY MFG	19,340	58	electric motors, generation and transmission supplies and equipment, household appliances and batteries.
3700	INDUSTRIAL	TRANSPORTATION EQUIPMENT MFG	180,554	22	making motor vehicles, aircraft, railroad, and other transportation equipment.
3730	INDUSTRIAL	SHIPBUILDING	18,239	15	building and repairing ships, barges and boats.
3800	INDUSTRIAL	PRECISION EQUIPMENT MFG	7,554	39	making scientific, photographic and optical equipment.
3900	INDUSTRIAL	MISCELLANEOUS MANUFACTURING	26,685	91	including toys, athletic goods and other items not listed elsewhere
4000	INDUSTRIAL	RAILROAD TRANSPORTATION	9,580	21	
4100	INDUSTRIAL	LOCAL AND SUBURBAN TRANSIT	36,521	82	operating taxis, buses and ambulances.
4200	COMMERCIAL	WAREHOUSING	376,527	1315	trucking, cold storage, van and storage firms and allied services.
4400	INDUSTRIAL	WATER TRANSPORTATION	70,473	126	marinas, passenger and freight, cargo handling.
4500	INDUSTRIAL	AIR TRANSPORTATION	138,524	12	passenger and freight, aircraft cleaning and janitorial services, airports.
4700	COMMERCIAL	TRANSPORTATION SERVICES	25,298	75	freight forwarding, stockyards, weigh stations, packing and allied services.
4800	COMMERCIAL	ELECTRONIC COMMUNICATIONS	36,632	120	telephone, telegraph, radio, TV systems and transmitting.
4900	COMMERCIAL	ELECTRIC, STEAM AND NATURAL GAS	29,689	66	utility systems.
4950	COMMERCIAL	SANITARY COLLECTION AND DISPOSAL	77,126	126	water, garbage, ash, groundwater remediation, sewage and acid waste.
5000	COMMERCIAL	WHOLESALE TRADE	40,219	305	excludes manufacturing, offices and food suppliers.
5300	COMMERCIAL	RETAIL TRADE, OTHER	854,411	4153	excludes manufacturing, offices, food, auto garages and auto dealers with repair facilities.
5400	COMMERCIAL	FOOD SALES	272,173	888	food suppliers, wholesale and retail, ice cream parlors, supermarkets, stores selling meat, fish produce, candy, health foods, doughnuts and grocery, retail bakeries.
5540	COMMERCIAL	GASOLINE AND OIL DEALERS	93,786	294	Sale of gasoline only, no repair (see 7500)
5811	COMMERCIAL	EATING PLACES, FAST FOOD	173,054	495	
5812	COMMERCIAL	EATING PLACES, RESTAURANTS	616,794	1331	bars with food service.
5813	COMMERCIAL	DRINKING PLACES, BARS,	50,476	199	without food service.

BCC	Category (CATG)	Brief Description (DESC1)	2005 (1000's of gallons)	2005 Accounts in BCC	Detail Description (DESC2)
		CLUBS			
6500	IRRIGATION	CEMETERIES	90,358	20	
6513	MULTIPLE FAMILY	APARTMENT BUILDING	8,661,245	9195	barracks (5 or more units on one meter), and mobile home parks.
6514	MULTIPLE FAMILY	MULTIPLE DWELLING - 2 TO 4 UNITS	2,895,631	19367	on one meter.
6800	COMMERCIAL	OFFICES	1,524,915	4256	professional, financial, real estate, post offices and all other offices and office buildings.
7000	COMMERCIAL	HOTELS WITH FOOD	307,041	127	motels with food service.
7001	COMMERCIAL	HOTELS WITHOUT FOOD SERVICE	318,717	243	temporary accommodations, hotels, motels, rooming and boarding houses WITHOUT food service.
7020	COMMERCIAL	BOARDING HOUSES	173,537	286	rooming houses, dormitories, fraternities, and sororities (with food service for residents only).
7200	COMMERCIAL	PERSONAL SERVICES	168,186	1259	artists, baby-sitting, barber shops, beauty salons, child care, health spa, escort services, locker rentals, steam baths, tailors, and all other services of a personal nature.
7210	INDUSTRIAL	COMMERCIAL LAUNDRIES	75,451	63	linen supply and diaper service.
7215	INDUSTRIAL	COIN OPERATED LAUNDROMATS	299,780	231	
7216	INDUSTRIAL	CLEANING AND DYEING FABRICS	40,803	116	using solvents, rugs and carpets.
7218	INDUSTRIAL	INDUSTRIAL LAUNDRIES	65,543	<10	cleaning rags and industrial uniforms.
7260	COMMERCIAL	CREMATORIES, FUNERAL HOMES	10,164	41	parlors of directors, morticians.
7300	INDUSTRIAL	LABORATORIES	514,644	152	food and non-health related research and testing, chemical radiation, fire extinguisher service and photographic studios.
7342	COMMERCIAL	FUMIGATING	284	<10	disinfection and exterminating services.
7500	COMMERCIAL	AUTOMOBILE REPAIR SERVICES	134,065	1139	includes body and fender shops, auto dealerships and gas stations with repair facilities, fork lift service, tire recapping, auto wrecking yards.
7539	INDUSTRIAL	BATTERY SERVICE	859	10	repair and rebuilding.
7542	INDUSTRIAL	AUTO LAUNDRIES	85,051	108	washing and polishing, car washes.
7600	COMMERCIAL	MISCELLANEOUS REPAIR SERVICES	7,742	132	non-automotive.
7699	INDUSTRIAL	SEPTIC TANK CLEANING	7,321	<10	
7900	COMMERCIAL	AMUSEMENT SERVICES	375,653	476	recreational centers, motion pictures and theaters.
7940	COMMERCIAL	EQUESTRIAN ACTIVITIES	80,594	19	stables, race tracks, horse breeding, riding schools.
7950	IRRIGATION	IRRIGATION USE ONLY	3,547,174	4345	planter strips, median strips.
7990	IRRIGATION	PARKS AND GARDENS	1,085,221	612	golf and country clubs, botanical gardens, aquariums.

BCC	Category (CATG)	Brief Description (DESC1)	2005 (1000's of gallons)	2005 Accounts in BCC	Detail Description (DESC2)
8000	INSTITUTIONAL	HEALTH SERVICES	642,367	1184	medical research and laboratories surgery, clinics, rest homes, dental offices, radiologists, pathological laboratories, convalescent hospitals.
8060	INSTITUTIONAL	HOSPITALS	399,900	132	excludes rest homes and convalescent hospitals.
8200	INSTITUTIONAL	SCHOOLS	1,636,542	1172	colleges, technical institutions, primary, secondary and nursery schools and libraries.
8600	INSTITUTIONAL	NON-PROFIT SERVICES/ORGANIZATION	534,910	1829	political, religious, union, fraternal, civic, museums and art galleries.
8800	SINGLE FAMILY	PRIVATE RESIDENCE	n.g.	n.g.	not given (n.g.)

Total BCC codes = 91

D.7 Texas Statewide Reporting of Water Use by Region

Figure D.4, including both table and pie chart, was provided by the Texas Water Development Board through its website at http://www.twdb.state.tx.us/waterplanning/waterusesurvey/estimates/2008/index.asp. See webpage listing under *Water Use Summary Estimates by Geographic Location*.

Figure D.4 illustrates results from mandatory water use reporting required in Texas as well a CII classifications of water use. More background is provided in Section 5.6.4 in Volume II.

