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California Energy Commission

FINAL STAFF REPORT

FINAL STAFF ANALYSIS of WATER EFFICIENCY STANDARDS for SPRAY SPRINKLER BODIES

2019 Appliance Efficiency Rulemaking
Docket Number 19-AAER-01

California Energy Commission

Gavin Newsom, Governor

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California Energy Commission

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PREFACE

On March 14, 2012, the California Energy Commission issued an order instituting rulemaking (OIR) to consider standards, test procedures, labeling requirements, and other efficiency measures to amend the Appliance Efficiency Regulations (California Code of Regulations, Title 20, Sections 1601 through Section 1609). In the OIR, the Energy Commission identified a variety of appliances with the potential to save energy or water or both. The OIR also authorizes the Energy Commission to investigate and adopt, if appropriate, additional priority measures as determined by the Lead Commissioner.

On April 21, 2017, the Energy Commission released an invitation to participate to provide interested parties the opportunity to inform the Commission about the product, market, and industry characteristics of the appliances identified in the OIR, as well as additional appliances. The Energy Commission reviewed the information and data received in the docket and hosted staff workshops on July 19 through 21, 2017, to vet this information publicly.

On July 18, 2017, the Energy Commission released an invitation to seek proposals for standards, test procedures, labeling requirements, and other measures to improve the efficiency and reduce the energy or water consumption of specified appliances. The Energy Commission reviewed the proposals received in the docket and hosted a staff webinar to vet those proposals on October 24, 2017. On February 12, 2018, staff released a draft analysis of the proposed standard and held a workshop on March 14, 2018 to receive comments from the public.

This staff analysis proposes standards for spray sprinkler bodies and the basis for such standards. The report includes analysis of the cost-effectiveness, technical feasibility, and statewide benefits of the proposed standard in support of the requirements of Section 25402(c)(1) of the Public Resources Code.

ABSTRACT

Assembly Bill 1928 (Campos, Chapter 326, Statutes of 2016) requires the California Energy Commission to adopt performance standards and labeling requirements for landscape irrigation equipment on or before January 1, 2019.

This staff report focuses on spray sprinkler bodies, a component of landscape irrigation systems. The water consumption of spray sprinkler bodies varies greatly, even within models of similar sizes and feature sets. To date, no federal or state regulations mandate cost-effective, readily available technologies to improve the performance of less efficient models.

This report proposes an addition to the Appliance Efficiency Regulations (California Code of Regulations, Title 20, Sections 1601 to 1609). California Energy Commission staff analyzed the cost-effectiveness and technical feasibility of proposed water efficiency standards for spray sprinkler bodies. The statewide water and energy (electricity) use and savings and other related environmental impacts and benefits are included in this analysis.

The proposed updates to Title 20 would set test methods and performance standards for spray sprinkler bodies. The update will require all spray sprinkler bodies to control the outlet flow rate over a specified range of inlet water pressures.

The proposed standard is cost-effective, technically feasible, and would save about 15 billion gallons of water and 54 gigawatt-hours (GWh) of electricity for the first year the standard is in effect and more than 152 billion gallons per year and 543 GWh of electricity at full stock turnover. Consumers will save about $22 per spray sprinkler body over the life of the device through reduced water use.

Keywords: Appliance Efficiency Regulations, appliance regulations, water efficiency, energy efficiency, irrigation equipment, landscape irrigation, sprinkler heads, spray sprinklers, spray sprinkler bodies

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EXECUTIVE SUMMARY

Since 1976, the California Energy Commission has adopted cost-effective and technically feasible appliance standards that set a minimum level of energy or water efficiency, as part of the Energy Commission's mandate to reduce the wasteful, uneconomic, inefficient, or unnecessary consumption of energy, including the energy associated with the use of water. Assembly Bill 1928 (Campos, Chapter 326, Statutes of 2016) requires the Commission to adopt performance standards and labeling requirements for landscape irrigation equipment, such as spray sprinkler bodies, on or before January 1, 2019.

Improving the efficiency of landscape irrigation represents an opportunity to save water in California. Landscape irrigation in urban areas in California consumes more than 1.1 trillion gallons of water per year. Staff identified over irrigation, excessive water pressure, and leakage during nonoperation as contributing to the inefficient irrigation of landscapes. The water is lost as it runs off the landscape, evaporates into the air, or drains beneath the reach of the plant roots, as shown in **Figure ES-1**. The losses may be significant, in the case of over irrigation, where Californians, on average, provide 50 percent more water than is needed.

Figure ES-1: Irrigation Water Losses

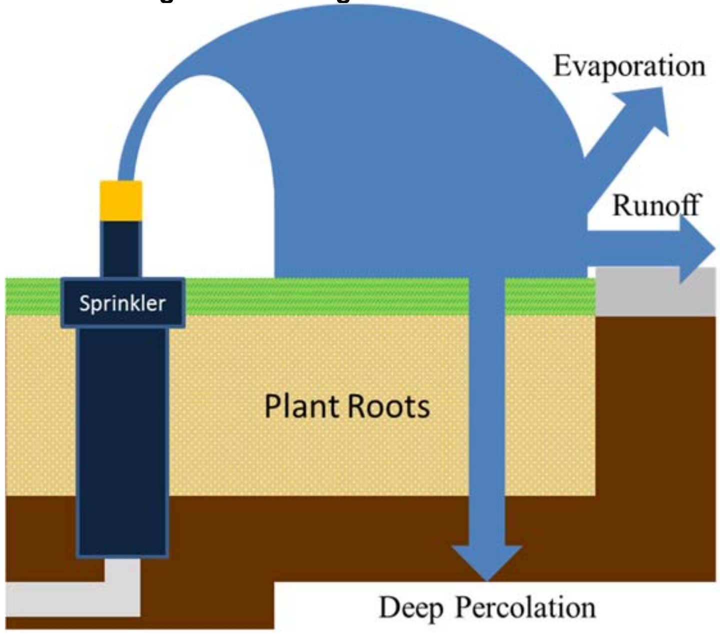

Illustration Credit: California Energy Commission

Californians water their landscapes through hand watering, lawn sprinklers, or drip irrigation. The staff proposal examines an opportunity to increase the water efficiency of the spray sprinkler body, a component of a spray sprinkler. Spray sprinkler bodies are offered with pressure regulation as an optional feature. Pressure regulation addresses the issue of excessive water pressure by maintaining the optimum water flow from the sprinkler regardless of the water pressure. By eliminating excessively high water flow, over irrigation will also be addressed. The widespread adoption of this standard will prevent the unnecessary and wasteful use of more than 152 billion gallons of water per year once fully implemented, while saving consumers money with products available to the market.

Figure ES-2: Spray Sprinkler Body

Photo Credit: Rain Bird

Energy Commission staff analyzed the cost-effectiveness, technical feasibility, and statewide energy and water savings of the proposed spray sprinkler body standard. Cost-effectiveness is a measure of the benefits to the consumer, compared to the costs to the consumer, due to requiring the appliance to be more water- or energy-efficient. The benefit to the consumer must exceed the cost to the consumer for the proposed standard to be cost effective. To determine cost effectiveness, staff must determine the value of the water or energy saved, the effect of the standard on the usefulness of the device, and the life-cycle cost to the consumer of the efficient device.

Technical feasibility means that products are technologically capable of meeting the proposed standard by the effective date. The Energy Commission must also consider other relevant factors, including the effect on housing costs, the total statewide costs and benefits of the standard over the lifetime of the product, economic impact on California businesses, and alternative approaches and associated costs.

Staff developed a proposal based upon the test method and pressure regulation performance standard of the U.S. Environmental Protection Agency's WaterSense Specification for Spray Sprinkler Bodies, Version 1.0. The proposal would require all spray sprinkler bodies manufactured on or after the effective date and sold or offered for sale in California to be certified to the Energy Commission as performed to the test method within the U.S. Environmental Protection Agency's WaterSense® Specification for Spray Sprinkler Bodies. The spray sprinkler bodies would be required to meet the performance standards of the WaterSense specification. The proposed effective date would be one year after adoption by the Energy Commission.[1]

The proposal is cost-effective. A compliant spray sprinkler body is estimated to cost $4.68 more than a noncompliant spray sprinkler body, and the consumer will save $31.90 over the 10-year lifetime of the product through a reduced water utility bill, resulting in $27.22 in net savings. The life-cycle benefit of $22.55 reflects a 3 percent annual discount rate applied to the savings so the incremental costs and savings can be compared in terms of net present value.

Table ES-1: Annual Water, Energy, and Monetary Savings

	Design Life (years)	Water Savings (gal/yr)	Embedded Electricity Savings (kWh/yr)	Incremental Costs ($)	Average Annual Savings ($/yr)	Life-Cycle Benefit ($)
Spray Sprinkler Bodies	10	554	2.0	$4.68	$3.19	$22.55

Source: California Energy Commission

The proposal is also technically feasible. The University of Florida tested six brands of spray sprinkler bodies. The test results show that four of the six brands will meet the proposed standard. The U.S. EPA WaterSense program lists 103 WaterSense labeled models from five manufacturers. The testing and WaterSense-labeled models demonstrates the technical feasibility of staff's proposal.

Finally, the proposal will deliver significant water, electricity, and monetary savings to California. **Tables ES-2** and **ES-3** provide estimates for first-year and stock turnover savings.

1 For the purposes of analysis, staff assumes October 1, 2020 effective date, one year from an anticipated adoption date of July 15, 2019.

Table ES-2: Water Savings and Energy Savings

Application	Water Savings Per Device (gal/yr)	Water Savings Per Location (gal/yr)	Statewide (Mgal/yr)	Embedded Electricity (GWh/yr)
Residential – Single Family	554	19,951	104,646	373
Residential - Multi-Family	554	2,377	11,397	41
Commercial excluding Schools	554	N/A	31,515	112
Government	554	N/A	4,727	17
Total	N/A	N/A	152,286	543

Source: California Energy Commission

Table ES-3: Statewide Monetary Savings

	First Year			Stock Savings		
Application	**Water Delivery (M$/yr)**	**Embedded Electricity (M$/yr)**	**Total (M$/yr)**	**Water Delivery (M$/yr)**	**Embedded Electricity (M$/yr)**	**Total (M$/yr)**
Residential Single Family	$60.3	$5.3	$65.6	$602.8	$53.4	$656.1
Residential Multi Family	$6.6	$0.6	$7.1	$65.6	$5.8	$71.5
Commercial excluding Schools	$18.2	$1.6	$19.8	$181.6	$16.1	$197.7
Government	$2.7	$0.2	$2.9	$27.2	$2.4	$29.6
Total	$87.8	$7.7	$95.4	$877.2	$77.7	$954.9

Source: California Energy Commission

The proposal will have a significant positive impact on the environment by reducing the diversion of billions of gallons of water from waterways and habitat. The reduction in diversions also reduces the energy required to pump water, with an associated reduction in greenhouse gas emissions.

CHAPTER 1: Legislative Criteria

Section 25402(c)(1) of the Public Resources Code mandates that the California Energy Commission reduce the inefficient consumption of energy and water by prescribing efficiency standards and other cost-effective measures for appliances whose use requires a significant amount of energy or water statewide. Such standards must be technically feasible and attainable and must not result in any added total cost to the consumer over the designed life of the appliance.

In determining cost-effectiveness, the Energy Commission considers the value of the water or energy saved, the effect on product efficacy for the consumer, and the life-cycle cost of complying with the standard to the consumer. The Commission also considers other relevant factors including, but not limited to, the effect on housing costs, the statewide costs and benefits of the standard over the lifetime of the standard, the economic impact on California businesses, and alternative approaches and the associated costs.

Section 25401.9 of the Public Resources Code requires the Energy Commission, to the extent that funds are available, to adopt by January 1, 2019, performance standards and labeling requirements for landscape irrigation equipment, including emission devices, for reducing the wasteful, uneconomic, inefficient, or unnecessary consumption of energy or water.

CHAPTER 2: Efficiency Policy

The Warren-Alquist Act[2] establishes the California Energy Commission as California's primary energy policy and planning agency and mandates the Energy Commission to reduce the wasteful and inefficient consumption of energy and water in the state by prescribing standards for minimum levels of operating efficiency for appliances that consume a significant amount of energy or water statewide.

For more than four decades, California has regularly increased the energy efficiency requirements for new appliances sold and new buildings constructed in the state. Through the Appliance Efficiency Program, appliance standards have shifted the marketplace toward more efficient products and practices, reaping significant benefits for California's consumers. The state's Title 20 Appliance Efficiency Regulations, along with federal appliance standards encompassing a variety of appliance types, saved an estimated 30,065 gigawatt-hours (GWh)[3]of electricity in 2015 alone, resulting in about $4.84 billion in savings[4] to California consumers. In the 1990s, the California Public Utilities Commission (CPUC) decoupled the utilities' financial results from their direct energy sales, promoting utility support for efficiency programs. These efforts have reduced peak load needs by more than 8,645 megawatts (MW) and continue to save about 32,594 GWh per year of electricity.[5] The potential for additional savings remains by increasing the energy efficiency and improving the use of appliances.

Improving California's Resiliency to Future Drought

On January 17, 2014, with California facing water shortfalls in the driest year in recorded state history, former Governor Edmund G. Brown Jr. proclaimed a state of emergency[6] and directed state officials to take all necessary actions to prepare for and respond to drought conditions. On September 13, 2016, the former Governor Brown signed Water Efficiency: Landscape Irrigation Equipment Act (Assembly Bill 1928,

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2 The Warren-Alquist State Energy Resources Conservation and Development Act, Division 15 of the Public Resources Code, § 25000 et seq., available at http://www.energy.ca.gov/2015publications/CEC-140-2015-002/CEC-140-2015-002.pdf.

3 California Energy Commission, *California Energy Demand 2016-2026 Revised Electricity Forecast*, January 2016, available at http://docketpublic.energy.ca.gov/PublicDocuments/15-IEPR-03/TN207439_20160115T152221_California_Energy_Demand_20162026_Revised_Electricity_Forecast.pdf.

4 Using current average electric power and natural gas rates of residential electric rate of $0.164 per kilowatt-hour, commercial electric rate of $0.147 per kilowatt-hour. This estimate does not incorporate any costs associated with developing or complying with appliance standards.

