



Potential Best Management Practice Reports: A Preliminary Assessment



November, 2022

Introduction

The California Urban Water Conservation Council published a series of Potential Best Management Practice (PBMP) Research Reports, beginning in August, 2004 and continuing for 26 reports until the final one in March, 2015. A wide variety of topics were examined, principally for the purpose of determining whether these water efficiency measures might be likely to achieve cost-effective water savings and would thus be a worthy investment for California water suppliers. The reports are archived on the California Water Efficiency Partnership website: <https://calwep.org/potential-best-management-practices/>

This Preliminary Assessment offers a simple review of each of the 26 PBMP Reports to determine the continued relevance of each proposed measure, and to identify those proposed measures that are worthy of further discussion and an investment in additional research. We have also ranked the potential new research options in order of our opinion as to importance, and that ranking is contained on page 31.

Where possible, the original authors of the reports were consulted for their views and input. Since John Koeller was involved in 17 of the original 26 reports, he and his co-authors became partners on this Preliminary Assessment. These co-authors include Gary Klein, Bill Hoffman, and Jim Riesenberger. Anil Bamezai was also contacted for his input. We were not able to reach Alain LaLonde, Nola Hastings, Melissa Baum-Haley, or Elizabeth Dougherty. Nonetheless, we still offer our assessment on the topics contained in those reports.

The Published PBMP Reports

#	Report Title	Date	Re-Evaluate?
1	Pre-Rinse Spray Valves	August, 2004	NO
2	Weather-Based Irrigation Controllers	August, 2004	NO
3	Steam Sterilizer Retrofits	August, 2004	NO
4	X-Ray Film Processor Recycling Units	August, 2004	NO
5	CII Cooling Water Efficiency	November, 2005	YES
6	High Efficiency Toilets and Urinals	November, 2005	YES
7	On-Premise Laundries	November, 2005	YES
8	Submetering of MF Residential Properties	November, 2005	MAYBE
9	Residential Dishwashers	October, 2006	NO
10	Hot Water Distribution	October, 2006	YES
11	Vehicle Wash Systems	October, 2006	MAYBE
12	Synthetic Turf	November, 2006	MAYBE
13	Commercial Ice Makers	June, 2008	NO
14	Commercial Dishwashers	June, 2010	NO
15	Distribution System Pressure Management	June, 2010	MAYBE
16	Pools, Spas and Fountains	September, 2010	YES
17	Tankless Water Heaters	September, 2010	MAYBE
18	Coin-Operated Clothes Washers	August, 2012	MAYBE
19	Graywater Use in California	September, 2012	NO
20	Water Use in Vacuum Pump Systems	December, 2012	YES
21	Turf Removal	September, 2013	NO
22	Plan Review	October, 2013	YES
23	Drip Irrigation	January, 2014	NO
24	Rotating Nozzles	January, 2014	NO
25	Soil Moisture Sensors	January, 2014	NO
26	Customer Water-Use Messaging	March, 2015	NO

Each individual PBMP Report is briefly reviewed. A priority ranking for the potential new research projects is on page 31 of this Assessment.

PBMP Report #1: Pre-Rinse Spray Valves

Date Published:

August, 2004

Author:

John Koeller

Assessment:

Massive replacement programs of non-efficient PRSVs in Calif and elsewhere have resulted in ample 'real world' water use data. The CUWCC's previous 3-phase statewide PRSV replacement program (which ran from 2002-2007) replaced approximately 41,000 PRSVs out of an estimated total of 100,000+ installed in the state. Subsequent reports by: (1) Eastern Research Group for WaterSense in 2008 and (2) U.S. DOE in 2022, provide extensive information on PRSVs from across the U.S. and provide ample historic and current information on PRSVs, their design and use, and their water savings potential.

The WaterSense program adopted a PRSV [specification](#) in 2013 based on the analysis described above. That specification was sunsetted when the US Department of Energy (DOE) adopted new Federal standards that are based upon much of the "real world" data. Maximum water use thresholds in the DOE standard are not substantially different from those previously set in the WaterSense specification.

Re-Examine?