2008 Water Use Survey Summary Estimates in Acre-Feet[1)]
Region and State Totals
Draft

Region	Population Estimates[2)]	Municipal	Manufacturing	Mining	Steam Electric	Irrigation	Livestock
A	375,568	77,727	47,274	870	8,577	1,887,897	49,691
B	200,632	31,608	2,085	186	6,647	94,944	8,861
C	6,347,359	1,264,490	47,415	10,638	14,457	27,865	16,192
D	750,641	116,457	93,559	211	45,720	27,668	21,766
E	775,544	119,534	5,862	48	3,286	392,382	2,515
F	598,967	116,149	11,273	4,041	5,549	419,272	14,411
G	1,882,994	322,787	22,600	17,289	52,062	287,034	46,680
H	5,861,517	873,098	538,558	8,130	79,033	228,963	12,289
I	1,044,693	180,483	222,218	40	29,224	94,704	19,194
J	124,661	24,128	24	74	0	5,752	2,226
K	1,378,209	251,896	21,914	17,104	45,949	394,176	12,449
L	2,401,648	406,335	82,919	10,908	55,568	372,536	22,802
M	1,512,392	238,817	4,083	664	1,224	1,038,890	4,737
N	554,187	102,057	51,230	2,365	2,032	28,515	7,002
O	468,744	76,796	10,949	1,607	19,195	4,540,124	54,293
P	49,218	7,149	902	94	0	154,598	3,906
Texas	**24,326,974**	**4,209,511**	**1,162,865**	**74,269**	**368,523**	**9,995,320**	**299,014**

[1)] An acre-foot is an amount of water to cover one acre with one foot of water and equals 325,851 gallons.

[2)] 2008 Total Population Estimates for Texas counties as of July 1, 2008 from the Texas State Data Center.

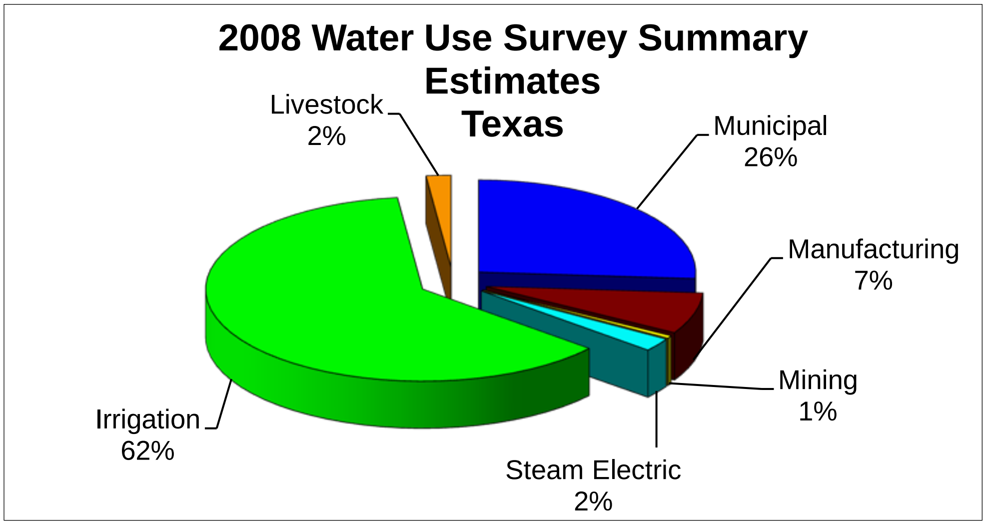


Figure D.4 - Texas Statewide Reporting of Water Use by Region

Appendix E: Supplemental Materials for Commercial, Industrial & Institutional Sectors and the BMPs

Appendix E includes additional information referred to in Section 7: Commercial, Institutional, & Industrial Sectors and the BMPs.

E.1 Food and Beverage Industry

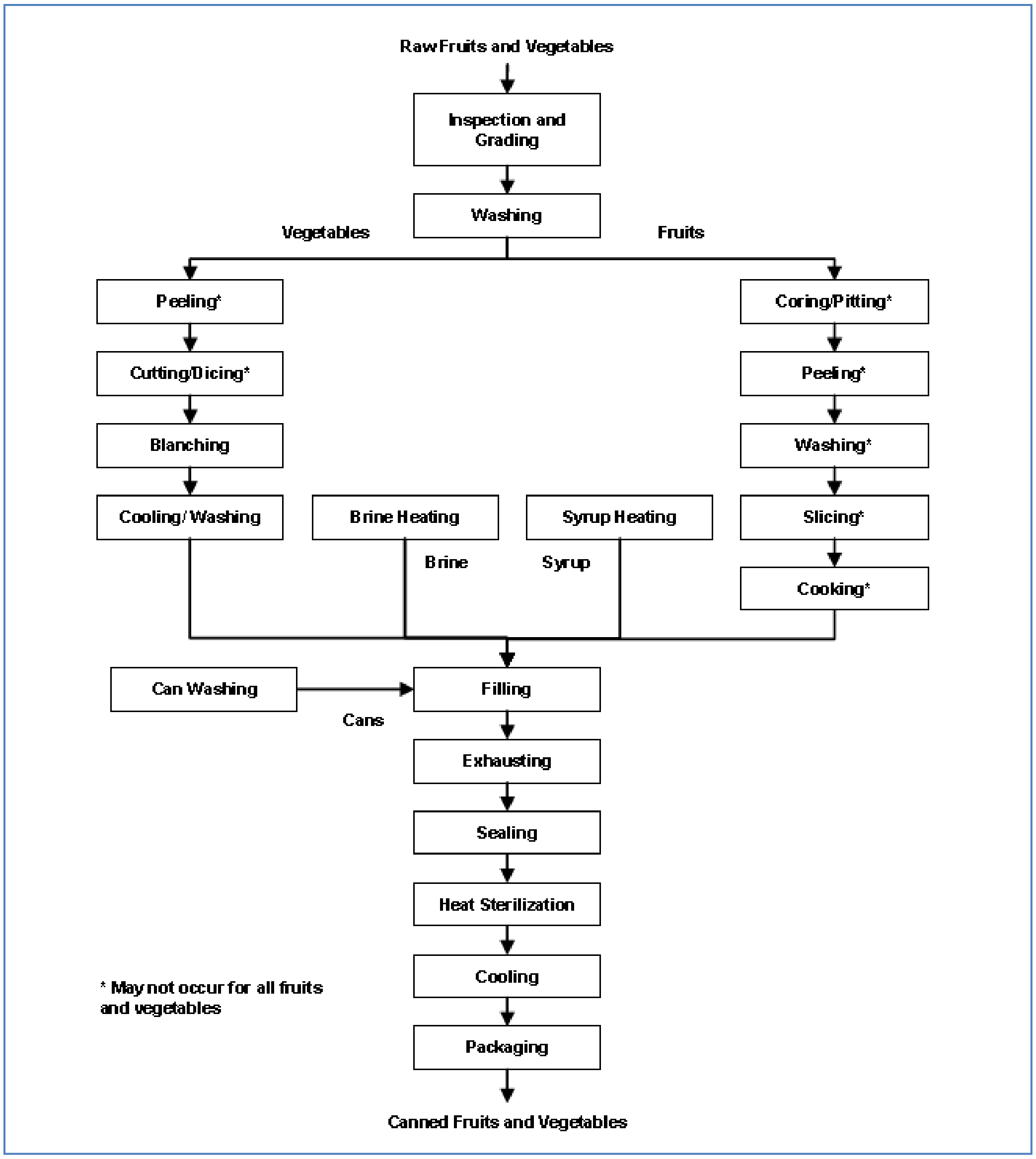
Regulations Impacting Food Processing Operations

At the State level there are the CDPH Food and Drug Branch codes including:

- Sherman Food, Drug, and Cosmetics Law
- California Cannery Inspection Program
- California Retail Food Code