5 California Energy Commission, *California Energy Demand 2016-2026 Revised Electricity Forecast,* January 2016, available at http://docketpublic.energy.ca.gov/PublicDocuments/15-IEPR-03/TN207439_20160115T152221_California_Energy_Demand_20162026_Revised_Electricity_Forecast.pdf.

6 Office of Edmund G. Brown Jr., "Governor Brown Declares Drought State of Emergency," January 17, 2014. Retrieved from http://gov.ca.gov/news.php?id=18368.

Campos, Chapter 326, Statutes of 2016) requiring the Energy Commission to adopt by January 1, 2019, performance standards and labeling requirements for landscape irrigation equipment, including, but not limited to, irrigation controllers, moisture sensors, emission devices, and valves. In response, the Energy Commission initiated a formal process to consider standards and test procedures, labeling requirements, and other efficiency measures for spray sprinkler bodies and irrigation controllers.[7] Although the drought has ended, the Energy Commission remains committed to helping ensure that water conservation remains a California way of life.

Water-Energy Nexus

Urban water use including landscape irrigation consumes significant energy to move and treat water. A 2005 Commission study estimated 7,500 GWh per year or roughly 3 percent of California state electrical energy is consumed to supply and treat water intended for urban consumption.[8] A more recent study by the Codes and Standards Enhancement (CASE) Team using data provided by the CPUC estimated the energy to supply water as 3,565 kilowatt-hours (kWh) per million gallons.[9] Appliance standards leading to the efficient use of water will lead to significant energy savings for California.

Reducing Electrical Energy Consumption to Address Climate Change

Appliance energy efficiency is identified as a key to achieving the greenhouse gas emission reduction goals of Assembly Bill 32 (Núñez, Chapter 488, Statutes of 2006)[10] and Senate Bill 32 (Pavley, Chapter 249, Statutes of 2016),[11] as well as the recommendations contained in the California Air Resources Board's *Climate Change Scoping Plan.*[12] Energy efficiency regulations are also identified as key components in reducing electrical energy consumption in the *2015 Integrated Energy Policy Report* (*IEPR*)[13] and the 2011 update to the CPUC's *Energy Efficiency Strategic Plan.*[14] Finally,

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7 California Energy Commission. 2017. *2017 Integrated Energy Policy Report*. California Energy Commission. Publication Number: CEC-100-2017-001-CMD, pg. 58.

8 Navigant Consulting, Inc. 2006. *Refining Estimates of Water-Related Energy Use in California*. California Energy Commission, PIER Industrial/Agricultural/Water End Use Energy Efficiency Program. CEC-500-2006-118. Pg. 16

9 Pike, Ed, and Daniela Urigwe, *Codes and Standards Enhancement (CASE) Response to Invitation to Submit Proposals- Irrigation Spray Sprinkler Bodies*, pg. 64, September 18, 2017

10 Assembly Bill 32, California Global Warming Solutions Act of 2006, available at https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=200520060AB32.

11 Senate Bill 32, California Global Warming Solutions Act of 2006, available at https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201520160SB32.

12 California Air Resources Board, *Climate Change Scoping Plan.* available at http://www.arb.ca.gov/cc/scopingplan/2013_update/first_update_climate_change_scoping_plan.pdf.

13 California Energy Commission, *2015 Integrated Energy Policy Report, 2015*, available at http://energy.ca.gov/2015_energypolicy/.

14 CPUC, *Energy Efficiency Strategic Plan*, updated January 2011, available at http://www.cpuc.ca.gov/NR/rdonlyres/A54B59C2-D571-440D-9477-3363726F573A/0/CAEnergyEfficiencyStrategicPlan_Jan2011.pdf.

former Governor Brown and the Legislature have identified appliance efficiency standards as a key to doubling the energy efficiency savings necessary to put California on a path to reducing its GHG emissions to 80 percent below 1990 levels by 2050.[15] This commitment was made to the Subnational Global Climate Leadership Memorandum of Understanding (Under2 MOU) agreement along with 167 jurisdictions representing 33 countries.[16]

On October 7, 2015, former Governor Brown signed the Clean Energy and Pollution Reduction Act of 2015 or Senate Bill 350 (De León, Chapter 547, Statutes of 2015), requiring the Energy Commission to establish annual targets for statewide energy efficiency savings and demand reduction that will achieve a doubling of energy savings from buildings and retail end uses by 2030.[17] Appliance efficiency standards will be critical in meeting this goal. In addition, the Energy Commission adopted the *Existing Buildings Energy Efficiency Action Plan* in September 2015 and updated it in December 2016 to transform existing residential, commercial, and public buildings into energy-efficient buildings.[18] Water end-use efficiency is one of the several strategies identified to increase efficiency in existing buildings.

Loading Order for Meeting the State's Energy Needs

California's loading order places energy efficiency as the top priority for meeting energy needs. The *Energy Action Plan II* strongly supports the loading order, which describes the priority sequence for actions to address increasing energy needs. Energy efficiency and demand response are the preferred means of meeting the state's growing energy needs.[19]

For the past 30 years, while per-capita electricity consumption in the United States has increased by nearly 50 percent, California's per-capita electricity use has been nearly flat. Continued progress in cost-effective building and appliance standards and ongoing enhancements to efficiency programs implemented by investor-owned utilities (IOUs), publicly owned utilities, and other entities have contributed significantly to this achievement.[20]

15 Gov. Edmund G. Brown Jr., "2015 Inaugural Address," available at http://gov.ca.gov/news.php?id=18828.

16 Subnational Global Climate Leadership Memorandum of Understanding, available at http://under2mou.org/background/.

17 California Energy Commission, *2016 Integrated Energy Policy Report Update*, available at http://docketpublic.energy.ca.gov/PublicDocuments/16-IEPR-01/TN216281_20170228T131538_Final_2016_Integrated_Energy_Policy_Report_Update_Complete_Repo.pdf.

18 California Energy Commission, *California's Existing Buildings Energy Efficiency Action Plan – 2016 Update,* available at http://docketpublic.energy.ca.gov/PublicDocuments/16-EBP-01/TN214801_20161214T155117_Existing_Building_Energy_Efficency_Plan_Update_Deceber_2016_Thi.pdf.

19 California Energy Commission, *Energy Action Plan II,* available at http://www.energy.ca.gov/energy_action_plan/2005-09-21_EAP2_FINAL.PDF, p. 2.

20 California Energy Commission, *Energy Action Plan II,* available at http://www.energy.ca.gov/energy_action_plan/2005-09-21_EAP2_FINAL.PDF, p. 3.

CHAPTER 3: Background

Introduction

In 1871, Joseph Lessler patented the first lawn sprinkler.[21] It consisted of a stand, a nozzle holder, and a flexible hose. Rotating and water propelled sprinklers were introduced in the 1890s.[22] The first in-ground pop-up sprinkler was patented more than 100 years ago in 1916.[23] Since these inventions, lawn sprinklers have been widely used to irrigate urban landscapes.

Figure 3-1: First Patented In-Ground Lawn Sprinkler

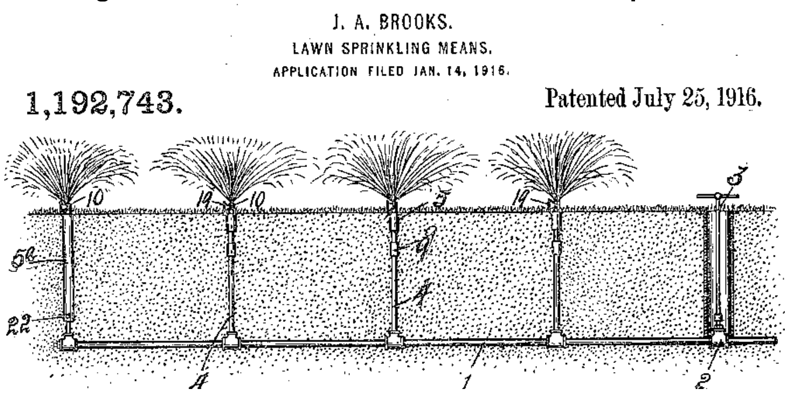


Illustration Credit: U.S. Patent 1192743 A

The California Department of Water Resources estimates that 34 percent of urban water use, or roughly 1.1 trillion gallons, is to irrigate residential landscapes. Large landscapes account for an additional 10 percent, or 325 billion gallons per year. Statewide landscape water use exceeds indoor residential water use.[24] Water-saving opportunities in landscape irrigation include the use of irrigation controllers, user education, and the use of efficient landscape irrigation equipment.[25]

Landscape Irrigation Methods

Residential and commercial property owners and occupants maintain their landscapes through several methods of irrigation, including hand watering, sprinkler systems, and drip irrigation systems. Hand watering is performed typically with a hose and a portable

21 "U.S. Patent 121949A, Sprinkler Dec. 19, 1871," available at https://www.google.com/patents/US121949.

22 "U.S. Patent 425340 A, Sprinkler Apr. 8, 1890," available at https://www.google.com/patents/US425340.

23 U.S. Patent US1192743 A, Sprinkler, Jul. 25, 1916, available at https://www.google.com/patents/US1192743.

24 California Department of Water Resources, *California Water Plan Update 2013, Volume 3*, Chapter 3, pg. 3-10, http://www.water.ca.gov/waterplan/docs/cwpu2013/Final/Vol3_Ch03_UrbanWUE.pdf.

25 Ibid, pg. 3-12 to 3-14.

sprinkler that may be moved about the landscape. Sprinkler systems are permanently plumbed systems relying upon subterranean piping, valves, and landscape emitters to spray water from fixed locations. Drip irrigation systems rely on a system of hoses and microemitters to deliver water as droplets to plantings.[26]

Figure 3-2: Hand, Lawn Sprinkler, and Drip Irrigation Systems

Hand Watering | Lawn Sprinkler | Drip Irrigation

Photo Credit: Home Depot

Lawn sprinklers irrigate from 50 percent[27] to 78 percent[28] of landscapes. Thus, due to the large water use of these sprinklers, increasing the irrigation efficiency of lawn sprinklers is a key component of California's efforts to make water conservation a way of life, as well as its energy efficiency strategy.

Challenges to Water Efficiency

Over Irrigation

Over irrigation of landscapes is a common occurrence in California and across the United States.[29] Over irrigation occurs when more water is applied to a landscape than can be used by the plants. The excess water is lost through deep percolation, runoff, and evaporation, as shown in **Figure 3-3**.

26 "Water Use It Wisely Campaign, Efficiency Irrigation," http://wateruseitwisely.com/100-ways-to-conserve/landscape-care/principles-of-xeriscape-design/efficient-irrigation/#pros.

27 Pike, Ed, and Daniela Urigwe, *Statewide Codes and Standards Enhancement (CASE) Team Response to Request for Proposals: Irrigation Spray Sprinkler Bodies*, pg. 39, September 18, 2017.

28 Aquacraft. 2011. *Embedded Energy in Water Studies Study 3: End-Use Water Demand Profiles*. Prepared for the California Public Utilities Commission. April 29, 2011. http://www.energy.ca.gov/appliances/2013rulemaking/documents/responses/Water_Appliances_12-AAER-2C/California_IOU_Response_to_CEC_Invitation_to_Participate-Lavatory_Faucets_and_Faucet_Accessories_REFERENCES/CPUC_2011a_Embedded_Energy_in_Water_Studies-Study_3.PDF.

29 North Texas Municipal Water District, *One Out of Three North Texans Admit to Watering Their Lawns Three or More Times a Week*, June 14, 2011; Dale J. Bremer, Steven J. Keeley, Abigail Jager, Jack D. Fry, and Cathie Lavis, *In-Ground Irrigation Systems Affect Lawn-watering Behaviors of Residential Homeowners*, American Society of Horticultural Science, HortTechnology Electronic Journal, October 2012; Metropolitan Council, Efficient Water Use on Twin Cities Lawns through Assessment, Research and Demonstration, December 2016, available at https://metrocouncil.org/Wastewater-Water/Publications-And-Resources/WATER-SUPPLY-PLANNING/Twin-Cities-Lawn-Irrigation-System-Surveys-And-Ass.aspx.

Figure 3-3: Over Irrigation Water Losses

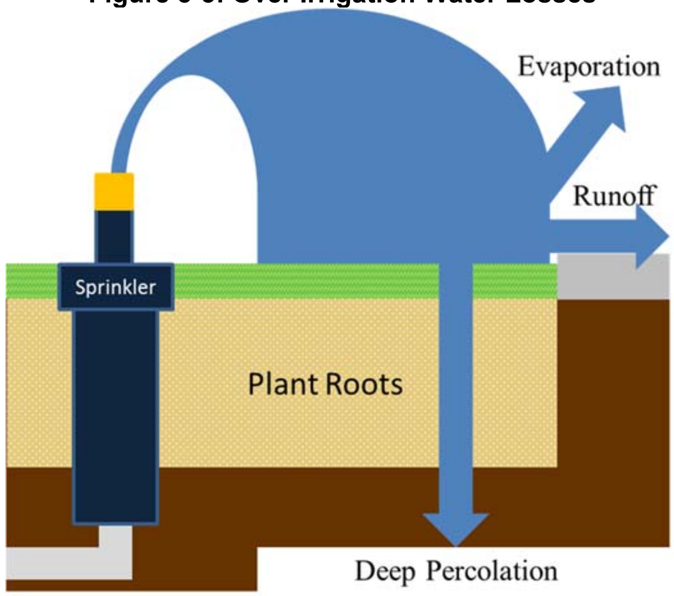


Illustration Credit: California Energy Commission

A study of smart irrigation controllers revealed how landscape irrigation practices vary in California. The study presents an application ratio, a comparison of how much water is applied versus how much water is needed. An application ratio of 100 percent means the water applied to the landscape would exactly meet the irrigation needs of the landscape. On average, Californians apply 50 percent more water than is needed.[30]

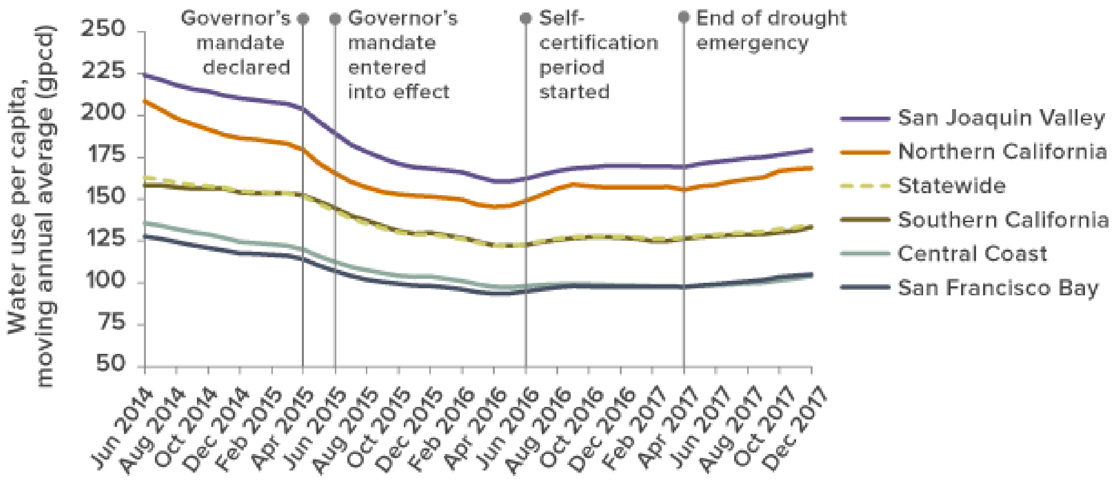
Stakeholders requested more information as to how irrigation practices may have changed due to mandatory water restrictions imposed by the State's drought emergency.[31] **Figure 3-4** show urban water use before and during this time.[32] While water use has declined since before the most recent drought, water use has increased since the water restrictions were removed. Measures to make irrigation equipment more water efficient will help to preserve savings while making California communities more drought resilient.