NO

PBMP Report #2: Weather-Based Irrigation Controllers

Date Published:

August, 2004

Authors:

John Koeller and Anil Bamezai

Assessment:

Weather-Based Irrigation Controllers (WBICs) and related accessory devices have been part of California water supplier landscape programs for over two decades. These installation programs have been extensively analyzed by in a number of studies in the past 18 years. The EPA WaterSense program also adopted a Weather-Based Irrigation Controller Specification in 2011 which was [updated and revised in September, 2021](#). The changes made to the specification reflect the December 2020 publication of the American National Standards Institute (ANSI)/American Society of Agricultural and Biological Engineers (ASABE) Standard S627, Weather-Based Landscape Irrigation Control Systems, which is consistent with the performance test method included in Version 1.0 of the WaterSense Specification for Weather-Based Irrigation Controllers.

Re-Examine?

NO

PBMP Report #3: Steam Sterilizer Retrofits

Date Published:

August, 2004

Authors:

John Koeller and Jim Riesenberger

Assessment:

The technology addressed in 2004 is still applicable. There are others making similar devices but the technology of heat transfer to the atmosphere is unchanged. Minimal domestic water is used in the process. Advances in product design make retrofits largely a thing of the past.

Re-Examine?

NO

PBMP Report #4: X-Ray Film Processor Recycling Units

Date Published:

August, 2004

Authors:

John Koeller and Jim Riesenberger

Assessment:

Film processors in medical installations (clinics, hospitals, imaging centers, etc.) have been replaced by digital systems. Film is rarely used now. Digital technology is faster, more precise, much easier to operate and requires no water. The old-style film processors have largely disappeared.

Re-Examine?

NO

PBMP Report #5: Commercial-Industrial Cooling Water Efficiency

Date Published:

November 2005

Authors:

John Koeller and Jim Riesenberger

Assessment:

The 2021-2022 AWE Cooling Technologies Study is a key document available to update this category of water efficiency. That Study Report identified a series of best practices and technologies that would serve as the foundation for an updated California analysis.

For example, in 2008, the attributes of several of these new technologies were displayed at various installations in California. The Valley View Casino & Hotel in Valley Center (San Diego County), owned by the San Pasqual Band of Mission Indians, installed a 1000-ton chilled water system built by TAS. The unique part of that installation is that it uses secondary water from their wastewater treatment plant. So, in a sense, this plant uses no domestic potable water. The system at Valley Center was installed in 2010 and is still operating as intended. Water CTI installed a similar, but much larger, system at the Pechanga Casino in Temecula (Riverside County).

The technology softens the incoming makeup water and removes about 95-98% of the hardness (calcium carbonate CaCO_3) from the makeup. This allows concentration cycles of over 50 (today, typical industry-wide cycles of concentration in San Diego and Riverside Counties are around 2 – 2 ½). Almost all the blowdown water is saved; the only water that goes to drain is the backwash from the two resin tanks (about every other day and about 200-500 gallons each time, depending upon the size of the system).

As expected, the chemical industry that has dominated this market for many years presents impediments to the adoption of this and other new technologies. It opposes new solutions because these designs require no potentially dangerous chemicals. In many applications today, for example, sulfuric acid is added to systems to drive up cycles of concentration in their applications. Double containment of these chemicals is required and handling them is dangerous.

Savings of up to about 6 cycles with the older technology were predicted in the 2005 paper. Potential savings are much greater with the new technologies identified in the AWE study report and it appears that an update to the original PBMP paper may be warranted to calculate the potential savings in the state of California.

Finally, ASHRAE Standard 191P, Standard for the Efficient Use of Water in Building Mechanical Systems (approval in process), addresses this topic and also needs to be considered.

Re-Examine?

YES

PBMP Report #6: High Efficiency Plumbing Fixtures -- Toilets and Urinals

Date Published:

November, 2005

Authors:

John Koeller

Assessment:

In the intervening period since the report was written, three significant actions have occurred: (1) Legislation (AB715 and SB409) was passed in California; (2) the California Energy Commission (CEC) tightened in 2016 the maximum water use specification for urinals (over the objections of water efficiency advocates since no field data existed on potential operational issues); and (3) more new high-efficiency (HE) toilets and urinals entered the marketplace. As of 2022, the marketplace for toilets is now comprised of over 180 different brands of residential product. The installed base of HE fixtures is now much larger than in 2005.