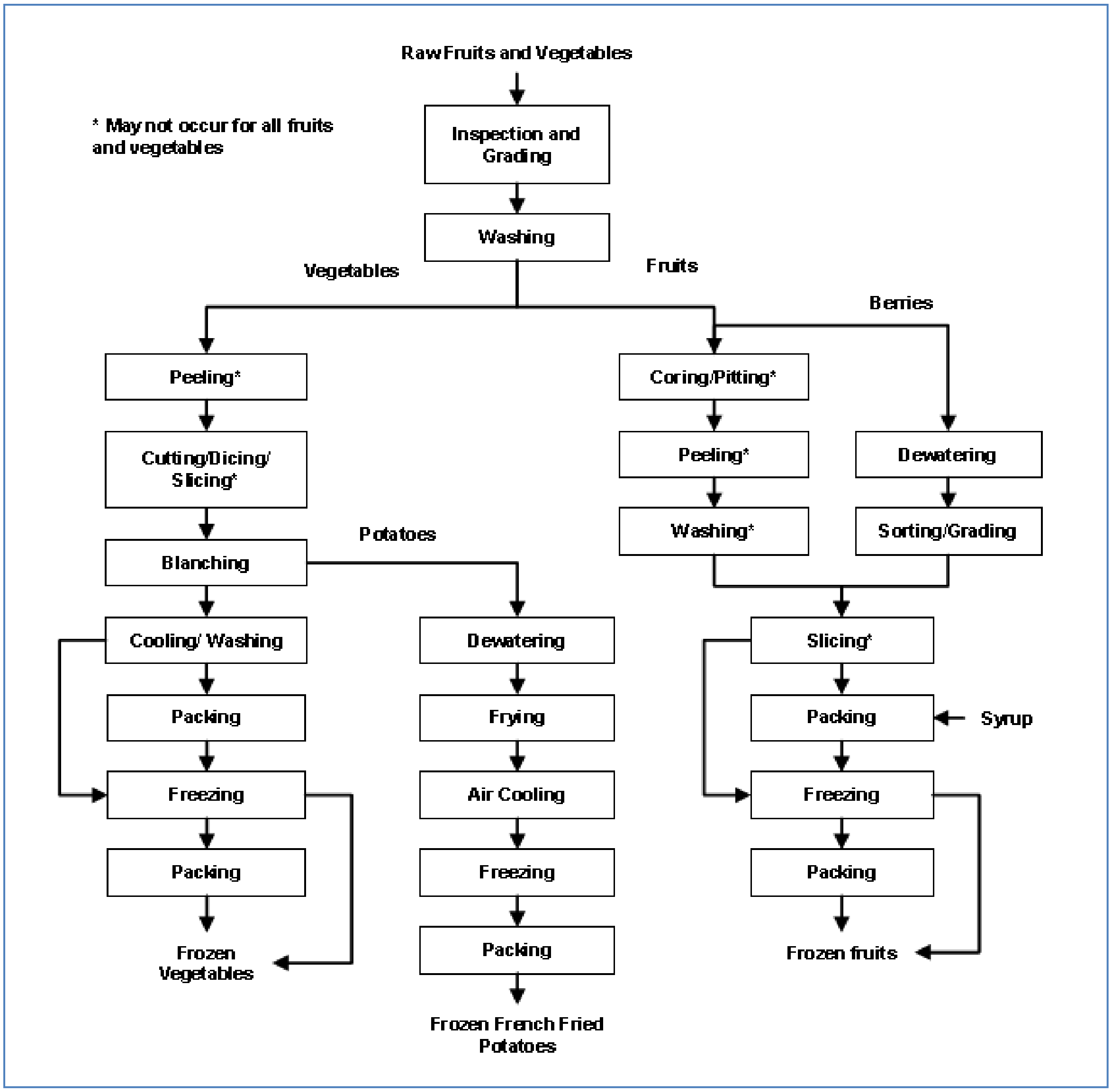
Other applicable regulations include:

- Cold Storage or Refrigeration Facility License Application
- Bottled Water Distributor and Cannery License Applications
- Export Document Requirements, Application, and Instruction
- Frozen Food Locker Plant License Application
- Organic Processed Products Registration Application
- Pet Food Processor License - Registration Application
- Processed Food Registration Application California Food Sanitation Act
- State of California Health and Safety Code
- California Code of Regulations
- California Processed Food Registration Questions and Answers
- Cannery Inspection Regulations California Cannery Laws
- California Cannery Inspection Program.



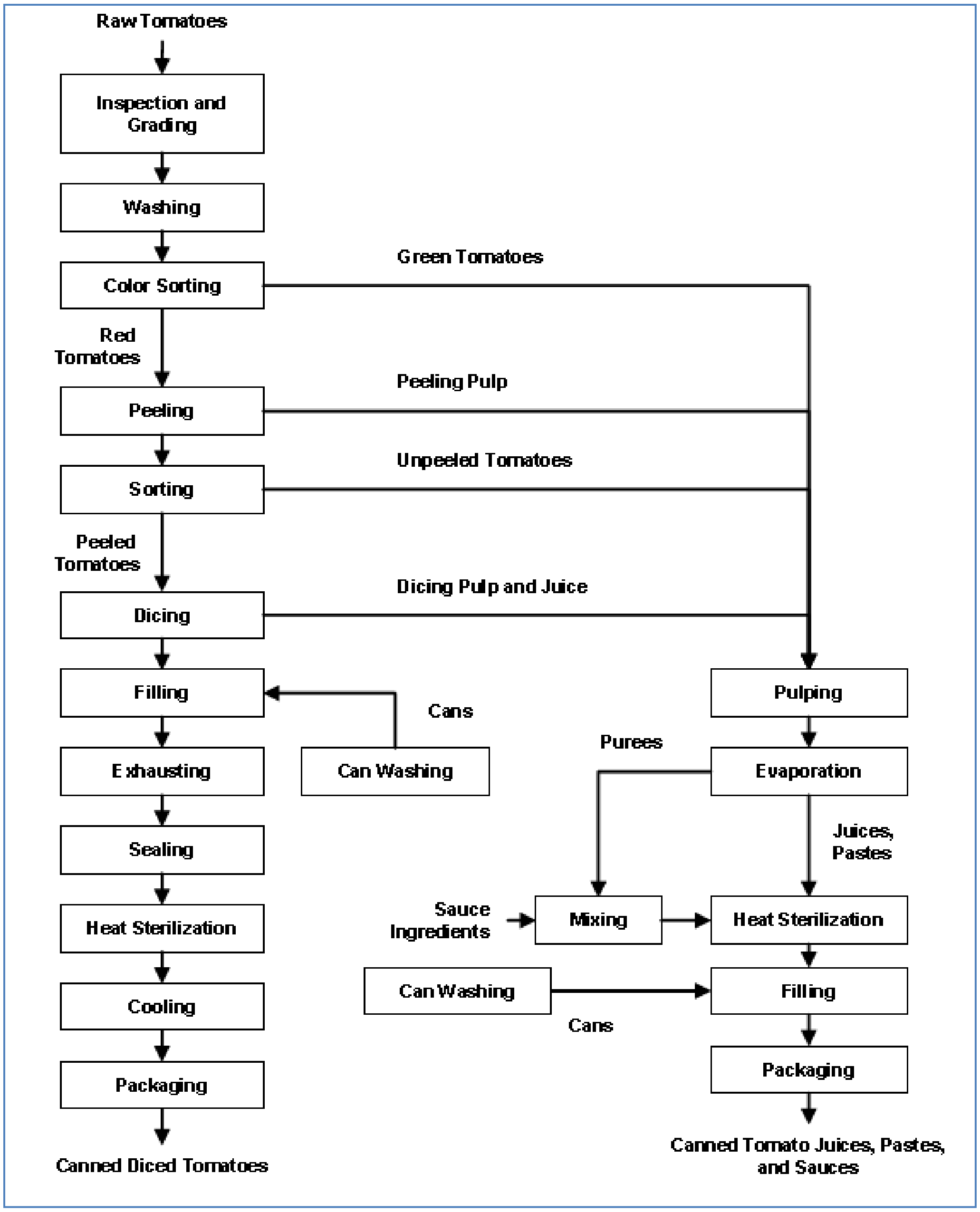
Source: Lawrence Berkley Laboratories:
www.industrialenergy.lbl.gov/drupal.files/industrial.../Fruit-Vegetables.pdf