30 Mayer, Peter, et al, *Evaluation of California Weather Based "Smart" Irrigation Controller Programs*, 2009, pg. 95, available at: http://ucanr.edu/sites/UrbanHort/files/99641.pdf.

31 Jacquard, Kelsey. 2018. " Kelsey Jacquard Comments Average Water Use in CA.", TN 223040, available at https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=17-AAER-08.

32 Hanak, Ellen and David Mitchell, Public Policy Institute of California, Are California's Cities Ready for the Next Drought, April 25, 2018, available at http://www.ppic.org/blog/californias-cities-ready-next-drought/.

Figure 3-4: California Urban Water Use 2014-2017



Source: Public Policy Institute of California

Water Supply Overpressure

Manufacturers design irrigation spray nozzles to operate at a water pressure between 30 to 45 pounds per square inch (psi).[33] Supply water pressure above the design pressure of the device can lead to inefficient device operation with excessive water flow rates; water lost to misting, wind drift, and evaporation; and poor uniformity. The supply water pressure to an irrigation system or device may vary significantly from location or time of day. A recent survey of California landscape irrigation contractors found most irrigation connections provide an excessive water pressure with a statewide water pressure mean average of 65 psi.[34] Stakeholder comments provided a second average water pressure estimate of 81 psi based upon the California Department of Water Resources (DWR) Water Use Efficiency Data collected from over 300 urban water suppliers.[35]

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33 Mecham, Brent, Irrigation Association, *Spray Sprinkler Bodies Docket Number: 17-AAER-08*, TN 221200, pg. 2, September 18, 2017.

34 Pike, Ed, and Daniela Urigwe, *Statewide Codes and Standards Enhancement (CASE) Team Response to Request for Proposals: Irrigation Spray Sprinkler Bodies*, pg. 94-95, September 18, 2017.

35 Tracy Quinn, Natural Resources Defense Council, *Opening Comments of Tracy Quinn, Docket Number: 17-AAER-08*, TN 222958, pg. 4, March 18, 2018.

Figure 3-5: California Average Static Water Supply Pressure

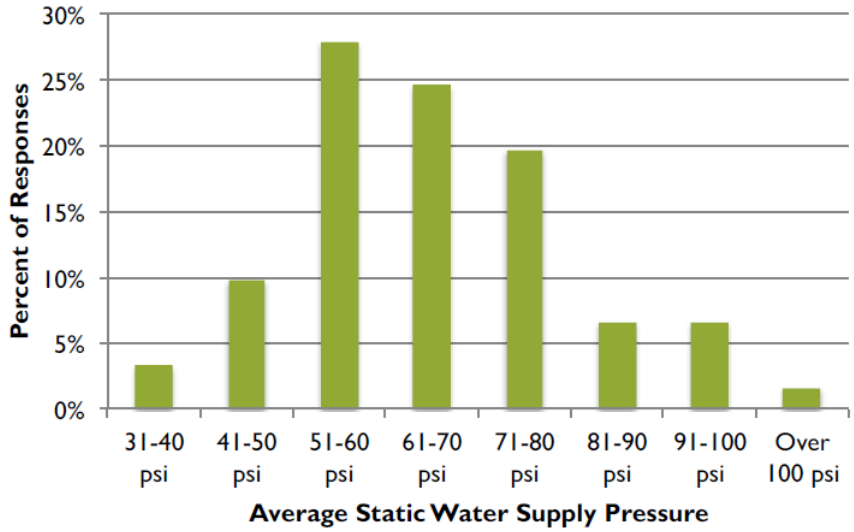

Illustration Credit: Evergreen Economics

Irrigation System Leaks During Nonoperation

Landscape irrigation components may be installed at differing elevations. If sprinkler heads are located at lower elevations than other parts of the system, then water may flow downhill and leak from the sprinkler heads when they're not operating.[36] The California investor-owned utilities' Codes and Standards Enhancement (CASE) team performed a survey of California to characterize the distribution of elevation changes within developed areas. The survey showed that elevation changes resulting in system drainage occur in most landscapes in California.[37] The study suggests an opportunity for savings by preventing drainage from the sprinkler heads.

Figure 3-6: Irrigation System Drainage

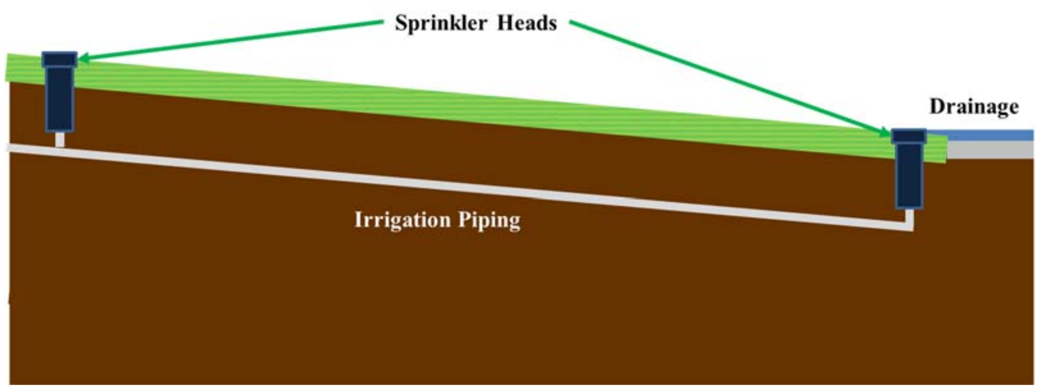

Illustration Credit: California Energy Commission

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36 Mecham, Brent, Irrigation Association, *Spray Sprinkler Bodies Docket Number: 17-AAER-05*, pg. 2, September 18, 2017.

37 Pike, Ed, and Daniela Urigwe, *Statewide Codes and Standards Enhancement (CASE) Team Response to Request for Proposals: Irrigation Spray Sprinkler Bodies*, pg. 24-25, September 18, 2017.

CHAPTER 4: Product Description

Landscape Emission Devices

The irrigation industry provides a wide variety of landscape emission devices adapted to best fit the needs of various landscapes. Emission devices are categorized according to the method of water delivery, water delivery rate, and installation. **Figure 4-1** shows the structure of the International Code Council (ICC) *802-2014 Landscape Irrigation Sprinkler and Emission Standard* definitions. This staff report follows this system of definitions in the discussion of landscape emission devices:

Figure 4-1: Landscape Emission Device Definitions

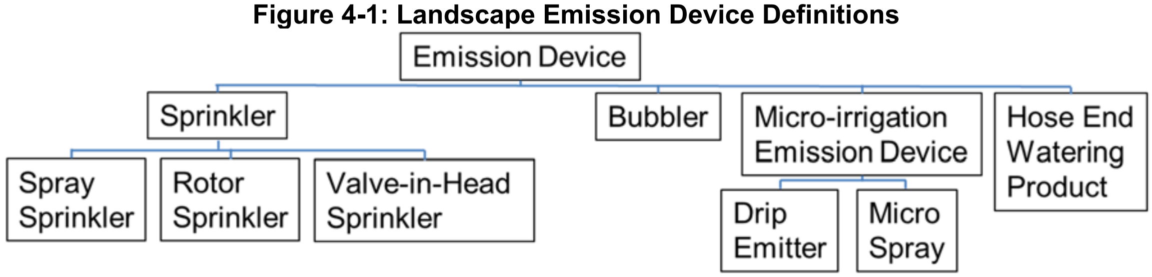

Illustration Credit: California Energy Commission

Sprinklers

Sprinklers are irrigation devices that convert irrigation water pressure to high-velocity water discharge through the air. Sprinklers are divided into three types: spray sprinklers, rotor sprinklers, and valve-in-head sprinklers. Each device is typically capable of a flow rate of more than 0.5 gallon per minute.[38]

Spray Sprinklers

A spray sprinkler relies upon a nonrotating nozzle to provide water over a continuous area. Spray sprinklers may be outfitted with a variety of nozzles, and the design of the sprinkler body may also vary depending upon the inclusion of a pop-up stem or retraction spring.

Pop-Up Spray Sprinklers

The pop-up spray nozzle sprinkler employs nozzles that spray water in a fixed pattern. They are typically used for small landscape areas, operating at 15 to 40 psi with a water spray distance of about 4 feet to 20 feet. The pattern of spray can be full-circle, half-

38 International Code Council, *Landscape Irrigation Sprinkler and Emitter Standard*, ANSI/ASABE/ICC 802-2014 Chapter 2, http://codes.iccsafe.org/app/book/content/2014_AMERICAN%20NATIONAL%20STANDARD/ICC%20802/CHAPTER%202%20DEFINITIONS.html.

circle, quarter circle, or rectangular strip. Some spray nozzles allow the user to set the angle of spray coverage. Spray nozzles are often interchangeable between bodies and are often marketed and sold separately. The pop-up mechanism relies upon a coil spring to retract the nozzle after sprinkler operation.

Figure 4-2: Pop-Up Spray Sprinkler

Photo Credit: Rain Bird

Pop-Up Multistream, Multitrajectory Spray Sprinklers

There are also multistream, multitrajectory spray nozzles that can be connected to spray sprinkler bodies. These nozzles use the flow of the water passing through them to rotate as they spray streams of water. Multistream, multitrajectory spray nozzles can provide a longer radius of throw and have higher recommended operating pressures of 40 to 45 psi. Multistream, multitrajectory spray nozzle sprinklers are different than the high-pressure gear rotor sprinklers.

Figure 4-3: Pop-Up Multistream, Multitrajectory Spray Sprinkler

Photo Credit: K-Rain

Pop-Up Gravity Retraction Spray Nozzle

Pop-up gravity retraction spray nozzle sprinklers are legacy sprinklers to older systems and were installed typically where water pressure is low.[39] The weight of the nozzle causes the nozzle to retract when not in use compared to the previous examples that

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39 "Sprinkler Warehouse product description." http://www.sprinklerwarehouse.com/Brass-Gravity-Sprinklers-s/9067.htm.

rely on a coil spring to retract the nozzle.[40] The design is susceptible to leakage at the base if insufficient water pressure is available to deploy the nozzle. The sprinkler body may be brass or plastic.

Figure 4-4: Pop-Up Gravity Spray Nozzle Sprinkler

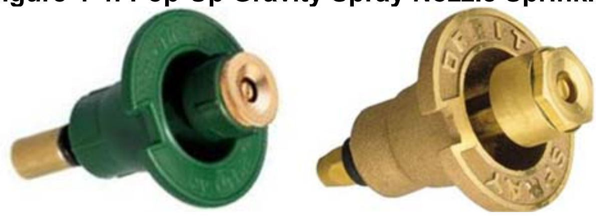

Photo Credit: Home Depot

Non-Pop-Up Spray Sprinklers

Some spray nozzle sprinklers do not pop-up while watering. Examples include shallow sprinklers intended to be flush with the ground and shrub spray sprinklers mounted to fixed risers to spray above shrubbery. Some shrub sprinklers are sold to be paired with a separately available riser pipe while other shrub sprinklers are sold with an adjustable riser.

Figure 4-5: Shrub Spray Sprinkler With Adjustable Riser

Photo Credit: Orbit Irrigation

40 Morningstar, Bird, *The Happy Gardener*, Chapter 8, http://www.happygardener.com/text/chap8/ch8doc1.htm.

Figure 4-6: Flush Spray Sprinkler

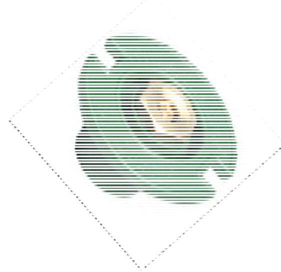

Photo Credit: Orbit Irrigation

Rotor Sprinklers

A rotor sprinkler rotates the nozzle or orifice to cover the irrigated area. The rotation may be driven by various means such as gear-driven turbines or impact mechanisms.

Gear-Driven Rotor Sprinklers

Gear-driven sprinklers use a turbine and gear train to impart a rotation to a nozzle. These typically operate at a higher pressure range of 30 to 100 psi (depending on model) and are most often used on larger landscapes due to the long water radius of throw (15 to 100 feet).[41] They offer quiet operation compared to other high-pressure sprinkler heads. The sprinklers provide larger water drops to reduce water waste from evaporation and misting.[42]

Figure 4-7: Gear-Driven Sprinkler

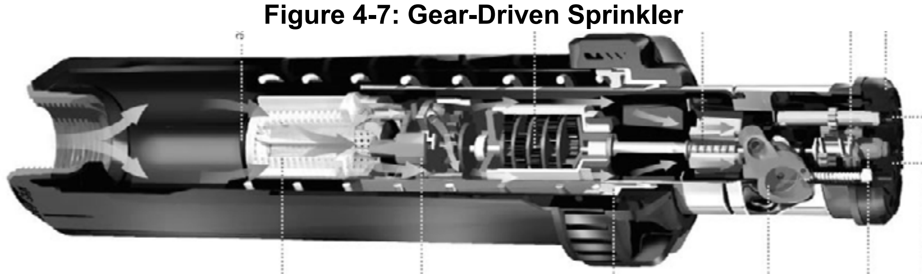

Photo Credit: Evergreen Sprinklers

Impact Rotor Sprinklers

Impact rotors were the first type of rotor sprinkler technology developed and offer the familiar sound of the spring-loaded mechanism impacting the water jet to impart rotation to the head. This type of sprinkler is used typically on larger landscapes. Impact sprinklers are offered as fixed or pop-up variants.[43]

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41 Sprinkler Warehouse, *The Different Types and Uses of Sprays, Rotors, and Impact Sprinklers,* http://www.sprinklerwarehouse.com/DIY-How-to-choose-a-sprinkler-head-s/7027.htm.