Yet, a significant number of non-efficient 3.5+ gpf 'legacy' toilet fixtures remain installed in California homes and businesses (estimated in a comprehensive 2022 study at a total of 2.4 million fixtures). At the same time, approximately 29 million aging 1.6 gpf toilets (some of which are over 30 years old) are installed as well. Forecasts of the installed base made in the 2005 study are no longer valid, yet it is unlikely that any update of that information would be helpful to the outreach by the water utilities, EXCEPT if programs were developed to specifically focus on replacing the non-efficient legacy toilets in a very short term.

Re-Examine?

YES -- FOR TOILETS ONLY -- BUT ONLY AS A PRE- REQUISITE TO A LEGACY TOILET REPLACEMENT PROGRAM

PBMP Report #7: On Premise Laundries

Date Published:

November, 2005

Authors:

John Koeller and James Riesenberger

Assessment:

While design of laundry equipment has progressed with new efficiencies in the past 17 years, there have been no updated assessments of the currently installed base of these high-efficiency machines or the potential for new water use reductions. There have been several changes in the technology that would enable more widespread use of ozone systems and the associated water savings. A project is currently underway with Quantum Energy Analytics to update this topic for the energy companies. These new ozone systems should be examined.

Re-Examine?

YES

PBMP Report #8: Submetering of Multi-Family Residential Properties

Date Published:

November, 2005

Authors:

John Koeller and Anil Bamezai

Assessment:

Since this report was written, California passed submetering legislation which took effect on January 1, 2018. As of that date, all new multi-family construction (defined as two or more units) that apply to a water purveyor for a water connection must include water submeters for each individual unit. At the same time, if an owner has a building constructed before January 1, 2018, and the owner elects to install submeters or already has submeters, the disclosure and billing requirements in the state law must be applied when billing tenants for water.

All property owners who are required to install submeters at their new buildings after January 1, 2018, must, at all times, bill residents for water service. However, this law does not affect ratio utility billing systems or RUBS. It does not prohibit their continued use in existing buildings.

This legislation covering new multi-family building construction offers the potential for new water savings analysis. However, whether or not an updated PBMP Review is justified is uncertain at this time.

Re-Examine?

MAYBE

PBMP Report #9: Residential Dishwashers

Date Published:

October 2006

Authors:

John Koeller

Assessment:

At the time of publication of the PBMP report, Energy Star did not include a maximum water use threshold in its residential dishwasher specification. That changed, however, subsequent to publication. The current water use threshold of 3.5 gallons per cycle (gpc) for standard residential dishwashers was published by Energy Star in 2016. Most products now offered in the marketplace are Energy Star compliant.

One of the concerns expressed at the time of the original PBMP report was that most dishwashers selected by the consumer would (by regulation) fall below the U.S. DOE-established maximum of 6.5 gpc, but not significantly so. Once the Energy Star requirements were established (which included water consumption), the marketplace became more focused on Energy Star-efficient products. While setting new, even more-stringent water use maximums (below Energy Star) at the local level for new construction may be feasible, such an action does not justify a re-examination of the original PBMP report. Moreover, according to the 2022 indoor water use study for southern California, only 1.3% of indoor water use is consumed by residential dishwashers since they have become more efficient over the years.

Re-Examine?

NO

PBMP Report #10: Hot Water Distribution

Date Published:

October 2006

Authors:

John Koeller and Gary Klein

Assessment:

Since 2006, the CA Energy Commission has made some changes to the Title 24 Chapter 6-Energy to give credit for more compact hot water distribution systems in residential new construction. However, these changes do not really do very much to save water or energy, because they don't reduce the length or volume in the hot water distribution system by very much compared to typical construction.

The recommendations in the 2006 PBMP report are more advanced. In addition, the Energy Commission funded a study entitled “Code Changes and Implications of Residential Low-Flow Hot Water Fixtures” that was published in 2021, which provides updated information and analysis on the benefits of architectural compactness, including water efficiency, public health, and reduced construction and operating costs.

The International Association of Plumbing and Mechanical Officials (IAPMO) developed a peak water demand calculator that enables the right-sizing of hot and cold-water distribution systems within buildings and in water utility distribution systems. Benefits include water efficiency, public health, and reduced construction and operating costs. Further assessment of the savings potential would be helpful.