Figure E.1 - Fruit and Vegetable Canning



Source: Lawrence Berkley Laboratories: www.industrialenergy.lbl.gov/drupal.files/industrial.../Fruit-Vegetables.pdf

Figure E.2 - Frozen Fruit and Vegetable Processing



Source: Lawrence Berkley Laboratories:
www.industrialenergy.lbl.gov/drupal.files/industrial.../Fruit-Vegetables.pdf

Figure E.3 - Tomato Product Processing

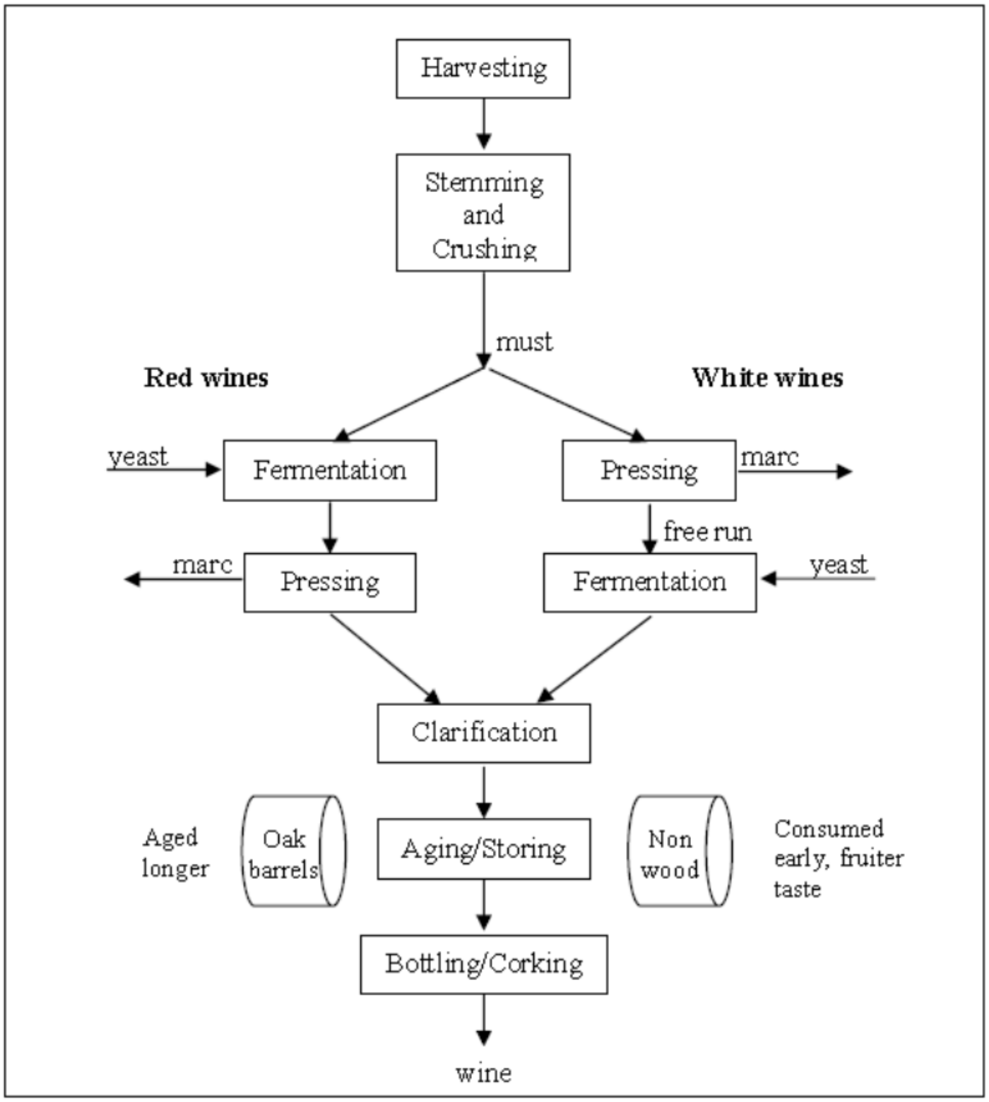


Figure E.4 - Wine Making Process

Since wine making is a major endeavor in California, several comprehensive studies of the industry have been conducted including:

- The Wine Institute, **Comprehensive Guide to Sustainable Management of Winery Water and Associated Energy**
- CEC and Lawrence Berkley Laboratories, **Best Winery Guidebook: Benchmarking and Energy and Water Savings Tool for the Wine Industry**