42 Rain Bird Corporation, "5000 Series Rotors," http://www.rainbird.com/homeowner/products/rotors/5000.htm.

43 Sprinkler Warehouse, *The Different Types and Uses of Sprays, Rotors, and Impact Sprinklers,* http://www.sprinklerwarehouse.com/DIY-How-to-choose-a-sprinkler-head-s/7027.htm.

Figure 4-8: Impact Sprinkler

Photo Credit: Rain Bird

Gun Sprinklers

Athletic field irrigation is accomplished through gun sprinkler systems. The systems are capable of flow rates as high as 1,200 gallons per minute and can fire water up to 100 feet. Gun systems require high pressures to operate.[44]

Figure 4-9: Gun Sprinkler System

Photo Credit: Nelson Irrigation

Valve-in-Head Sprinklers

Valve-in-head sprinklers contain an integral valve used to remotely control the operation of individual sprinklers. The sprinklers are typically found on landscapes where there is a need for a high level of control, such as a golf course.

44 Nelson Irrigation Corporation, "Sports Field Applications," http://www.nelsonirrigation.com/media/resources/BG_SPORTSFIELD.pdf.

Bubblers

Bubblers are emission devices that are used to flood the soil and are typically used for the deep watering of shrubs and trees. The water spreads through the ground from the point of emission rather than being projected in a sprinkler system.[45]

Figure 4-10: Bubbler

Photo Credit: Hunter Industries

Micro Irrigation Emission Devices

Drip emitters, drip-line emitters, and micro spray emitters discharge water in the form of droplets at very slow flow rates. Micro irrigation systems typically have many distribution points. Micro irrigation systems may be placed upon the surface of the landscape or may be buried below the surface.[46]

Figure 4-11: Types of Drip Emitters

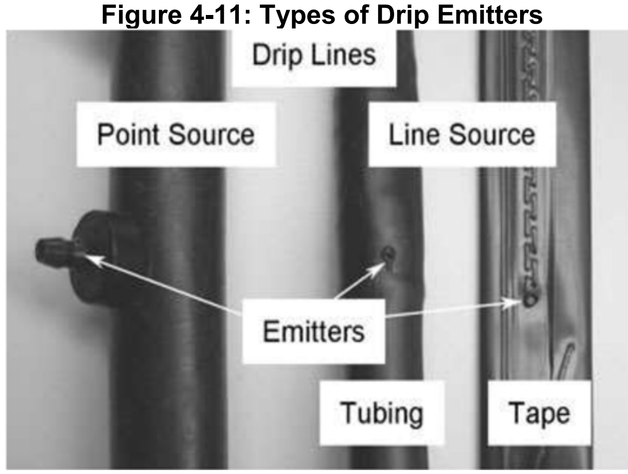

Photo Credit: New Mexico State University

45 Hunter Industries, "Bubblers and Bubbler Nozzles," http://www.hunterindustries.com/irrigation-product/nozzles/bubblers-bubbler-nozzles.

46 Hunter Industries, "Subsurface Irrigation Under Turf, Gardens, Small Shrubs," http://www.hunterindustries.com/irrigation-product/nozzles/bubblers-bubbler-nozzles.

Figure 4-12: Microspray Emitter

Photo Credit: Sprinkler Warehouse

Hose-End Watering Products

Hose-end watering products are intended for temporary placement by the user. Examples include portable lawn sprinklers and hand-held sprayers.

Figure 4-13: Hose-End Watering Products

Photo Credit: Nelson Irrigation

Landscape Emission Device Water Efficiency Technologies

Pressure Regulation

Pressure regulation provides for a uniform output pressure so that the emission device will perform at the designed pressure conditions. Manufacturers sell pressure regulation devices either incorporated into the emission device or as a separate device to be installed close to the water source connection. The pressure-regulating device adjusts the outlet pressure as the inlet pressure varies to prevent over pressurization of the landscape emission device or irrigation system.[47]

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47 Palumbo, Greg, and David Perl, Rain Bird Corporation, *Saving Water With Pressure Regulation and Check Valves- Introduction to Hydraulics*, pg. 16-30, https://www.rainbird.com/landscape/resources/webinars/Saving%20Water%20%20-%20Intro%20to%20Hydraulics.pdf.

Sprinkler Pressure Regulation

Sprinklers with pressure regulation control the output pressure to the spray nozzle to maintain the manufacturer-recommended operating pressure as the input pressure varies. Pressure-regulated sprinklers prevent excessive water flow rates, misting, wind drift, evaporation, and poor uniformity. Sprinklers are sold with and without pressure regulation.[48]

Typically, these devices feature a spring-operated flow tube centered within the sprinkler stem, which can move up and down between seats on either end of the flow tube. The movement of the tube relative to the inlet seat regulates how much water can flow through the stem, thus regulating water pressure at the outlet to the nozzle. The level of outlet-pressure regulation is determined by the strength of the spring. Different manufacturers may implement specific pressure regulation features differently and often have patented technologies.[49]

Pressure-regulator adapters are available for some landscape emission devices sold without pressure regulation, such as shrub sprinklers. The devices are threaded onto the supply pipe below the emission device.

Figure 4-14: Pressure Regulator Shrub Adapter

Photo Credit: Hunter Industries

Microemitter Pressure Regulation

Microemitter devices such as drip emitters, drip-line emitters, and bubblers are designed to operate at specific water pressures. Pressure-regulating devices are sold as part of water supply connection kits. Pressure regulation is not available as an integral feature of the microemitter.[50]

Drain Check Valve

A drain check valve closes the irrigation system to prevent water from draining from the system when the system is not operating. Irrigation systems may have drain check valves that are integral to the emission device, installed in-line with the irrigation piping, or installed underneath an emission device. Check valves can be added to most

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48 Lacey, Dustin, *Project PRS: How Much Water Can You Really Save?*, Rain Bird Corporation, pg. 6-12, https://www.watersmartinnovations.com/documents/sessions/2015/2015-T-1536.pdf.

49 Senninger Irrigation, *How Does a Pressure Regulator Work?* http://www.senninger.com/how-does-a-pressure-regulator-work/.

50 Rain Bird Corporation, Landscape Dripline System, pg. 5, http://www.rainbird.com/documents/diy/bro_landscapedriplinesystem.pdf.

irrigation spray heads in the field as an add-on or sold as integral parts of the sprinkler head assembly.[51]

Missing Nozzle

Some sprinkler manufacturers offer a missing-nozzle flow feature called a flow-interrupting device.[52] The feature may reduce or stop water flow from the sprinkler when a nozzle or pop-up stem is missing or damaged.

Pressure-Compensating Screens

Some irrigation spray sprinkler bodies and bubblers[53] are available with pressure-compensating screens to reduce outlet pressure. Pressure-compensating screens are passive and fit inside the irrigation body pop-up stem. They have no moving parts. Pressure-compensating screens do not regulate pressure but impart a pressure drop by acting as an additional obstruction to water flow within the pop-up stem. The screens permit the outlet pressure to fluctuate as the irrigation system inlet pressure fluctuates.[54]

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51 Palumbo, Greg, and David Perl, Rain Bird Corporation, *Saving Water With Pressure Regulation and Check Valves- Introduction to Hydraulics*, pg. 10, https://www.rainbird.com/landscape/resources/webinars/Saving%20Water%20%20-%20Intro%20to%20Hydraulics.pdf.

52 Qualified Water Efficient Landscaper, "QWEL Curriculum, Class 11, New Technology," pg. 17-18, http://www.qwel.net/wp-content/uploads/2011/04/QWEL-Class-11-2012.pdf.

53 Sprinkler Warehouse, "Hunter PCB-20 PCB Bubbler Nozzle," http://www.sprinklerwarehouse.com/Hunter-Sprinkler-Spray-Nozzles-p/pcb-20.htm.

54 http://www.irrigationtutorials.com/irrigation-sprinkler-head-selection/.

CHAPTER 5: Regulatory Approaches

California Energy Commission staff considered and studied regulatory pathways to achieve water savings in spray sprinkler bodies. Staff evaluated the Irrigation Association Sprinkler Standards, the International Code Council (ICC) Landscape Irrigation Sprinkler and Emission Standard, and the U.S. Environmental Protection Agency (U.S. EPA) WaterSense Specification for Spray Sprinkler Bodies.

Voluntary Standards

Irrigation Association Sprinkler Standards

The Irrigation Association (IA) developed and released several test methods with the Smart Water Application Technologies (SWAT) initiative. The goal of the initiative is to maintain a vibrant landscape while using a minimum amount of water. Although the test procedures have influenced the development of other landscape irrigation equipment test procedures and standards, no state or local regulations or product rebate programs reference the procedures.

IA released the *SWAT Testing Protocol for Spray Head Sprinkler Nozzles Performance Characteristics Version 3.2* in April 2015.[55] The test procedure tests sprinkler nozzle performance individually and in groups for distance of throw, nozzle flow, and precipitation rate. The test procedure defines the method to measure performance but does not set a performance standard.

The IA released the *SWAT Testing Protocol for Pressure Regulating Spray Head Sprinklers* V.3.0 in May 2012.[56] The procedure measures performance of pressure-regulating spray and multitrajectory nozzles. The test procedure also records the performance of sprinkler heads with a missing nozzle feature. The test method does not set a performance standard. IA provided recommended revisions to Version 3.0 as part of its comments to the Commission docket.[57]

55 Irrigation Association, *Smart Water Application Technologies Spray Head Sprinkler Nozzles Performance Characteristics Equipment Functionality Testing Protocol, Version 3.2*, April, 2015. https://www.irrigation.org/uploadedFiles/SWAT/Draft_Protocols/Spray_Head_Nozzles_Performance_Characteristics_Version%203.2_4-21-2015_Final.pdf.

56 Irrigation Association, *Smart Water Application Technologies Pressure Regulating Spray Head Sprinklers Equipment Functionality Testing Protocol*, Version 3.0, May, 2012. https://www.irrigation.org/uploadedFiles/SWAT/Draft_Protocols/Pressure%20Regulating%20Spray%20Head%20Sprinklers%20Testing%20Protocol%20Version%203.0%20May%202012.pdf.

57 Mecham, Brent, Irrigation Association, *Comment to Docket on the Invitation to Submit Proposals*, September 18, 2017, http://docketpublic.energy.ca.gov/PublicDocuments/17-AAER-08/TN221200_20170918T112728_Brent_Mecham_Comments_Proposed_Testing_of_Spray_Sprinklers.pdf.

The IA released the *SWAT Testing Protocol for Pop-up Sprinkler Head Check Valves Version 2.3* in June 2014. The test procedure tests integral check valve performance of sprinkler heads for seat tightness or leak resistance during nonoperation. The procedure verifies performance when new and after 2,500 cycles.[58]

International Code Council and American Society of Agriculture and Biology Engineers Sprinkler Standard

The International Code Council (ICC) developed and adopted the ASABE/ICC 802-2014, *Landscape Irrigation Sprinkler and Emission Standard*. The standard provides a test method and design and performance requirements for turf grass and landscape irrigation emitters to determine pressure-regulating, integral check valve, and missing nozzle performance. The standard does not specify a performance requirement for pressure regulation or missing nozzle performance. The standard sets a minimum check valve performance standard at a pressure head of 7 feet.[59] The U.S. EPA WaterSense Specification was developed from the ICC standard. The California Department of Water Resources references the ICC standard in the Model Water Efficient Landscape Ordinance.

ICC has begun developing the next edition of the standard. The ICC call for public input was due December 11, 2017.

U.S. Environmental Protection Agency WaterSense

The U.S. EPA WaterSense program developed a voluntary test method and standard based on ANSI ASABE/ICC 802-2014 *Landscape Irrigation Sprinkler and Emitter Standard*. The EPA evaluated the test method and measured spray sprinkler body performance for pressure regulation.[60] On September 21, 2017, the EPA published the WaterSense Specification for Spray Sprinkler Bodies. The EPA modified the test procedure to include step testing with pauses between test points, a reduction of the number of water pressure test points, and monitoring of the outlet flow rate. The EPA set minimum pressure regulation requirements based upon the as-tested performance of spray sprinkler bodies.[61]

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58 Irrigation Association, *Smart Water Application Technologies Pop-up Sprinkler Head Check Valves Equipment Functionality Testing Protocol, Version 2.3*, June 2014, https://www.irrigation.org/uploadedFiles/SWAT/SWAT%20Pop-up%20Sprinkler%20Head%20Check%20Valve-V2.3%20%206-18-2014.pdf.

59 International Code Council, ASABE/ICC 802-2014, *Landscape Irrigation Sprinkler and Emission Standard*, http://codes.iccsafe.org/app/book/content/2014_AMERICAN%20NATIONAL%20STANDARD/ICC%20802/CHAPTER%203%20GENERAL%20REQUIREMENTS%20FOR%20SPRINKLERS%20AND%20BUBBLERS.html.

60 Dukes, Michael D. Ph. D, P.E., University of Florida, *Pressure Regulating Spray Sprinkler Body Final Test Report*, January 16, 2017, https://www.epa.gov/sites/production/files/2017-03/documents/ws-background-ssb-performance-testing-report1.pdf.

61 U.S. Environmental Protection Agency, *WaterSense® Specification for Spray Sprinkler Bodies Supporting Statement*, September 21, 2017, https://www.epa.gov/sites/production/files/2017-09/documents/ws-products-support-statement-ssb.pdf.