Re-Examine?

YES

PBMP Report #11: Vehicle Wash Systems

Date Published:

October 2006

Authors:

John Koeller and Chris Brown

Assessment:

Most car wash regulations are at the local level. However, as of Jan 1, 2014, the state regulation in Sections 10950-953 of Section 6 of the California Water Code imposed a requirement that a minimum of 60 percent of water be recycled. Many car washes (self-service), repair shops, and detail shops are exempt from these state restrictions.

However, car washes have become quite efficient in their water usage by:

- (1) **Use of high-flow / high-pressure systems.**
- (2) **Using recycled water for the main wash cycle.** Recapturing used water and collecting it into large tanks for re-use enables each gallon to be re-used four to five times.

Re-Examine?

MAYBE

PBMP Report #12: Synthetic Turf

Date Published:

November 2006

Authors:

John Koeller and Anil Bamezai

Assessment:

The viability of synthetic turf has been established (in certain types of installations). However, not all water providers view Synthetic Turf as a suitable replacement for grass. This topic should be re-examined only if more information is needed on health & safety, physical life, and economic feasibility.

Re-Examine?

MAYBE

PBMP Report #13: Commercial Ice Makers

Date Published:

June 2008

Authors:

John Koeller and Bill Hoffman

Assessment:

Adopted federal requirements and Energy Star specifications have made further assessment of commercial ice makers unnecessary.

Re-Examine?

NO

PBMP Report #14: Commercial Dishwashers

Date Published:

June 2010

Authors:

John Koeller and Bill Hoffman

Assessment:

Adopted federal requirements and Energy Star specifications have made further assessment of commercial dishwashers unnecessary.

Re-Examine?

NO

PBMP Report #15: Distribution System Pressure Management

Date Published:

June 2010

Authors:

John Koeller and Alain LaLonde

Assessment:

The original study was performed by Alain Lalonde, and it was prepared well in advance of the passage of SB 555 in California, which requires water suppliers to reduce their real losses based on a customized target set by the State Water Resources Control Board. Given the linear relationship of pressure to leakage, better management of system pressures will obviously help a water supplier in reducing the amount of real losses required for compliance under SB 555. The real question is whether CalWEP needs to fund continued research into the best pressure management methods, or whether this topic is already being handled at AWWA Cal-Nevada.

Re-Examine?

MAYBE

PBMP Report #16: Pools, Spas, and Fountains

Date Published:

September 2010

Authors:

John Koeller and Bill Hoffman

Assessment:

This has received only modest attention in the past 12 years. Some water efficiency professionals have proposed pool covers for single-family dwellings, but this has been shown to be of questionable value in a [study](#) published in 2004. Further assessment of savings potential would be helpful as it relates to: (1) pools in non-residential applications; and (2) technologies and operating practices as they apply to evaporation barriers (beyond standard pool covers), backwash and cartridge cleaning, TDS control, and other savings potential as discussed in the original PBMP report.

Re-Examine?

YES

PBMP Report #17: Tankless Water Heaters

Date Published:

September 2010

Authors:

John Koeller and Gary Klein

Assessment:

As stated in the 2010 report, tankless water heaters in and of themselves do not save water. What has changed since 2010 is that there has been a policy shift toward electrification of water heating, with an emphasis on the use of heat pump water heaters (HPWH). However, it is difficult to install a HPWH very close to all fixtures in a building.

Updating the 2010 report to be more focused on electric tankless water heaters would be helpful, since electric tankless point-of-use water heaters can save more water than gas tankless water heaters for two reasons: they can be located very close to fixtures and they ramp up to temperature much more quickly than gas.

Re-Examine?

MAYBE

PBMP Report #18: Coin-Operated Clothes Washers

Date Published:

August 2012

Authors:

Anil Bamezai

Assessment:

Both Federal and EnergyStar standards have changed since the report was completed in 2012 and there is currently an open docket proceeding at the DOE regarding revision of commercial clothes washer energy and water standards. Information about latest water and energy standards might be useful to update. How these revised standards possibly influence “savings potential,” I suspect, is swamped by uncertainty identified in the 2012 report, which still remains. The California Energy Commission (CEC) is staying with the Federal standards for commercial clothes washers at this time, so it is not likely that CEC will be a factor in this product category.