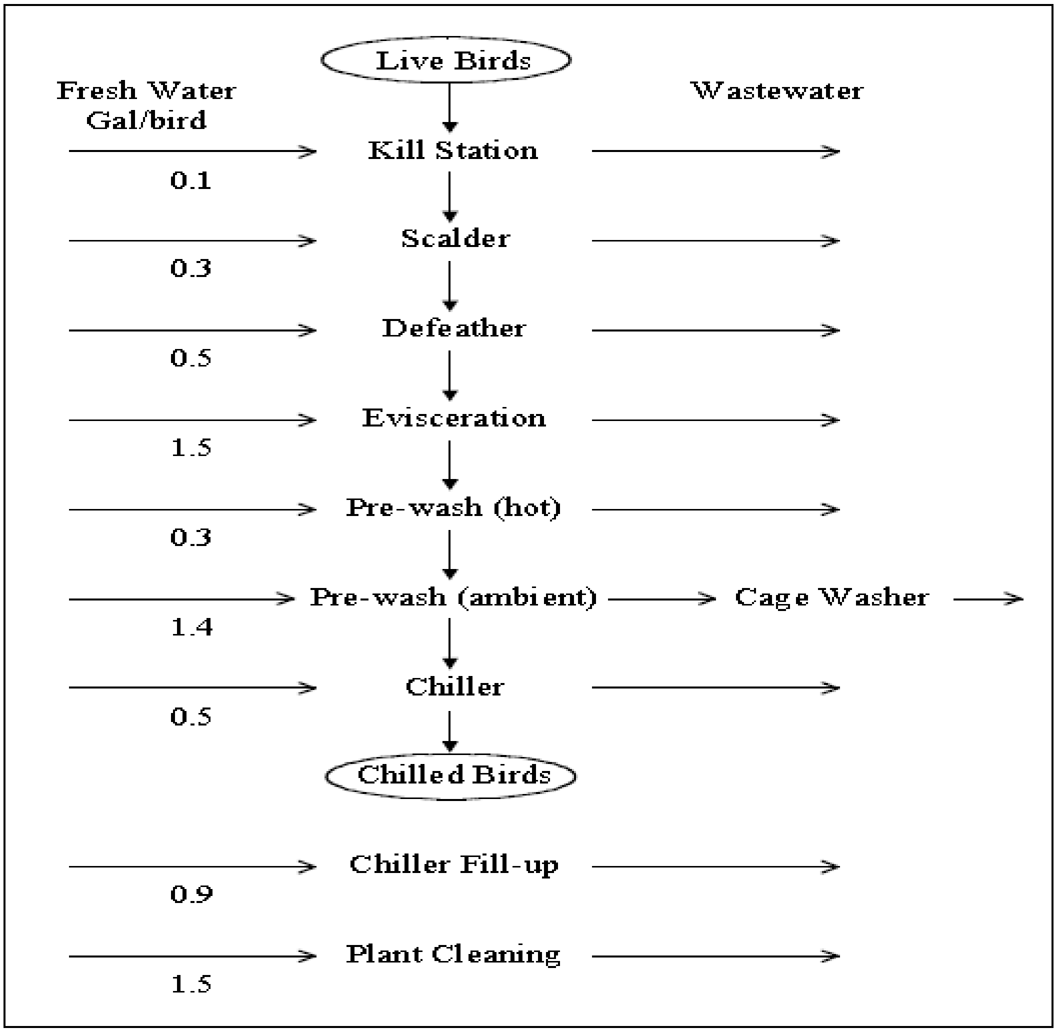
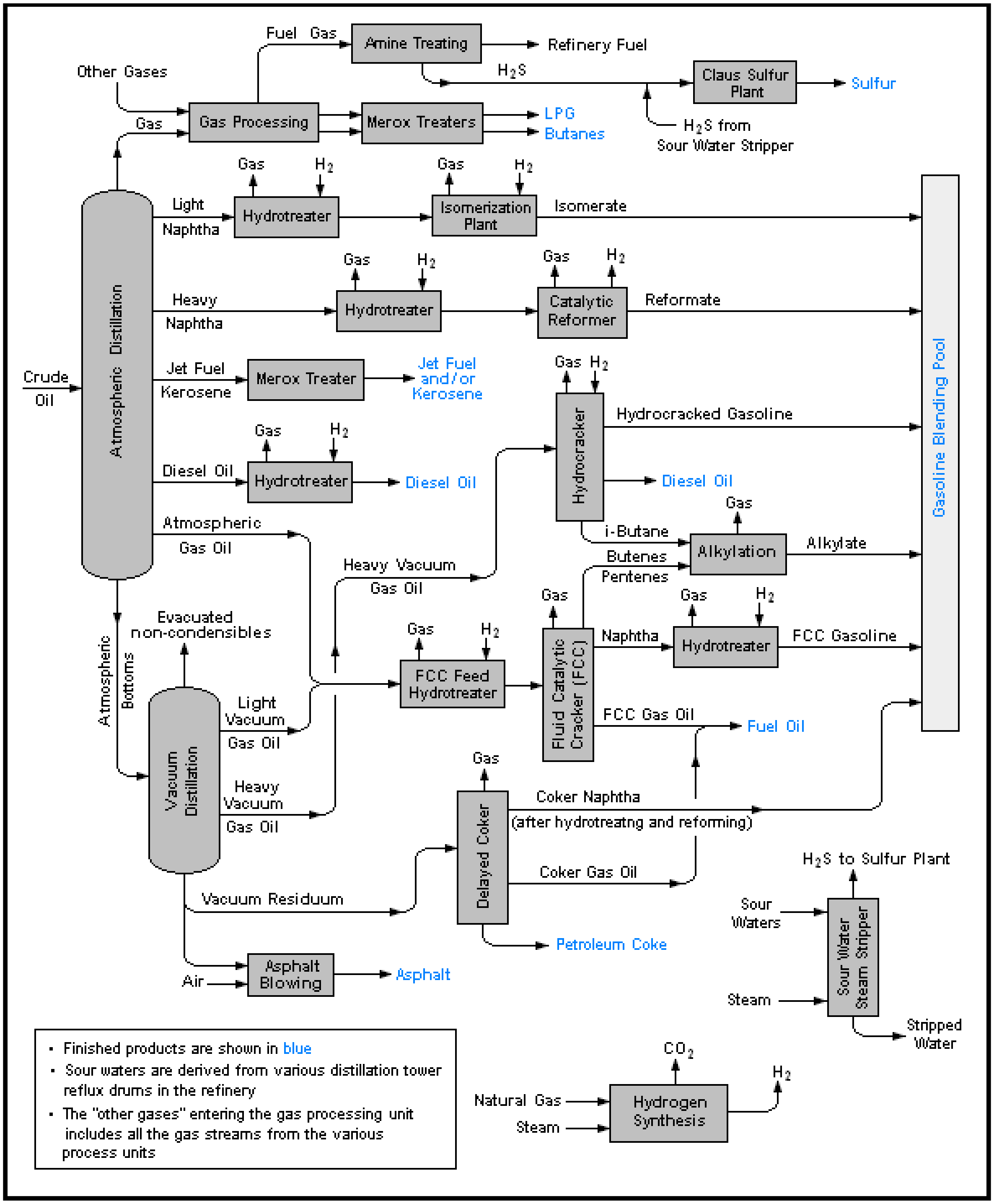


Figure E.5 - Water Use in Chicken Processing

Table E.1 - Examples of Equipment Used for Poultry Processing That Must be Cleaned

Processing Stage	Equipment
Arrival	• Bird crate washers • Flat belt conveyors • Killing machines • Overhead lubricators • Stunners (high frequency) • Telescopic piping
Picking/Defeathering	• Bleeding trough • Blood tanks and pumps • Blood tanks • Chain and shackle washer • Feet and hock pickers, cutters and unloaders • Feather conveyors • Feather pickers
Evisceration	• Air scissors • Bird unloaders • Eviscerating trough • Giblet and gizzard pumps, washers and processing • Inside outside bird washers • Inspection stands • Long guns • Neck cutters/skinners • Vacuum Systems (lungs)
Cut-Up and Deboning	• Cone lines • KFC cut-up saws • Mechanical deboners • Skinning machine • Stainless steel tables • Three piece wind cutter • Hopper weighers
Transportation Systems	• Conveyor systems of all types • Chain and shackles conveyors • Totes • Diaphragm pumps
Packing and Shipping	• Bagging systems • Boxing systems • Refrigeration equipment • Loading equipment