International Association of Plumbing and Mechanical Officials

The International Association of Plumbing and Mechanical Officials (IAPMO) Green Plumbing & Mechanical Code Supplement Section 413.10.2 requires that sprinkler heads "utilize pressure regulating devices (as part of irrigation system or integral to the sprinkler head to maintain manufacturer's recommended operation pressure for each sprinkler and nozzle type)." The voluntary supplement serves as a resource for jurisdictions implementing green building and water efficiency programs.[62]

In November 2017, IAPMO released the 2017 Water Efficiency and Sanitation Standard (2017 WE Stand) that replaced the Green Plumbing & Mechanical Code Supplement. The WE Stand committee considered various proposals to improve the water efficiency of landscape irrigation. The Energy Commission participated as part of the Technical Committee. The standard remains voluntary and maintains many of the requirements of the preceding green code supplement, such as pressure regulation within irrigation systems.

Other Regulations and Approaches

California Model Water Efficient Landscape Ordinance

Per Executive Order B-29-15 of April 1, 2015, the Department of Water Resources (DWR) updated the State's Model Water Efficient Landscape Ordinance (MWELO) through expedited regulation. Cities and counties are responsible for adopting and reporting a water-efficient landscape ordinance. Local agencies had until December 1, 2015, to adopt MWELO or adopt a local ordinance that is at least as effective in conserving water as MWELO. Local agencies had until February 1, 2016, to work together to adopt a regional ordinance. To comply, local agencies were required to perform one of the following actions:

- Adopt MWELO by reference Sections 490-495, Chapter 2.7, Division 2, Title 23 in the California Code of Regulations.
- Adopt the actual text of MWELO, Sections 490-495, Chapter 2.7, Division 2, Title 23 in the California Code of Regulations.
- Amend an existing or adopt a new local ordinance or regional ordinance to achieve the same savings as the MWELO regulations.
- Take no action and allow the MWELO to go into effect by default, and adopt a local or regional ordinance later.

62 International Association of Plumbing and Mechanical Officials, *2012 Green Plumbing and Mechanical Code Supplement*, pg. 15, http://www.iapmo.org/Documents/2012GreenPlumbingMechanicalCodeSupplement.pdf.

MWELO applies to:

- New construction projects with an aggregate, or combined, landscape area equal to or greater than 500 square feet requiring a building or landscape permit, plan check, or design review.
- Rehabilitated landscape projects with an aggregate landscape area equal to or greater than 2,500 square feet requiring a building landscape permit, plan check, or design review.
- Cemeteries.
- Existing landscapes installed before December 1, 2015, greater than one acre.

In MWELO, local agencies are encouraged to take measures beyond those in MWELO, including measures that account for local climate, geology, topography, and environmental conditions. MWELO includes requirements for the inclusion of pressure-regulating devices and antidrain valves. However, these requirements are applied in design and construction and could possibly be omitted in the adoption of comparable regulations by local authorities.

California Independent Technical Panel on Demand Management Measures

DWR coordinated an effort to identify water-saving measures for landscape irrigation equipment and practices that culminated in the May 2016 *Recommendations Report to the Legislature on Landscape Water Use Efficiency*.[63] Section 7-2 recommends that the Energy Commission adopt appliance efficiency standards for spray sprinkler bodies that would require pressure regulation and drainage check valves.

California State Water Resources Control Board Measures

Per Executive Orders B-37-16 and B-40-17 the California State Water Resources Control Board issued regulations to permanently prohibit certain wasteful water uses.[64] The regulations added chapter 3.5, Article 2, *Wasteful and Unreasonable Water Uses*, to Title 23, division 3 of the California Code of Regulations. Section 963(b)(1) provides the following prohibitions. The prohibitions apply to a variety of water users including homeowners, homeowners' associations, cities and counties. Violations can lead to fines of up to $500 dollars per each day that the violation occurs.

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63 Department of Water Resources, *Recommendations Report to the Legislature on Landscape Water Use Efficiency*, May 2016, pg. 45-46, http://www.water.ca.gov/wateruseefficiency/sb7/committees/urban/u2/docs/ITP%20Final%20Report%20to%20Legislature%2005-16-16%20watermark.pdf.

64 California State Water Resources Control Board, Regulation on Wasteful and Unreasonable Water Uses website, available at: https://www.waterboards.ca.gov/water_issues/programs/conservation_portal/regs/wasteful_water_uses.html#documents.

Wasteful and Unreasonable Water Uses Prohibitions:

- Don’t allow runoff from irrigated landscapes
- Don’t wash vehicles without a shutoff nozzle attached to hose
- Don’t water driveways and sidewalks
- Don’t use potable water in fountains, unless the water is recirculated
- Don’t irrigate in the rain
- Don’t serve drinking water, unless a customer asks
- Don’t irrigate turf on medians and ‘parkways,’ unless the landscape performs a neighborhood function

Regulations in Other States

The Texas Administrative Code specifies, “No irrigation design or installation shall require the use of any component, including the water meter, in a way which exceeds the manufacturer's published performance limitations for the component.” This rule goes on to specify that methods must be used to ensure that emission devices be installed in a way that does not subject them to pressures above or below those published by the manufacturers. Methods listed include, but are not limited to, “a pressure regulator, or pressure compensating spray heads.”[65]

Vermont Statute Title 9, Energy Efficiency Standard for Appliances and Equipment (9 V.S.A Sections 2793-2796), sets testing and efficiency standards for spray sprinkler bodies identical to the U.S. EPA WaterSense Specification for Spray Sprinkler Bodies, Version 1.0.[66]

Rhode Island is considering Bill 7828 to add SSBs to the state appliance standards. The bill proposes testing and efficiency standards for SSBs identical to the U.S. EPA WaterSense Specification for Spray Sprinkler Bodies, Version 1.0.[67]

There are no federal efficiency standards for spray sprinkler bodies.

Consideration of Alternative Proposals

The staff proposal was analyzed to determine whether it meets the legislative criteria for the Energy Commission’s prescription of appliance efficiency standards. Staff also reviewed and analyzed the WaterSense specification as well as other state and local

65 “Texas Administrative Code, Title 30, Part 1, Chapter 344, Subchapter F, STANDARDS FOR DESIGNING, INSTALLING, AND MAINTAINING LANDSCAPE IRRIGATION SYSTEMS, Rule 344.62 (a) and (c),” http://www.tceq.state.tx.us/assets/public/compliance/compliance_support/regulatory/irrigation/forms_li/344.62.pdf.

66 Vermont Statutes, Title 9, Chapter 074, Section 2793-2796, Energy Efficiency Standards for Appliances and Equipment, available at: https://legislature.vermont.gov/statutes/section/09/074/02793.

67 State of Rhode Island Bill H 7828 2018, *An Act Relating to Public Utilities and Carriers- The Energy and Consumer Savings act of 2005*, available at: http://webserver.rilin.state.ri.us/billtext18/housetext18/h7828.htm.

standards. Staff will continue to analyze and consider alternative proposals as they are provided to the Energy Commission.

Alternative 1: No Standard

Staff believes proposing no standard for all spray sprinkler bodies would represent a lost opportunity for water savings in California.

Alternative 2: Pressure Regulation Standard

Staff studied proposing pressure regulation for all spray sprinkler bodies since many products are available with pressure regulation. Pressure regulation provides significant water savings, and when combined with the previous work performed by WaterSense, there is sufficient information to analyze cost-effectiveness, technical feasibility, and statewide water savings.

Alternative 3: Pressure Regulation and Check Valve Standard

Staff studied proposing pressure regulation and check valves on all spray sprinkler bodies since this is another common product offering. At this time, there is no available performance data to demonstrate cost-effectiveness and technical feasibility of the drain check valve. Staff has determined not to include the drain check valve as a water-saving measure but would consider this feature in the future when information becomes available regarding drain check valve performance.

Alternative 4: Pressure Regulation, Check Valve, and Missing Nozzle Standard

Staff studied proposing pressure regulation, check valve, and missing nozzle standards for all spray sprinkler bodies since some products are sold with this combination of features. Staff found insufficient evidence to estimate missing nozzle water savings and did not find a ready test procedure to verify missing nozzle performance. Staff does not propose to include missing nozzle capability in the proposed standard.

Test Method Selection

Energy Commission staff reviewed the available test procedures for spray sprinkler body pressure regulation. Staff identified the ANSI ASABE/ICC 802-2014, the IA *SWAT Testing Protocol for Pressure Regulating Spray Head Sprinklers* V.3.0, and the U.S EPA *WaterSense Specification for Spray Sprinkler Bodies, V.1.0* for evaluation.

CHAPTER 6: Staff Proposal for Spray Sprinkler Bodies

Energy Commission staff has analyzed equipment and practices of landscape irrigation, as well as the cost-effectiveness and technical feasibility of regulating spray sprinkler bodies. Staff has determined that the water and energy savings under the proposed standard are significant while imparting a small incremental cost to consumers. The proposed standard is attainable with products currently available in the market.

Scope

Energy Commission staff reviewed the readiness of the various types of landscape emitters discussed in this report for water-saving regulations. Staff reviewed available test procedures, availability of products with pressure regulation, and whether the products meeting the standard would provide significant water savings. Staff proposed regulations for spray sprinkler bodies due to the availability of test methods, test data, currently compliant products, and significant cost-effective water savings. **Table 6-1** shows examples of the landscape emission devices that are in-scope or out-of-scope of the regulation. Staff provides descriptions of the landscape emission devices in Chapter 4.

Table 6-1: Examples of In and Out of Scope Landscape Emission Devices

In-Scope Devices	Out-of-Scope Devices
Pop-Up Spray Sprinkler Pop-Up Multi-Stream Multitrajectory Sprinklers Pop-Up Gravity Retraction Spray Nozzle Non-Pop-Up Spray Sprinklers Spray Sprinkler Bodies Shrub Adapters	Gear Driven Rotor Sprinklers Impact Rotor Sprinklers Gun Sprinklers Valve-in-Head Sprinklers Bubblers Micro irrigation Emission Devices Hose-End Watering Products

Source: California Energy Commission

Test Procedure

Staff proposes to use U.S EPA *WaterSense Specification for Spray Sprinkler Bodies, V.1.0* as the test procedure for spray sprinkler bodies. All spray sprinkler bodies manufactured on or after October 1, 2020,[68] must be certified as tested in a lab approved by the Energy Commission per *WaterSense Specification for Spray Sprinkler Bodies Version 1.0, September 21, 2017*.

Standard

Staff's proposed standard for all spray sprinkler bodies sold or offered for sale in California would align with the U.S. EPA WaterSense Specification. Specifically: All spray sprinkler bodies manufactured on or after October 1, 2020,[69] must be certified to the Energy Commission as meeting the following requirements when tested per *WaterSense Specification for Spray Sprinkler Bodies Version 1.0, September 21, 2017*:

- Maximum flow rate at any tested pressure level—the percentage difference between the initial calibration flow rate and the maximum flow rate at any tested pressure level, averaged for the selected samples at the test pressure levels where the maximum flow rate occurred, shall not exceed +/- 12.0 percent.
- Average flow rate across all tested pressures—the percentage difference between the initial calibration flow rate and the flow rate at each tested pressure level, averaged across all pressure levels and all selected samples, shall not exceed +/- 10.0 percent.
- Minimum outlet pressure—the average outlet pressure at the initial calibration point (as described in WaterSense Specification for Spray Sprinkler Bodies Versions 1.0) of the selected samples shall not be less than two thirds of the regulation pressure.

The WaterSense test method and performance standard found within the specification were well vetted by the EPA in a public proceeding and the EPA sponsored efforts by the University of Florida to suggest improvements to the underlying ASABE/ICC 802-2014 pressure regulation test method. The EPA showed the test method reveals differences in the ability of SSB to regulate pressure and use water efficiently. Testing by the EPA showed the standard of the specification as technically feasible and yielding significant water savings.

The regulation will result in water savings by creating mandatory standards for products sold or offered for sale in California. Based on its independent analysis of the available data, staff has concluded that these proposed regulations are cost-effective and technically feasible. Staff assumptions and calculations are provided in Appendix A.

Certification

Manufacturers would be required to certify each model of spray sprinkler body, whether sold with or without a nozzle, to the Energy Commission's appliance efficiency database. Certifying each model will allow for effective enforcement of the proposed standard by providing regulators with a list of products that could be legally sold in

69 For the purposes of analysis, staff assumes October 1, 2020 effective date, one year from an anticipated adoption date of July 15, 2019.

California. Certifying will also allow distributors and retailers to verify that products can be legally sold prior to sale.

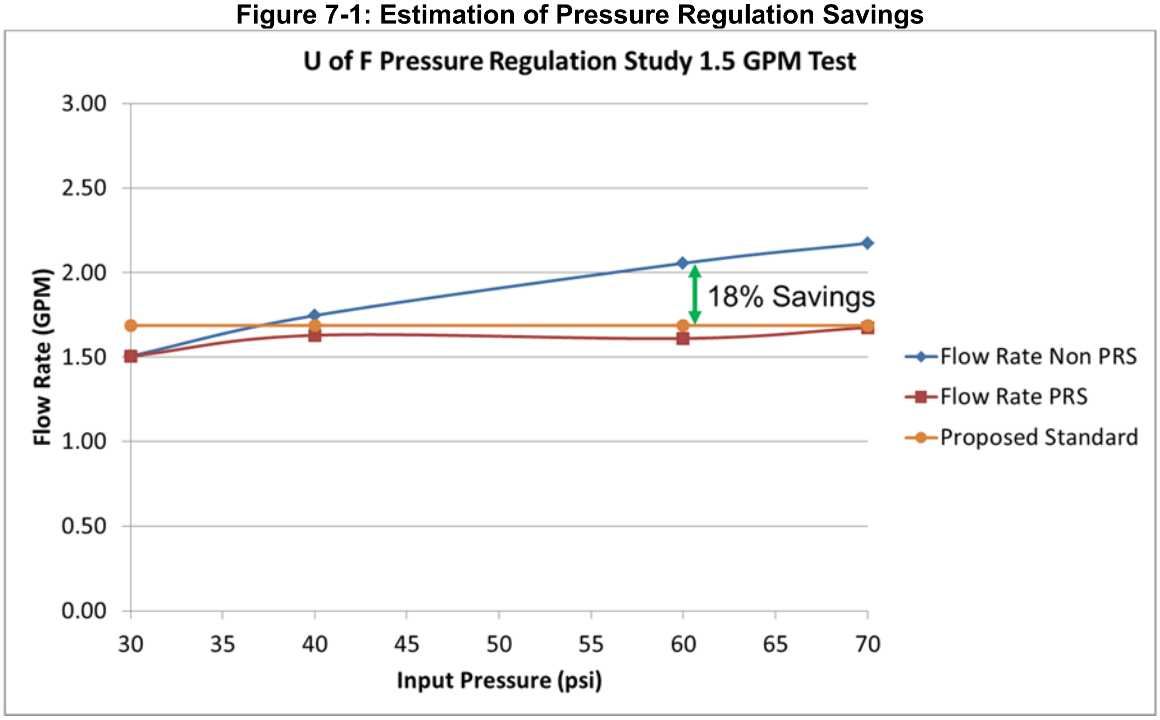
Marking

All appliances will need to be marked with the manufacturer name, brand name, or trademark; the model number; and the date of manufacture, permanently, legibly, and conspicuously on an accessible place on each unit, on the unit packaging, or, where the unit is contained in a group of several units in a single package, on the packaging of the group. Staff does not propose any additional marking or labeling requirements for spray sprinkler bodies. The date of manufacture marking shall provide at a minimum the month and year that the product was produced. The marking will enable effective enforcement by requiring sprinklers within the scope of the regulations to be identifiable.