The author suggests contacting the water agencies that have or have had coin-op retrofit programs to evaluate available feedback about how well their programs are working and what it might take to improve program uptake. Would higher incentives help? Better targeting and messaging? Water agency feedback should help guide whether throwing additional resources at these topics is worth it.

Re-Examine?

MAYBE

PBMP Report #19: Graywater Use in California

Date Published:

September 2012

Authors:

Elizabeth Dougherty and Michael Murphy

Assessment:

After this comprehensive report on graywater was published, the AWE Water Efficiency Research Committee identified the need for additional analysis to determine the factors in calculating the costs and benefits associated with retrofits of single-family graywater systems. This analysis was carried out by Bill Gauley and published by AWE in 2017. Entitled “Water Savings and Financial Benefits Associated with Single Family Graywater Package Systems”, the report is posted on the AWE website [here](#). In general, the Gauley report found that retrofits of existing homes for graywater package systems are not generally cost-effective unless utility water shortages are severe and consumer rates are high. However, some California water agencies do indeed offer graywater retrofit rebates, such as the Valley Water District in Santa Clara county. Valley Water has also have developed a local graywater installation ordinance.

As the California drought worsens, on-premise graywater use will receive more priority attention. The IAPMO WE-Stand water efficiency plumbing code contains a chapter on graywater, developed by water efficiency and graywater experts. Having practical graywater standards available to adopt in the statewide building and plumbing codes would be a strong step forward. Given how much information is already available on potential savings, more research is not necessary.

Re-Examine?

NO

PBMP Report #20: Water Use in Vacuum Pump Systems

Date Published:

December 2012

Authors:

Anil Bamezai and James Fryer

Assessment:

Vacuum pumps and systems are used in a wide range of commercial and industrial settings, and are often very specialized systems. The report found that dry vacuum pumps could generate cost effective water savings in sectors such as Dental and Medical. The real issue is program uptake. There are no water efficiency standards for these technologies, and water use efficiency is entirely a byproduct of retrofit of traditional liquid ring vacuum pumps with dry vacs.

The author suggests contacting the water agencies that have or have had dry vac retrofit programs to evaluate available feedback about how well their programs are working and what it might take to improve program uptake. Higher incentives? Better targeting and messaging? That feedback will then help determine whether a reexamination of this topic is worth it.

Re-Examine?

MAYBE

PBMP Report #21: Turf Removal

Date Published:

September 2013

Authors:

Melissa Baum-Haley

Assessment:

The PBMP report contains useful information about turf removal programs. This is a topic that continues to get additional research. Since this PBMP report was published in 2019, the Alliance for Water Efficiency published a study entitled "[Landscape Transformation: An Assessment of Water Utility Programs and Market Readiness Evaluation](#)." It examined success rates of removal, customer satisfaction, cost effectiveness, and market readiness. AWE further published a water utility [Guide](#) to designing Landscape Transformation programs.

Since turf removal has been widely incentivized in California, water agencies that have undertaken these programs also would have information to share. The question becomes whether this issue needs further analysis. Based on the extensive information already available, the benefits of doing evaluation work, in addition to the excellent resources already available (include the original PBMP Report), seem to be of minimal benefit.

Re-Examine?

NO

PBMP Report #22: Plan Review

Date Published:

October 2013

Authors:

Nola Hastings

Assessment:

The purpose of this report was to determine the conservation value of a general plan review, permitting, and inspection process wherein water suppliers participate in local planning and zoning review of development applications for new housing and CII.

A basic resource for a general conservation plan review has been East Bay Municipal Utility District's [WaterSmart Guidebook](#), which includes an excellent description of the benefits of adopting a water efficiency plan-review process for new construction. When done successfully, a water utility plan review program has the potential to maximize water efficiency, providing benefits to all stakeholders, including the community and the environment.

A well-conducted Plan Review is also an intrinsic component of successful municipal landscape ordinances developed under the Model Water Efficiency Landscape Ordinance (MWELo).