Appendix E.2: Petroleum Refining and Chemical Industries



Source: http://en.wikipedia.org/wiki/Oil_refinery

Figure E.6 - Basic Oil Refining Process

Appendix E.3 - Pharmaceutical and Biotech Industries

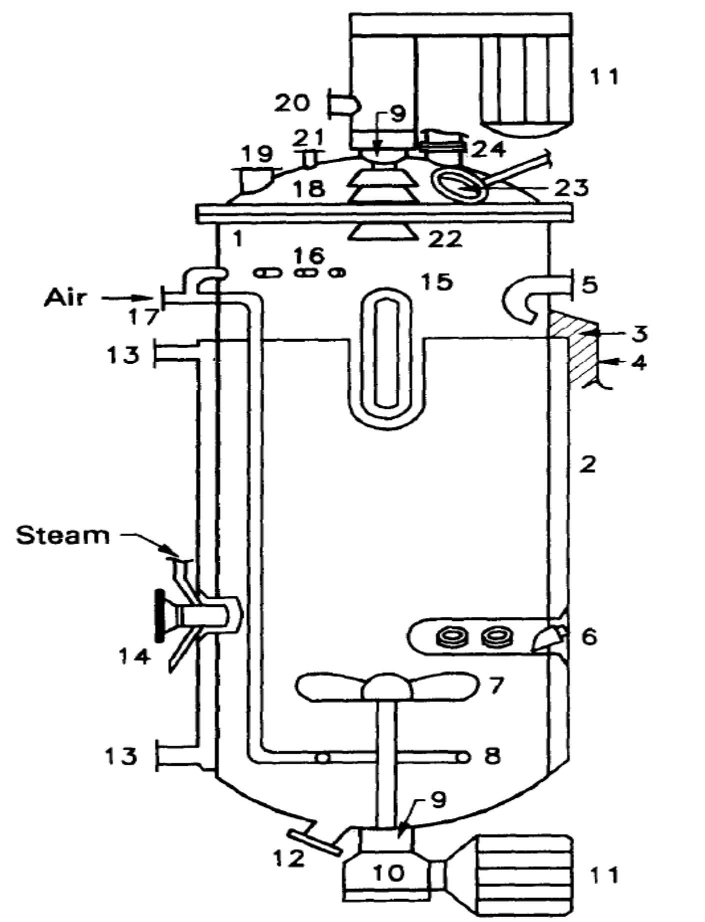


Fig. 1. A typical bioreactor: (1) reactor vessel; (2) jacket; (3) insulation; (4) shroud; (5) inoculum connection; (6) ports for pH, temperature and dissolved oxygen sensors; (7) agitator; (8) gas sparger; (9) mechanical seals; (10) reducing gearbox; (11) motor; (12) harvest nozzle; (13) jacket connections; (14) sample valve with steam connection; (15) sight glass; (16) connections for acid, alkali and antifoam chemicals; (17) air inlet; (18) removable top; (19) medium or feed nozzle; (20) air exhaust nozzle; (21) instrument ports (several); (22) foam breaker; (23) sight glass with light (not shown) and steam connection; (24) rupture disc nozzle.

Source: Clean-in-place systems for industrial bioreactors: design, validation and operation, Yusuf Chisti and Murray Moo-Young, Journal of Industrial Microbiology, 1994

Figure E.7 - Biological Fermentation Bioreactor

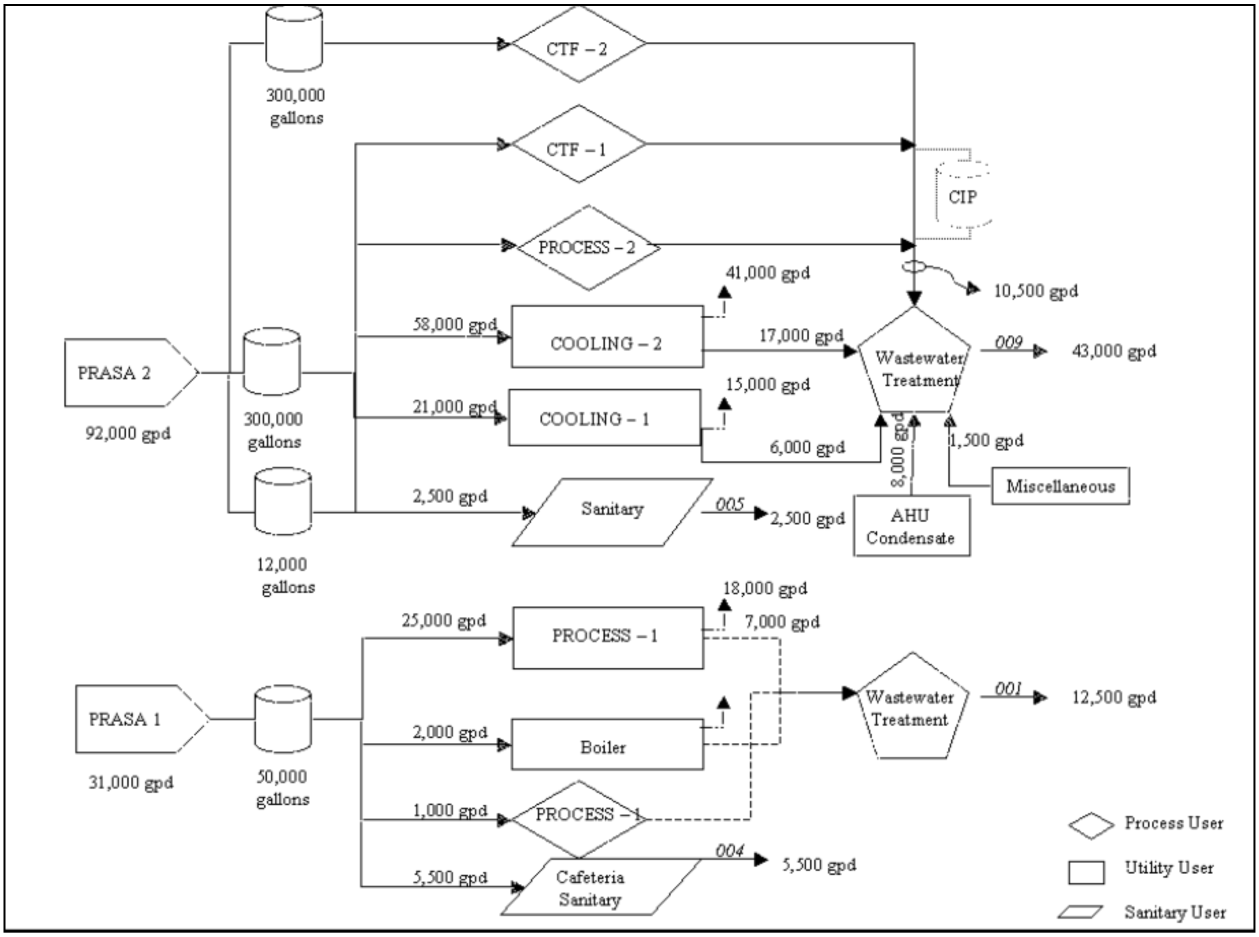


Figure E.8 - Example of a Water Balance from an Actual Pharmaceutical Industry
Source: Joseph G. Cleary, P.E., BCEE, Water Conservation and Reuse Case Study in Pharmaceutical Industry. HydroQual, Inc. 1200 MacArthur Blvd., Mahwah, NJ 07430

Appendix F: Standards and Codes for Water Use Efficiency

Industry standards and codes applied to residential and commercial for water use efficiency in water-using appliances are summarized in Table F.1. This table is reference in Section 8 of the CII Task Force report. Standards from the following organizations are presented in the table within this appendix:

- EPAct 1992, EPAct 2005, ‘‘Energy Independence and Security Act of 2007’’ (or backlog NAECA updates)
- WaterSense® or Energy Star®
- Consortium for Energy Efficiency

Acronyms and abbreviations for this table are defined within.

Table F.1 - Standards and Codes for Water Use Efficiency

Fixtures and Appliances	**EPAct 1992, EPAct 2005, ''Energy Independence and Security Act of 2007''** ***(or backlog NAECA updates)***		**WaterSense® or Energy Star®**		**Consortium for Energy Efficiency**	
	Current Standard	**Proposed/Future Standard**	**Current Requirements**	**Proposed/Future Requirements**	**Current Specification**	**Proposed/Future Specification**
Residential Toilets (Water Closets)	1.6 gpf[255]	1.28 gpf/ 4.8 Lpf proposed by efficiency advocates for tank-type only	Tank-type toilets only: WaterSense® = 1.28 gpf (4.8L) with at least 350 gram waste removal + LADWP Supplementary Purchase Specification (SPS) Effective Nov 2011, EPA announced revisions to product specifications for sampling, product marking, & flapper seals, see: http://www.epa.gov/WaterSense/docs/revised_het_spec_revisions_summmary_050611_final508.pdf		No specification	
Residential Lavatory (Bathroom) Faucets	2.2 gpm at 60 psi[256]	1.5 gpm/ 5.7 Lpm proposed by efficiency advocates	WaterSense® = 1.5 gpm maximum & 0.8 gpm minimum at 20 psi		No specification	
Residential Kitchen Faucets				None proposed at this time	No specification	
Residential Showerheads	2.5 gpm at 80 psi		WaterSense® = 2.0 gpm max with spray force & coverage		No specification	

[255] EPAct 1992 standard for toilets applies to both commercial and residential models.
[256] EPAct 1992 standard for faucets applies to both commercial and residential models.