CHAPTER 7: Savings and Cost Analysis

The proposed standard for spray sprinkler bodies would significantly reduce water and energy consumption. Staff estimated per device water savings by reviewing performance data gathered by the U.S. EPA WaterSense. **Figure 7-1** shows the average pressure regulation performance for spray sprinkler bodies with and without pressure regulation. Staff calculated the percentage savings by assuming that noncompliant devices are improved only to comply minimally with the proposed standard. The average dynamic inlet water pressure to the spray sprinkler body was assumed to be 61 pounds per square inch (psi) based upon a CA DWR data[70] and accounting for pressure losses in the irrigation valve and piping. **Appendix B** describes staff's analysis of water pressure conditions in the state of California and sources of pressure loss before the spray sprinkler body.

Figure 7-1: Estimation of Pressure Regulation Savings



Source: California Energy Commission illustration with U.S. EPA WaterSense performance data

To determine incremental costs of sprinkler heads that meet the proposal, Energy Commission staff gathered retail price data from sprinkler vendor websites. The data

70 California Department of Water Resources, Water Urban Efficiency Data, 2015 Urban Water Management Plans, available at: https://wuedata.water.ca.gov/awwa_plans.

were analyzed to estimate the cost difference to consumers with the addition of the pressure regulation feature.

Table 7-1: Annual Water, Energy, and Monetary Savings

Product Type	Design Life (years)	Water Savings (gal/yr)	Embedded Electricity Savings (kWh/yr)	Incremental Costs ($)	Average Annual Savings ($/yr)	Life-Cycle Benefit ($)
Spray Sprinkler Bodies	10	554	2.0	$4.68	$3.19	$22.55

Source: California Energy Commission

The values in **Table 7-1** list the design life, incremental cost, and monetary savings in 2017 dollars. The average annual savings are the savings that consumers will receive once the product is installed.

The annual savings of each unit are calculated by multiplying the annual water savings by the water delivery charge of $5.76 per 1,000 gallons.[71] Embedded electricity savings are not included in the life-cycle cost analysis. The life-cycle benefit represents the savings the consumer will receive over the life of the appliance and is the product of the average annual savings multiplied by the average design life of the unit. Staff applied a 3 percent discount rate to calculate the net present value of the anticipated savings over the design life. The net life-cycle benefits are the differences between the net present value of the savings and the incremental cost of each compliant unit.

Staff performed a sensitivity analysis to identify the minimum inlet water pressure that would provide consumers with cost-effective water savings due to the proposed standard. The proposed standard remains cost-effective for inlet pressures at or above 40 psi.[72] A study of inlet pressures shows that 8 of 10 Californians have an inlet pressure at or above 40 psi and will receive cost-effective water savings from switching from spray sprinkler bodies without pressure regulation to spray sprinkler bodies with pressure regulation.[73]

Staff reviewed a report sponsored by the California Public Utilities Commission to determine the average size of a yard for a single-family home and the percentage of

71 California Department of Water Resources, Water Urban Efficiency Data, 2015 Urban Water Management Plans, available at: .https://wuedata.water.ca.gov/awwa_plans.

72 At 40 psi, the water savings rate is 3.4 percent, yielding a yearly savings of $0.61. The savings over 10 years discounted by 3 percent per year is $4.86. The life-cycle benefit is $0.54 = $5.22 - $4.68.

73 Pike, Ed, and Daniela Urigwe, *Statewide Codes and Standards Enhancement (CASE) Team Response to Request for Proposals: Irrigation Spray Sprinkler Bodies*, pg. 94-95, September 18, 2017.

homes that have an automatic irrigation system.[74] Staff then used 2016 demographic information from the California Department of Finance to find the number of single-family and multi-family homes in California.[75] Staff relied on this information to calculate that 232 million sprinkler heads are in use in California. Staff estimated that 63 million sprinkler heads are used for commercial irrigation from information provided by the Pacific Institute.[76] Staff assumes 9.5 million sprinkler heads around government facilities. Assuming a 10 percent replacement rate based upon a 10-year design life, staff estimates 30 million sprinkler head shipments per year in California.

The savings estimates compare the baseline water and energy consumption for sprinkler heads with the respective water and energy consumption under the proposed standards. For statewide estimates, these savings are multiplied by sales for first-year figures and by total California stock. These calculations are available in **Appendix A**. In **Tables 7-2** and **7-3**, the potential water and energy savings of the proposed standards are provided. Water and energy savings are further separated into first-year savings and stock savings. *First-year savings* are the annual reduction of water and energy consumed associated with annual sales, one year after the standards take effect. *Annual stock savings* are the annual water and energy savings achieved after all existing stock in use complies with the proposed standards.

Staff calculations and assumptions used to estimate first-year savings and stock change savings are provided in **Appendix A**. As provided in **Table 7-2**, if all sprinkler heads complied with the proposed standards (annual stock savings), California would save 543 GWh of energy per year and about 152 billion gallons of water. Staff calculated the benefit to water utilities by using the 2016 annual average electric rate of $0.1431/kWh from the agriculture and water-pumping sectors.[77] The proposed standards for spray sprinkler bodies would save water utilities roughly $8 million in the first year and $78 million after total stock turnover in reduced electricity costs. Water consumers would save $87 million in the first year and $877 million at total stock turnover, assuming a water delivery charge of $5.76 per 1,000 gallons of water.[78]

An Energy Commission report on water supply electricity demand found that the outdoor water use of a California home contributes 0.038 kW to peak demand on a peak

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74 Funk, Andrew, and William DeOreo, *Embedded Energy in Water Studies Study 3: End-Use Water Demand Profiles*, 2011, pg. 88.

75 California Department of Finance, E-5 Population and Housing Estimates for Cities, Counties, and the State, 2011-2016 with 2010 Census Benchmark, May 2016, http://www.dof.ca.gov/Forecasting/Demographics/Estimates/E-5/.

76 Gleick, Peter H., Dana Haasz, et al, *Waste Not, Want Not: The Potential for Urban Water Conservation in California*, Pacific Institute, 2003, Appendix D, pg. 11.

77 Marshall, Lynn, "*California Energy Demand 2018-2030 Revised Baseline Forecast - Mid Demand Case, Form 2.3*," Energy Commission Supply Analysis Office, available at http://www.energy.ca.gov/2017_energypolicy/documents/2017-12-15_workshop/2017-12-15_middemandcase_forecst.php.

78 California Department of Water Resources, Water Urban Efficiency Data, 2015 Urban Water Management Plans, available at: .https://wuedata.water.ca.gov/awwa_plans.

day.[79] Staff calculated the peak power reduction by multiplying the 0.038 kW/residence by 5.8 million homes with spray sprinkler body irrigation by an 18 percent savings rate. The peak reduction is 41 MW. Multi-family irrigation savings would reduce peak demand by 4 MW. Commercial irrigation savings would reduce the peak demand by 14 MW using similar assumptions to residential irrigation. The total peak reduction would be 59 MW.

Table 7-2: Water Savings and Energy Savings

Application	Water Savings Per Device (gal/yr)	Water Savings Per Location (gal/yr)	Statewide (Mgal/yr)	Embedded Electricity (GWh/yr)
Residential – Single Family	554	19,951	104,646	373
Residential - Multi-Family	554	2,377	11,397	41
Commercial excluding Schools	554	N/A	31,515	112
Government	554	N/A	4,727	17
Total	N/A	N/A	152,286	543

Source: California Energy Commission

Table 7-3: Statewide Monetary Savings

	First Year			Stock Savings		
Application	**Water Delivery (M$/yr)**	**Embedded Electricity (M$/yr)**	**Total (M$/yr)**	**Water Delivery (M$/yr)**	**Embedded Electricity (M$/yr)**	**Total (M$/yr)**
Residential Single Family	$60.3	$5.3	$65.6	$602.8	$53.4	$656.1
Residential Multi Family	$6.6	$0.6	$7.1	$65.6	$5.8	$71.5
Commercial excluding Schools	$18.2	$1.6	$19.8	$181.6	$16.1	$197.7
Government	$2.7	$0.2	$2.9	$27.2	$2.4	$29.6
Total	$87.8	$7.7	$95.4	$877.2	$77.7	$954.9

Source: California Energy Commission

In conclusion, the proposed standards are clearly cost-effective, as consumers will receive a net savings from the installation of spray sprinkler bodies over the life of the product.

79 House, Lon W, Ph.D., *Water Supply Related Electricity Demand in California,* pg. 52 and 63, December 2006, available at http://www.waterandenergyconsulting.com/WEDemandReport.pdf.

CHAPTER 8: Technical Feasibility

Compliant Product Availability

EPA WaterSense Product Testing

The EPA collaborated with the University of Florida to test pressure regulating and nonpressure-regulating spray sprinkler bodies. The efforts led the EPA to release the *WaterSense Specification for Spray Sprinkler Bodies, V1.0* that provides a test method and minimum performance standards for spray sprinkler bodies. The EPA used the University of Florida data to show the test method within the WaterSense specification will provide accurate and repeatable results. The EPA set minimum performance standards based upon the data provided by the University of Florida. The University of Florida study shows four of the six brands tested will meet the WaterSense standard. The results of the University of Florida study are shown in **Figures 8-1, 8-2, and 8-3.** The staff proposal requires certification to the WaterSense Specification. Therefore, the University of Florida study demonstrates the staff proposal is technically feasible.