When the PBMP report was written, the water and land use coordination issue was discussed (SB 601 and SB 221, the "show me the water" statutes, were mentioned). What has developed since this report is the concept of water-neutral or even water-positive development, whereby new development not only has to comply with efficiency requirements, but new water demand must be "offset" with other efficiency retrofits to make the development "neutral" or even "water positive." This is a strategy that should be explored further as a potential large area of savings as California's drought and growth continue.

Re-Examine?

YES

PBMP Report #23: Drip Irrigation

Date Published:

January 2014

Authors:

Melissa Baum-Haley

Assessment:

This report goes into useful detail on drip and micro-irrigation systems. Since the report was published, the American Society of Agricultural and Biological Engineers (ASABE), an ANSI accredited standards developer, adopted, in partnership with the WaterSense program, new landscape irrigation guidelines that include micro-irrigation (drip and micro-spray) as its own section within the standard. The Landscape Irrigation Sprinkler and Emitter Standard was finalized in September, 2014.

Re-Examine?

NO

PBMP Report #24: Rotating Nozzles

Date Published:

January 2014

Authors:

Melissa Baum-Haley

Assessment:

This detailed analysis of multi-stream, multi-trajectory (MSMT) rotating nozzles contains much information and documentation of the savings potential of this technology. A number of water agencies have been incentivizing distribution of the devices, including the “FreeSprinklerNozzles.com” program founded by Wester Municipal Water District in partnership with the Toro company.

After the Rotating Nozzles PBMP report was published, the California Energy Commission opened a standards proceeding for spray sprinkler bodies. A new regulation went into effect October 1, 2020. As of that date, all sprinkler nozzles sold in California must meet testing requirements and be listed in the Energy Commission database. In addition, The American Society of Agricultural and Biological Engineers (ASABE), an ANSI accredited standards developer, worked in partnership with the WaterSense program on a Landscape Irrigation Sprinkler and Emitter Standard, which was officially adopted in September, 2014.

Re-Examine?

NO

PBMP Report #25: Soil Moisture Sensors

Date Published:

January 2014

Authors:

Melissa Baum-Haley

Assessment:

Soil moisture sensor (SMS) systems offer the opportunity to optimize irrigation based on measured plant demand in the irrigated system. Smart controller devices, such as weather-based irrigation controllers (WBIC) or SMS, utilize weather data and/or soil moisture readings to schedule irrigation. These devices can include onsite weather sensors, soil moisture sensors, or offsite weather data sent to the controller. This report focused on soil moisture sensor (SMS) systems as a device potential for outdoor water savings and contains extensive information on the application of this technology.

Since the report was published in 2014, the EPA WaterSense program developed a [specification](#) for soil-moisture-based irrigation controllers, which was adopted in February, 2021 after extensive stakeholder involvement.

Re-Examine?

NO

PBMP Report #26: Customer Water-Use Messaging

Date Published:

March 2015

Authors:

Nola Hastings and Galib Rustamov

Assessment:

This report was published to highlight the benefits of non-price interventions using behavioral economics and social norming, where customers are “nudged” with specific information to show that their water use is out of alignment with their perceptions, and more importantly, similar households in their area. Piloted originally in the energy sector, these programs have rapidly expanded into the water sector. WaterSmart, Droplet Technologies, and DropCountr are three companies that were featured in the report that have been working with water suppliers for a number of years. The AWE Home Water Works Calculator was also featured in the report, as was a description of Community-based social marketing.

As AMI becomes more prevalent, water agencies can also build their own customer web portals where social norming messaging can be sent directly to their customers.

The report documented what research had been conducted on the messaging programs’ water conservation savings and the programs’ cost-effectiveness. The information is still current and does not need to be updated.

Re-Examine?

NO

Priority Ranking of Possible New Research*

Priority	Report Title
1	Cooling Water Efficiency
2	On-premise Laundries
3	High Efficiency Toilets and Urinals
4	Distribution System Pressure Management
5	Plan Review and Water Neutral Development
6	Pools, Spas, and Fountains
7	Tankless Water Heaters
8	Residential Hot Water Distribution
9	Multi-Family submetering
10	Vehicle wash systems
11	Coin-Operated Clothes Washers
12	Water Use in Vacuum Pump Systems
13	Synthetic Turf

*These are the Report topics marked YES or MAYBE in the PBMP Assessment "Re-Examine" section.



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