Fixtures and Appliances	EPAct 1992, EPAct 2005, ''Energy Independence and Security Act of 2007'' *(or backlog NAECA updates)*		WaterSense® or Energy Star®		Consortium for Energy Efficiency	
	Current Standard	**Proposed/Future Standard**	**Current Requirements**	**Proposed/Future Requirements**	**Current Specification**	**Proposed/Future Specification**
			requirements			
Residential Clothes Washers	MEF(modified energy factor) ≥ 1.26 ft^3/kWh/cycle WF ≤ 9.5 gal/cycle/ft^3 Note: MEF measures energy consumption of the total laundry cycle (wash + dry). The higher the number, the greater the energy efficiency	DOE has published a proposed rule for machines made after March 7, 2015 and before Jan. 1, 2018 as follows: For STANDARD washers of ≥ 1.6 ft^3 (a) front loading: MEF=1.84 & **WF (water factor)=4.7** (b) top loading: MEF =1.29 & **WF=8.4** For SMALL washers of < 1.6 ft^3 : (a) front loading: MEF=1.13 & **WF=8.3** (b) top loading: MEF=0.86 & **WF=14.4** DOE has also published a proposed rule for machines made after Jan 1, 2018: For STANDARD washers of ≥ 1.6 ft^3 (a) front loading: MEF=1.84 & **WF=4.7** (b) top loading: MEF =1.57 & **WF=6.5** For SMALL washers of < 1.6 ft^3 : (a) front loading: MEF=1.13 & **WF=8.3** (b) top loading:	Energy Star (DOE) Effective Jan 1, 2011: MEF ≥ 2.0 **WF ≤ 6.0 gal/cycle/ft^3** New: Energy Star Most Efficient (Tier 2 Energy Star) Effective Jan 1, 2012 to Dec 31, 2012 ,: washers greater than 2.5 cubic feet, MEF 3.0 ft^3/kWh/cycle; WF 3.3 gal/cycle/ft^3 And for compact capacity washers less than 2.5 cubic feet, MEF 2.3 and WF 4.5 Note: Only EPA certified by independent body residential clothes washers (no combo washer-dryers) with capacity larger than 1.6 cubic feet are eligible for the Most Efficient Label	Energy Star will likely modify the current specification on or before March 7, 2015. Most Efficient Energy Star (Tier 2) may continue in 2013	Effective Jan 1, 2011, Tier 1: MEF ≥ 2.0 ft^3/kWh/cycle; WF ≤ 6.0 gal/cycle/ft^3 Tier 2: MEF ≥ 2.2 ft^3/kWh/cycle; WF ≤ 4.5 gal/cycle/ft^3 Tier 3: MEF ≥ 2.4 ft^3/kWh/cycle; WF ≤ 4.0 gal/cycle/ft^3	

Fixtures and Appliances	EPAct 1992, EPAct 2005, ‘‘Energy Independence and Security Act of 2007’’ *(or backlog NAECA updates)*		WaterSense® or Energy Star®		Consortium for Energy Efficiency	
	Current Standard	**Proposed/Future Standard**	**Current Requirements**	**Proposed/Future Requirements**	**Current Specification**	**Proposed/Future Specification**
		MEF=1.15 & **WF=12.0**				
Standard Size and Compact Residential Dishwashers [257]	STANDARD models: Energy: ≤ 355 kWh/yr **WF ≤ 6.5 gallons/cycle** COMPACT Models: Energy: ≤ 260 kWh **WF ≤ 4.5 gallons/cycle**	Final Rule of DOE, 5/30 2012, effective 5/30/2013: STANDARD Size Models: Energy: ≤ 307 KWh/year **WF ≤ 5.0 gallons/cycle** COMPACT Models: Energy: ≤ 222 kWh/yr **WF ≤ 3.5 gallons/cycle**	Energy Star (DOE) Effective Jan 20, 2012: STANDARD Size Models: Energy: ≤295 kWh/year **WF ≤ 4.25 gallons/cycle** COMPACT Models: Energy: ≤222 kWh/year **WF ≤ 3.5 gallons/cycle** kWH/yr has replaced EF as a metric since it includes the cycles the		Effective Jan. 20, 2012: Tier 1: EF ≥ 0.75 cycles/kWh; and 295 max kWh/year; **WF ≤4.25 gallons/cycle** *Compact models = less than 8 place settings*: EF ≥ 1.0	Could adjust tiers when new Energy Star becomes effective

[257] ***Standard models*:** capacity is greater than or equal to eight place settings and six serving pieces; ***Compact models*:** capacity is less than eight place settings and six serving pieces

Fixtures and Appliances	EPAct 1992, EPAct 2005, ''Energy Independence and Security Act of 2007'' *(or backlog NAECA updates)*		WaterSense® or Energy Star®		Consortium for Energy Efficiency	
	Current Standard	Proposed/Future Standard	Current Requirements	Proposed/Future Requirements	Current Specification	Proposed/Future Specification
			machine can run for each kWh, but also includes standby power (when the machine isn't cycling)		cycles/kWh; 222 max kWh/year; **WF ≤3.5 gallons/cycle**	

Fixtures and Appliances	EPAct 1992, EPAct 2005 *(or backlog NAECA updates)*		WaterSense® or Energy Star®		Consortium for Energy Efficiency	
	Current Standard	**Proposed/ Future Standard**	**Current Requirements**	**Proposed/Future Requirements**	**Current Specifica-tion**	**Proposed /Future Specification**
Commercial Toilets (Water Closets)	1.6 gpf[258]/6.0 Lpf Except blow-out fixtures: 3.5-gpf/13 Lpf **Note:** Some states prohibit blow-out at 3.5 gpf	1.28 gpf - 4.8 Lpf proposed by efficiency advocates for tank-type only	Tank-type toilets only: WaterSense®= 1.28 gpf (4.8L) with at least 350 gram waste removal + LADWP Supplementary Purchase Specification (SPS) + other requirements	Flushometer valve/ bowl combinations: WaterSense® specification in development. No release date promised.	No specification	.
Commercial Urinals	1.0 gpf	0.5 gpf - 1.9 Lpf proposed by efficiency advocates	WaterSense® = 0.5 gpf/1.9Lpf (flushing urinals only – non-water urinals not covered by WS)		No specification	
Commercial Faucets	Private (single-user) faucets, including residential within commercial bldg: 2.2 gpm at 60 psi[259] All other commercial faucets (except metering) per ANSI standard: 0.5 gpm at 60 psi[5] Metering (auto shut off) faucets: 0.25 gallons per cycle[260] (**no maximum flow rate**)			WaterSense® draft specification currently under consideration	No specification	

[258] EPAct 1992 standard for toilets applies to both commercial and residential models.
[259] In addition to EPAct requirements, the American Society of Mechanical Engineers standard for public lavatory faucets is 0.5 gpm at 60 psi (ASME A112.18.1-2005). This maximum has been incorporated into the national Uniform Plumbing Code and the International Plumbing Code for all except private applications, private being defined as residential, hotel guest rooms, and health care patient rooms. All other applications subject to the 0.5 gpm/1.9 Lpm flow rate maximum.
[260] Metering faucets not subject to flow rate maximum