Figure 8-1: EPA WaterSense Average Flow Rate Requirement

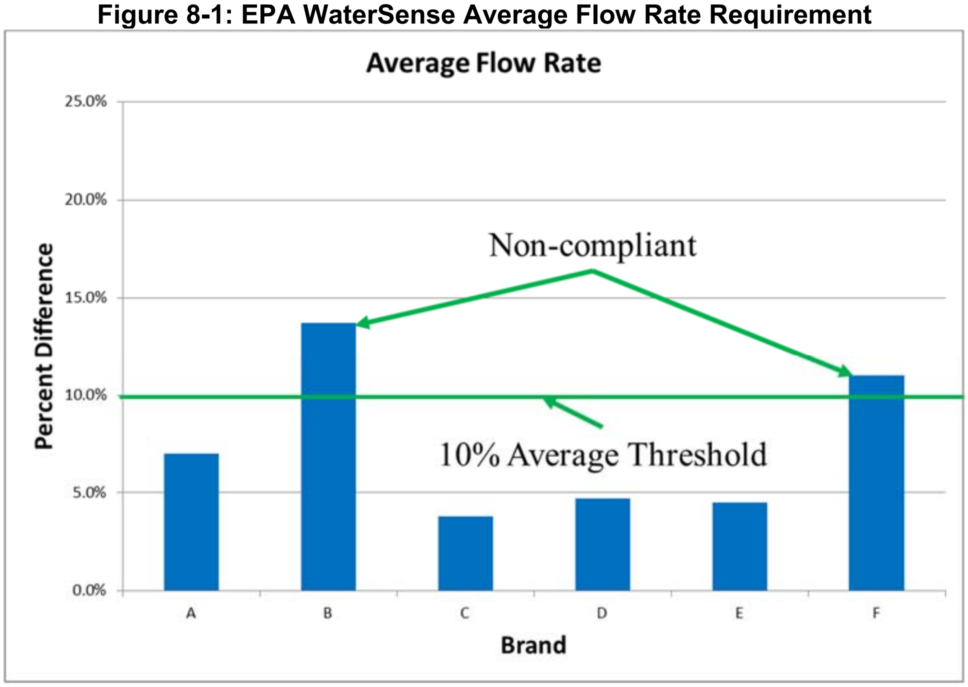

Illustration Credit: California Energy Commission with EPA WaterSense Data

Figure 8-2: EPA WaterSense Maximum Flow Rate Requirement

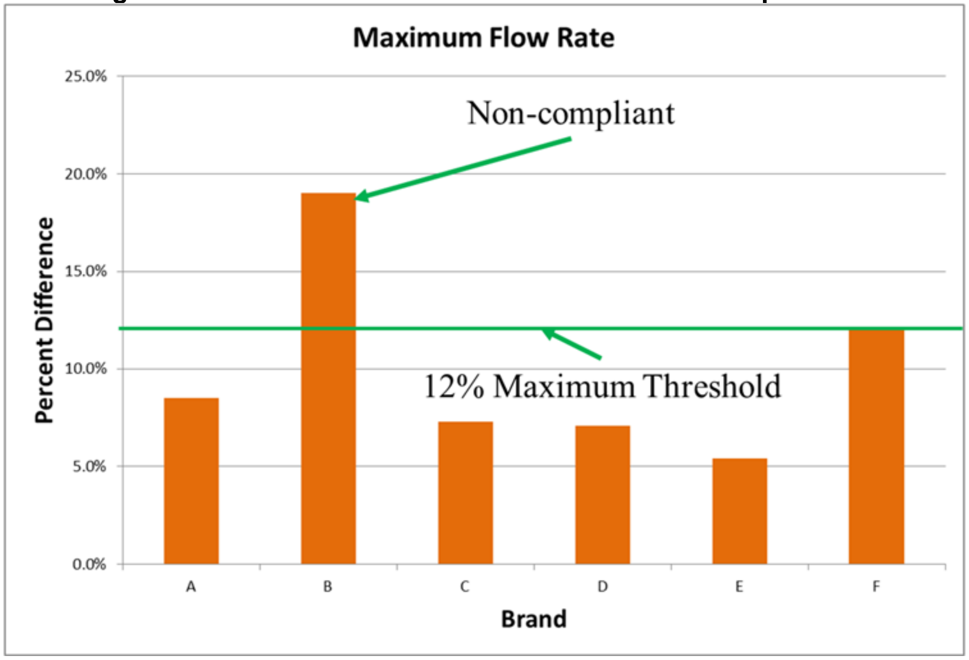

Illustration Credit: California Energy Commission with EPA WaterSense Data

Figure 8-3: EPA WaterSense Minimum Outlet Pressure Requirement

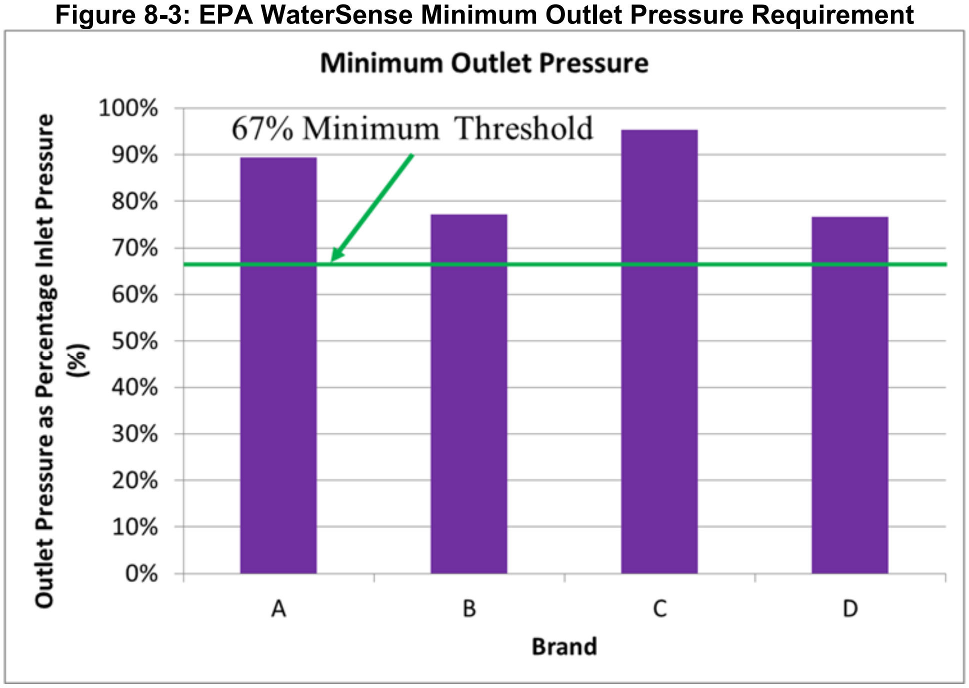

Illustration Credit: California Energy Commission with EPA WaterSense Data

Additional Pressure Regulation Product Testing

In 2014, the University of Arizona conducted a study of pressure-regulated sprinklers manufactured by Rain Bird. The study showed that the incorporation of pressure regulation can lead to substantial water savings. **Table 8-1** shows water usage differed widely between spray sprinkler heads with pressure regulation versus those without pressure regulation. The reductions in flow due to pressure regulation are consistent with the University of Florida study and further demonstrate the technical feasibility of the staff proposal at the inlet pressures greater than 30 psi.

Table 8-1: Project PRS Spray Results

Inlet Pressure (psi)	Flow Rate Without PR (GPM)	Flow Rate With PR (GPM)	Savings per Spray Head (GPM)	% Savings
30	0.65	0.65	.00	0%
40	0.6657	0.6303	0.035	5%
50	0.717	0.6403	0.077	11%
60	0.7583	0.6503	0.108	14%
70	0.794	0.6603	0.134	17%
80	0.824	0.6703	0.134	19%

Source: Rain Bird Corporation

Staff Market Survey

Staff surveyed the spray sprinkler body market to identify companies marketing products containing integral pressure regulation. The companies and product lines are described below.

- Rain Bird markets the 1800 PRS line of spray sprinklers and the 5000 PRS line of gear-driven sprinkler heads with pressure regulation.[80, 81]
- Toro markets the 570Z series sprinkler head with pressure regulation that maintains a steady outlet pressure of 30 psi over the recommended range of inlet pressures.[82]
- Orbit markets the Eco-Spray head that maintains a constant 30 psi outlet pressure with integral pressure regulation.[83]
- Hunter markets the Pro-Spray PRS30 and PRS40 product line with integral pressure regulation and drain check valves.[84]
- Staff also found pressure-regulated models available from K-Rain and Irritrol.

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80 Palumbo, Greg, and David Perl, Rain Bird Corporation, *Saving Water With Pressure Regulation and Check Valves- Introduction to Hydraulics*, pg. 30, https://www.rainbird.com/landscape/resources/webinars/Saving%20Water%20%20-%20Intro%20to%20Hydraulics.pdf.

81 Rain Bird Corporation, http://www.rainbird.com/landscape/products/sprayBodies/1800PRS.htm.

82 The Toro Company, "570Z Pressure Regulating Spray Heads," http://watersmart.toro.com/570z-pressure-regulating-spray-heads/.

83 Orbit Irrigation Products, https://www.orbitonline.com/products/sprinkler-systems/sprinklers/spray-heads/pressure-regulating-hydroseal-springloded-pop-up/4-pr-eco-spray-slpu-wflush-plug.

84 Hunter Industries, "Pro-Spray PRS40," http://www.hunterindustries.com/irrigation-product/spray-bodies/pro-spray-prs40.

The variety of products available from multiple manufacturers confirms compliant product availability and a lack of any intellectual property barriers that could otherwise prevent competition.

Irrigation Association Market Survey

The IA submitted comments to the docket listing manufacturers and model numbers of spray sprinklers with pressure regulation. **Table 8-2** lists manufacturers identified as offering pressure-regulating sprinklers.[85]

Table 8-2: List of Manufacturers With Pressure Regulation Products

Hydro-Rain	Signature	Irritrol	HIT Products	Orbit
Toro	K-Rain	Weathermatic	Hunter Industries	Rain Bird

Source: Irrigation Association

U.S. EPA WaterSense Labeled Products

On March 13, 2019, the U.S. EPA WaterSense product website showed 103 spray sprinkler body models with the WaterSense label. Hunter Industries, Irritrol, Rain Bird Industries, Weathermatic and TORO each had WaterSense models.[86] The WaterSense models show spray sprinkler bodies are available from multiple manufacturers. Since the proposed standard is identical to the WaterSense program the proposed standard is technically feasible.

2-Inch Gravity Retraction and Pop-Up Sprinklers

Staff reviewed the availability of 2-inch gravity retraction and pop-up sprinkler-compliant products and found that these products are not available with pressure regulation. However, these products do not appear to provide a unique utility or consumer efficacy that would merit exempting them from the regulations. For example, a consumer could retrofit a 2-inch gravity or pop-up sprinkler with a 4-inch pop-up sprinkler using industry-accepted practices,[87] such as installing swing pipe fittings and flexible pipes that can adapt the existing lawn irrigation system so a compliant 4-inch pop up can be installed flush with the ground without modifying the existing irrigation plumbing system. The approach is cost-effective and technically feasible, even with the additional products to adapt the interface. Staff found the cost of a swivel arm or a funny pipe at less than $1. The life-cycle benefit would be reduced by $1 from around

85 Mecham, Brent, Irrigation Association, *Comment to Docket on the Invitation to Submit Proposals*, September 18, 2017, pg. 41-42, http://docketpublic.energy.ca.gov/PublicDocuments/17-AAER-08/TN221200_20170918T112728_Brent_Mecham_Comments_Proposed_Testing_of_Spray_Sprinklers.pdf.

86 US EPA WaterSense Product Search website, https://www.epa.gov/watersense/product-search, search conducted on March 13, 2019.

87 Sprinkler Warehouse, "How to Connect Your Sprinkler Head to the Underground Pipe." https://www.sprinklerwarehouse.com/articles.asp?id=198.

$22 to $21, which is still very cost-effective. **Figure 8-4** shows two possible methods to adapt the interface.

Figure 8-4: 2-Inch Gravity and Pop-Up Replacement Options

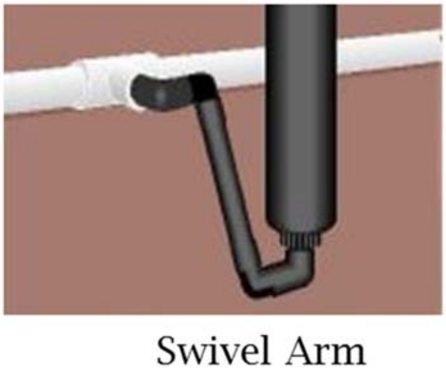

Photo Credit: Sprinkler Warehouse and Gem Sprinkler

Low Pressure Zones and Pressure Regulated SSB

Stakeholders requested that the Commission study the use of pressure regulated spray sprinkler bodies in low pressure zones where water pressure may be lower than 30 psi. Staff and the CASE Team reviewed product information for both pressure regulated and non-pressure regulated models and did not find differences in the operating pressure ranges provided by the manufacturers. Landscape irrigation design handbooks offered by manufacturers do not provide recommendations against the use of pressure regulated sprinklers in low pressure areas.[88] Staff reviewed recommendations for sprinklers operating in low pressure areas and found common solutions to include determining if a leak is in the irrigation system, reducing the number of sprinklers per irrigation zone[89] or reducing the sprinkler precipitation rate through nozzle retrofits.[90] Staff did not find a recommendation to remove pressure regulating sprinklers from low pressure zones to fix irrigation issues. Therefore, staff concludes that pressure regulating spray sprinkler bodies will perform as well as non-pressure regulating heads in low pressure zones.

88 Hunter Industries, *RESIDENTIAL SPRINKLER SYSTEM DESIGN AND INSTALLATION GUIDE*, available at https://www.hunterindustries.com/sites/default/files/design_guide_Residential_System_LIT-226-US.pdf, Rain Bird, *Landscape Irrigation Design Manual*, available at http://www.rainbird.com/sites/default/files/media/documents/2018-02/IrrigationDesignManual.pdf, The Toro Company, *Sprinkler Planning and Installation Guide*, https://media.toro.com/documents/irrigation/sprinkler-pig.pdf.

89 Irrigation Tutorials, *How to Fix Sprinkler Heads That Do Not Completely Pop-Up*, available at: https://www.irrigationtutorials.com/faq/heads-do-not-popup.htm.

90 Hunter Industries, *MP Rotator Low System Pressure Application*, available at: https://www.hunterindustries.com/en-metric/site-study/mp-rotator-low-system-pressure-application.

CHAPTER 9: Environmental Impacts and Benefits

Impacts

Spray sprinkler bodies are usually replaced when they are at the end of their useful lives; therefore, replacement of these appliances would present no additional impact to the environment beyond the natural cycle.

Typically, these devices feature a spring-operated flow tube centered within the sprinkler stem, which can move up and down between seats on either end of the flow tube. The movement of the tube relative to the inlet seat regulates how much water can flow through the stem, thus regulating water pressure at the outlet to the nozzle. The level of outlet-pressure regulation is determined by the strength of the spring. Different manufacturers may implement specific pressure regulation features differently and often have patented technologies. The proposed standards do not require the use of any specific material to improve the efficiency of the product.

Since these improvements are already common practice, updating the water efficiency of spray sprinkler bodies is not likely to change industry practice, the spray sprinkler body design, or the material composition of these spray sprinkler bodies. In addition, the non-hazardous materials found in the final product do not pose any harm to the user and would not cause a significant environmental impact.

The marking requirement would require product information to appear on the appliance or its packaging. The marking requirement could be accomplished with existing marking techniques and would not cause a significant environmental impact.

Benefits

For homes and workplaces, reducing water consumption would reduce the demand for available and shrinking water supplies, which will help decrease the need of investing in costly, large-scale infrastructure projects such as dams, canals, and reservoirs. It will also result in reduced operating costs for water utilities, as it takes a significant amount of energy to get water to the spray sprinkler bodies at a home or business. Energy is needed to extract water from the source; to treat, distribute, and use it; and to collect and treat wastewater for release back into the environment.

Furthermore, reducing water consumption would improve water quality and help the state maintain higher water levels in lakes, rivers, and reservoirs. On the demand side, reducing water consumption will improve air quality by reducing greenhouse gases emitted in the production of energy used to transport and treat California's water.

The proposed standards would save significant amounts of water, estimated at about 152 billion gallons annually, after full-stock turnover. The decrease in water consumption will result in increased availability of water to other users, decreased need for diversions, decreased associated environmental impacts to riparian and wetland habitats from those diversions, and decreased drought impacts on California.

APPENDIX A: Staff Assumptions and Calculation Methods

Appendix A discusses the information and calculations used to characterize spray sprinkler bodies in California, the current water and energy use, and potential savings. Staff considered information from a variety of sources including information contained in the CASE and Irrigation Association proposals submitted to the California Energy Commission. Staff presents the research and methods to illustrate staff's approach to water and energy consumption and savings. Staff has rounded the results of the calculations as they are presented in this appendix. Unrounded numbers are used for subsequent calculations.

Assumptions

Table A-1 summarizes the values and assumptions used to analyze consumption and savings.

Table A-1: Summary of Values and Assumptions

Value	Units	Description	Source
72%	Percentage	Automatic irrigation (single-family)	CALMAC[91]
3,809	Sq. Feet	Avg. irrigated area single-family home	CALMAC[92]
429	Sq. Feet	Avg. irrigated area multifamily unit	City of Santa Cruz[93]
93,900	Gallons	Outdoor water use of a single-family home	CALMAC[94]
8,094,422	Homes	California single-family detached homes (2016)	California Department of Finance[95]
977,593	Units	California Single Family Attached Homes (2016)	California Department of Finance[96]
1,123,464	Units	California Multifamily Units (2-4 units) (2016)	California Department of Finance[97]
3,225,488	Units	California Multifamily Units (5 plus units) (2016)	California Department of Finance[98]
36	Sprinklers	Sprinklers per single-family detached house	Staff Assumption
10%	Percentage	Compliant product market share	Irrigation Association[99]
$0.1431	$ per kWh	Agriculture and water pumping sector 2016 annual average electric rate	Commission Staff[100]
10	Years	Sprinkler design life	Commission Staff
3,565	kWh/MGal	Embedded electrical energy for water deliveries.	Pike & Urigwe, 2017[101]
$5.76	$ per kGal	2016 Population weighted average delivery price paid by consumers	CA Department of Water Resources[102]

Source: California Energy Commission and as noted

91 Funk, Andrew, and William DeOreo, *Embedded Energy in Water Studies Study 3: End-Use Water Demand Profiles,* 2011, pg. 89.