Fixtures and Appliances	EPAct 1992, EPAct 2005 *(or backlog NAECA updates)*		WaterSense® or Energy Star®		Consortium for Energy Efficiency	
	Current Standard	**Proposed/ Future Standard**	**Current Requirements**	**Proposed/Future Requirements**	**Current Specifica-tion**	**Proposed /Future Specification**
Commercial Clothes Washers	MEF ≥ 1.26 ft^3/kWh; **WF ≤ 9.5 gal/cycle/ft^3**	Proposed Jan 1, 2013: Top loaders: 1.6 MEF and **WF ≤8.5 gal/cycle/ft^3** Front loaders: 2.0 MEF and **WF ≤5.5 gal/cycle/ft^3**	**Energy Star:** MEF ≥ 2.0ft^3/kWh/cycle; **WF ≤ 6.0 gal/cycle/ft^3**	**Energy Star :** **Effective February 1, 2013** 2.2 MEF and **≤ 4.5 WF** For both front and top loaders (defined as a soft-mounted front or top loading machine for use in common area and coin-op laundries with capacity greater than 1.6 cubic feet and not a combo washer-dryer)	(Note: this spec covers only normal capacity family washers, NOT large capacity commercial washers) Tier 1: 2.0 MEF **WF ≤ 6.0 gal/cycle/ft^3** Tier 2: 2.200 MEF **WF ≤ 4.5 gal/cycle/ft^3** Tier 3: 2.40 MEF **WF ≤ 4.0 gal/cycle/ft^3**	Considering changes for 2013

Fixtures and Appliances	EPAct 1992, EPAct 2005 *(or backlog NAECA updates)*		WaterSense® or Energy Star®		Consortium for Energy Efficiency	
	Current Standard	**Proposed/ Future Standard**	**Current Requirements**	**Proposed/Future Requirements**	**Current Specifica-tion**	**Proposed /Future Specification**
Commercial Dishwashers	No standard		**Energy Star (EPA)** using NSF/ANSI standards for water use and ASTM standards for energy use **Effective 10/11/2007** *Under counter*: Hi Temp: 1.0 gal/rack; <= 0.90 kW; Lo Temp 1.70 gal/rack <= 0.5 kW *Stationary Single Tank Door*: Hi Temp: 0.95 gal/rack; <= 1.0 kW Lo Temp: 1.18 gal/rack; <= 0.6 kW *Single Tank Conveyor*: Hi Temp: 0.70 gal/rack; <= 2.0 kW; Lo Temp: 0.79 gal/rack; <= 1.6 kW *Multiple Tank Conveyor*: Hi Temp: 0.54 gal/rack; <= 2.6 kW Lo Temp: 0.54 gal/rack; <= 2.0 kW	**Energy Star-Effective 2/1/2013** *Under counter*: Hi Temp: <= 0.86 gal/rack <=. 0.5 kW; Lo Temp 1.19 gal/rack <= 0.5 kW *Stationary Single Tank Door*: Hi Temp: 0.89 gal/rack; <= 0.7 kW; Lo Temp: 1.18 gal/rack; <= 0.6 kW *Pot, Pan, and Utensil* Hi Temp: <=0.58 gal/rack; <= 1.2 kW; Lo Temp: <= 0.58 gal/rack; <= 1.0 kW *Single Tank Conveyor*: Hi Temp: 0.70 gal/rack; <= 1.5 kW; Lo Temp: 0.79 gal/rack; <= 1.5 kW *Multiple Tank Conveyor*: Hi Temp: 0.54 gal/rack; <= 2.25 kW; Lo Temp: 0.54 gal/rack; <= 2.0 kW *Single Tank Flight Type* Requires formula for both hi and low temp machines: Gph<= 2.97 times sf of belt + 55 *Multiple Tank Flight Type* Requires formula for both hi and low temp machines: Gph<=4.96 times sf of belt +17 **NOTE: See full Energy Star requirements for definitions and details.**	Same as current Energy Star	CEE waiting for final test methods before reviewing possible changes to their specifications

Fixtures and Appliances	EPAct 1992, EPAct 2005 *(or backlog NAECA updates)*		WaterSense® or Energy Star®		Consortium for Energy Efficiency	
	Current Standard	Proposed/ Future Standard	Current Requirements	Proposed/Future Requirements	Current Specifica-tion	Proposed /Future Specification
Automatic Commercial Ice Makers[261]	Effective 1/1/2010: Energy and condenser water efficiency standards vary by equipment type on a sliding scale depending upon harvest rate and type of cooling (see link to additional information at end of this table)	DOE proposes not to regulate potable water use in commercial ice machines (April 2011 NOPR)	**Energy Star (EPA)** Energy and water efficiency standards vary by equipment type on a sliding scale depending upon harvest rate and type of cooling (see link to additional information at end of this table). Water cooled machines excluded from Energy Star		Energy and water (potable and condenser) standards are tiered and vary by equipment type on a sliding scale depending upon harvest rate and type of cooling (see link to additional information at end of this table)	
Commercial Pre-rinse Spray Valves (for food service appli-cations)	Flow rate ≤ 1.6 gpm (no pressure specified; no performance requirement)		No specification	**WaterSense®** specification in development in conjunction with Energy Star, ASME, and industry manufacturers. Specification to be released to public in 2012.	No specification (program guidance recommends 1.6 gpm at 60 psi and a cleanability requirement)	

[261] Optional standards for other types of automatic ice makers are also authorized under EPAct 2005.

Fixtures and Appliances	EPAct 1992, EPAct 2005 *(or backlog NAECA updates)*		WaterSense® or Energy Star®		Consortium for Energy Efficiency	
	Current Standard	Proposed/ Future Standard	Current Requirements	Proposed/Future Requirements	Current Specifica-tion	Proposed /Future Specification
Commercial Steam Cookers[262]	No standard		**Energy Star (EPA)** *Electric*: 50% cooking energy efficiency; idle rate 400–800 Watts *Gas*: 38% cooking energy efficiency; idle rate 6,250–12,500 British thermal units/hour *No specified water use factor		*Electric*: 50% cooking energy efficiency; idle rate 400–800 Watts *Gas*: 38% cooking energy efficiency; idle rate 6,250–12,500 British thermal units/hour Water Use Factor (for both electric and gas models): Tier 1A: ≤ 15 gal/hr Tier 1B: ≤ 4 gal/hr	

[262] Idle rate standards vary for 3-, 4-, 5-, and 6-pan commercial steam cooker models.

Information/materials on EPAct 2005/NAECA standards:

Schedule for development of appliance and commercial equipment efficiency standards:
http://www.eere.energy.gov/buildings/appliance_standards/2006_schedule_setting.html

Commercial Clothes Washers and Dishwashers (agenda/presentations at 4/27/06 DOE public meeting on rulemaking):
http://www.eere.energy.gov/buildings/appliance_standards/residential/home_appl_mtg.html

Automatic Commercial Ice Maker Standards:
http://www.eere.energy.gov/buildings/appliance_standards/pdfs/epact2005_appliance_stds.pdf (Page 18)

Pre-rinse Spray Valves
http://www.eere.energy.gov/buildings/appliance_standards/pdfs/epact2005_appliance_stds.pdf (Page 10)

Information/materials on Energy Star specifications:

Residential Clothes Washers
http://www.energystar.gov/index.cfm?c=clotheswash.pr_crit_clothes_washers

Commercial Clothes Washers
http://www.energystar.gov/index.cfm?fuseaction=clotheswash.display_commercial_cw

Residential Dishwashers
http://www.energystar.gov/index.cfm?c=dishwash.pr_dishwashers

Commercial Dishwashers
http://www.energystar.gov/index.cfm?c=new_specs.comm_dishwashers

Automatic Commercial Ice Makers
http://www.energystar.gov/index.cfm?c=new_specs.ice_machines

Commercial Steam Cookers
ttp://www.energystar.gov/index.cfm?c=steamcookers.pr_steamcookers