92 Ibid., pg. 88.

93 City of Santa Cruz Water Department, *Residential and Commercial Baseline Water Use Survey*, May 2013, pg. 39, http://www.cityofsantacruz.com/home/showdocument?id=32326.

94 Ibid., pg. 88.

95 California Department of Finance, "E-5 Population and Housing Estimates for Cities, Counties, and the State, 2011-2018 with 2010 Census Benchmark," May 2016, http://www.dof.ca.gov/Forecasting/Demographics/Estimates/E-5/.

96 Ibid.

97 Ibid.

98 Ibid.

99 Mecham, Brent, Irrigation Association, *Comment to Docket on the Invitation to Submit Proposals*, September 18, 2017, pg. 45, http://docketpublic.energy.ca.gov/PublicDocuments/17-AAER-08/TN221200_20170918T112728_Brent_Mecham_Comments_Proposed_Testing_of_Spray_Sprinklers.pdf.

100 Marshall, Lynn, "California Energy Demand 2018-2030 Revised Baseline Forecast - Mid Demand Case, Form 2.3," Energy Commission Supply Analysis Office, available at http://www.energy.ca.gov/2017_energypolicy/documents/2017-12-15_workshop/2017-12-15_middemandcase_forecst.php.

101 Pike, Ed, and Daniela Urigwe, Statewide Codes and Standards Enhancement (CASE) Team Response to Request for Proposals: Irrigation Spray Sprinkler Bodies, pg. 64, September 18, 2017

Stock and Sales

Table A-2 shows staff's estimate for landscape spray sprinkler bodies in California since no published source for stock sprinkler heads are available. Staff also reviewed estimates provided by the CASE team. The estimates provide a means of validation to the staff estimate since they are similar in magnitude. Annual shipments are determined by dividing the estimated stock by the design life of the device.

Table A-2: Summary of Residential Stock and Shipment Estimates

Estimate	Stock (units)	Shipment
Energy Commission	210 million	21.0 million
CASE Team[103]	170 million	18.6 million

Source: California Energy Commission and as noted

Typical Yard Head to Head Spacing Calculation Method

Figure A-1: Head-to-Head Sprinkler Layout for Typical Turf Yard

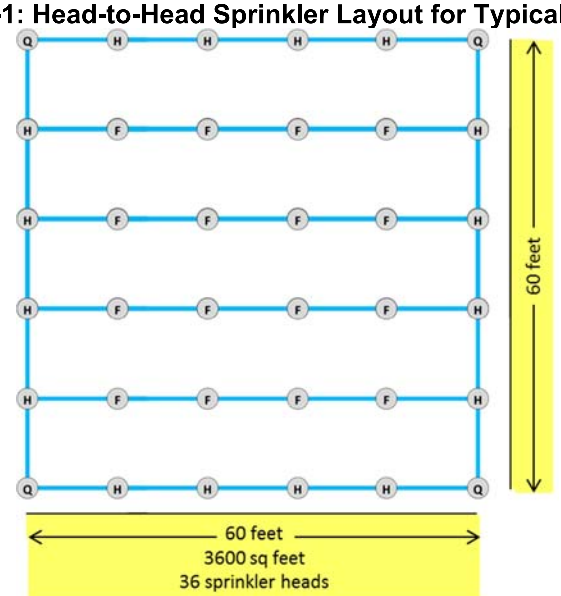

Illustration Credit: CASE Team as modified by the Energy Commission

Various irrigation manufacturer design guides recommend head-to-head spacing where the sprinkler heads are arranged so the spray from one sprinkler head will reach the adjacent sprinkler heads.[104] The overlapping sprays mean several sprinkler heads contribute to the watering of an area in the yard. Staff illustrated the head-to-head spacing for a 3,600 sq. ft. yard, which is equivalent to the average California yard, as

102 California Department of Water Resources, Water Urban Efficiency Data, 2015 Urban Water Management Plans, available at:.https://wuedata.water.ca.gov/awwa_plans.

103 Pike, Ed, and Daniela Urigwe, *Statewide Codes and Standards Enhancement (CASE) Team Response to Request for Proposals: Irrigation Spray Sprinkler Bodies*, pg. 36, September 18, 2017.

104 Rain BIRD Sprinkler Manufacturing Corporation, *Landscape Irrigation Design Manual*, 2000, pg. 41.

determined in the CALMAC study for the California Public Utilities Commission.[105] Staff estimates this arrangement would require 36 sprinkler heads with a 12-foot radius of throw. Staff determined that roughly 5.8 million houses in California would have an automatic sprinkler system based upon data from the California Department of Finance and CALMAC study.[106] [107]

Staff estimated the number of multifamily sprinklers based on estimates of the number of single family attached and multifamily units in California. Staff assumed 429 square feet of irrigated ground per unit and that each sprinkler irrigates 100 square feet. With these assumptions staff determined there are approximately 23 million spray sprinkler bodies installed in multifamily housing in California.

Commercial and industrial water use estimates are shown in **Table A-3**. The estimates are updated to year 2016. Staff assumed that much of the water use at golf courses and schools would require sprinklers outside the proposed scope of the regulation. Staff estimated the stock and shipments by dividing the total water use by the baseline water use per device.

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105 Funk, Andrew, and William DeOreo, *Embedded Energy in Water Studies Study 3: End*-Use *Water Demand Profiles,* 2011

106 Ibid.

107 California Department of Finance, “E-5 Population and Housing Estimates for Cities, Counties, and the State, 2011-2016 with 2010 Census Benchmark,” May 2016, http://www.dof.ca.gov/Forecasting/Demographics/Estimates/E-5/.

Table A-3: Summary of Commercial Water Use

Commercial or Industrial Sector[108]	2000 Landscape Use (Thousand Acre-ft/yr)	2000 Landscape Use (MG/yr)	2016 Landscape Use (MG/yr)	Water Use In-scope (%)	In-scope water use (MG/yr)
Offices	132	42,997	60,596	100%	60,596
Schools	180	58,632	82,632	20%	16,526
Restaurants	14	4,560	6,427	100%	6,427
Retail	23	7,492	10,558	100%	10,558
Hospitals	7	2,280	3,213	100%	3,213
Hotels	6	1,954	2,754	100%	2,754
Textiles	0.7	228	321	100%	321
Metals	1.6	521	735	100%	735
Food Processing	2.9	945	1,331	100%	1,331
Paper and Pulp	0.1	33	46	100%	46
High Tech	6	1,954	2,754	100%	2,754
Laundries	1.5	489	689	100%	689
Golf Courses	420	136,808	192,807	10%	19,281
Other	170.2	55,440	78,133	100%	78,133
Total	965	314,332	442,997		203,365

Source: California Energy Commission

2000 Landscape Use (MG/yr) = 2000 Landscape Use (thou acre-ft/yr) * 1000 / 3.07 MG/acre-ft

2016 Landscape Use (MG/yr) = 1,360 / 965 * 2000 Landscape Use (MG/yr)

Where 1,360 acre-ft/yr is the 2016 commercial landscape water use and 965 acre-ft/yr is the 2000 commercial landscape water use.

In scope water use = 2016 Landscape Use (MG/yr) * % of water use in scope

108 Gleick, Peter H., Dana Haasz, et al, *Waste Not, Want Not: The Potential for Urban Water Conservation in California*, Pacific Institute, 2003, Appendix D, pg. 11.

Stock Calculation:

Residential:

Single-Family Homes x % Homes with Automatic Irrigation= Homes with Automatic Irrigation

8,094,422 Homes *72%=5,827,984 Homes with Automatic Irrigation

Homes with automatic irrigation* 36 devices/home = Stock Sprinklers

5,827,984 homes*36 devices/home=209,807,418 Sprinkler heads

Multifamily:

Multifamily sprinklers = [{(Attached single family homes + multifamily (2-4 units) + multifamily (5+ units)} x irrigated space per unit] / (irrigated space per sprinkler)

22,850,878 Sprinklers = (977,593 units + 1,123,464 units + 3,225,488 units) * 429 sq ft/unit * 1 sprinkler/100 sq ft

Commercial:

203,365 Mg/yr / 2955 g/yr/device = 68,820,759 sprinkler heads

Staff will exclude schools from the calculation of savings.

203,365 Mg/yr - 16,526 Mg/yr = 186,839 Mg/yr Commercial use excluding schools.

186,839 Mg/yr / 2955 g/yr/device = 63,228,088 sprinkler heads

Government:

Evergreen Economics estimated sprinklers around government facilities as 9.5 million devices based upon government and commercial employment.[109] Since government employment is 15% the size of commercial employment, Evergreen Economic assumes the number of government sprinkler devices will be proportional to the commercial devices.

63,228,088 sprinkler heads x 15% = 9,484,213 sprinkler heads

Annual Sales Calculation:

Stock Sprinklers/ Design Life = Yearly Sales

305,370,609 Sprinklers/10 years = 30,537,061 Sprinklers per year

109 Helvoight, Ted, Evergreen Economics, *Economic Impact Analysis of the Water Efficiency Standards for Spray Sprinkler Bodies*, pg. 6-7. September 13, 2018.

Sprinkler head design life is estimated by surveying manufacturer and contractor websites.[110]

Table A-4: Estimated Stock and Sales

Application	First-Year Sales (Annual Units)	Stock (Units)	Design Life (years)
Residential – Single Family	20,980,742	209,807,418	10
Residential -Multifamily	2,285,088	22,850,878	10
Commercial excluding Schools	6,322,809	63,228,088	10
Government	948,421	9,484,211	10
Total	30,537,060	305,370,596	N/A

Source: California Energy Commission and Evergreen Economics

Baseline Water and Energy Use

Landscape water usage may be calculated from recommendations on the water required by the landscape. Staff gathered irrigation data from the University of California, Division of Agriculture and Natural Resources (UC ANR), regarding recommended weekly sprinkler run times. Recommended run times vary by season and climate region and are expressed in minutes, assuming a precipitation rate of 1 inch per hour.[111] The recommendation takes into account the irrigation efficiency, effects of percolation, and incident rainfall. Staff converted the run times to inches of precipitation per year and then averaged the regions to arrive at the average required inches of precipitation the sprinklers must provide. The total volume of water provided by sprinklers is then calculated by multiplying the inches of precipitation by the area of the yard. The per-device volume of water is calculated by dividing the volume of water delivered to the yard by the number of devices.

UC ANR Calculation Method

Total Run Time Region 1 (Northern California Coast) =

(Jan+Feb+Mar+Apr+May+Jun+Jul+Aug+Sep+Oct+Nov+Dec) (minutes/week) x Week to Month Conversion Factor)

52 weeks/ 12 months = 4.3 weeks per month

110 TriState Water Works, "How Long Will My Sprinkler System Last?" http://www.tristatewaterworks.com/how-long-will-my-sprinkler-system-last/.

111 University of California, Agriculture and Natural Resources, "Lawn Watering Guide for California," Publication 8044, http://anrcatalog.ucanr.edu/pdf/8044.pdf.

(7+18+27+34+44+48+47+45+38+24+16+11) (minutes/week)x 4.3 = 1,543.7 minutes per year

Total precipitation = Run time (minutes)/60 minutes per hour * precipitation rate

1,543.7 minutes per year/60 minutes per hour x 1 inch per hour = 25.7 inches per year

Average Total Precipitation across all regions=

(Region 1 Precipitation +Region 2 Precipitation + Region 3 Precipitation +Region 4 Precipitation + Region 5 Precipitation +Region 6 Precipitation +Region 7 Precipitation +Region 8 Precipitation +Region 9 Precipitation +Region 10 Precipitation +Region 11 Precipitation)/ 11 regions

(25.7+40.1+40.9+51.5+50.8+46.9+49.1+43.7+41.2+55.7+75.5)(inches per year)/11 regions= 47.4 inches per year

Water volume per yard=area of yard (sq. ft.)*inches of precipitation/12 inches per foot

3,809 sq. ft. x 47.4 inches per year/12 inches per foot = 15,037 cubic feet per year

15,037 cubic feet x 7.48 gallons per cubic foot= 112,476 gallons per year

Water per emission device per year = Water volume per yard/number of devices

112,476 gallons/36 devices = 3,124 gallons per device per year

Baseline Water Consumption

Gallons per device per year x Total Stock= Baseline Water Consumption

3,124 gallons per device per year x 209,807,418 devices = 655,508 million gallons per year

Alternatively water usage may also be estimated based upon data gathered in the CALMAC study of 415 single family residential sites.[112] The study estimates that on average 93,900 gallons are used for outdoor water use.[113] The 93,900-gallon value agrees well with the 112,476 gallon value calculated by the UC ANR method.

CALMAC Calculation Method

Water Emission per device per year= Water volume per yard/number of devices

93,900 gallons/36 devices = 2,608 gallons per device per year

Baseline Statewide Water Consumption

Gallons per device per year x Total Stock= Baseline Water Consumption

112 Funk, Andrew, and William DeOreo, *Embedded Energy in Water Studies Study 3: End*-Use *Water Demand Profiles*, 2011, pg. 54.

113 Ibid., pg. 88.

2,608 gallons per device per year x 209,807,418 devices = 547,248 million gallons per year

Smart Irrigation Controller Calculation Method

The Smart Irrigation Controller report found an average total precipitation of 52.5 inches per year.[114] Staff used the same method as the UC UNR method to estimate per device and statewide water use.

3,809 sq. ft. x 52.5 inches per year/12 inches per foot = 16,664 cubic feet per year

16,664 cubic feet x 7.48 gallons per cubic foot= 124,650 gallons per year

Water per emission device per year = Water volume per yard/number of devices

124,650 gallons/36 devices = 3,462 gallons per device per year

CASE Team Estimate

The CASE provides a statewide baseline water use estimate of 551,000 million gallons/yr. Staff divided the baseline estimate by the estimated stock to determine the per device use.

Baseline Water Consumption/ year/Total Stock = Gallons per device per year

551,000 million gallons/yr /209,807,418 devices = 2,626 gallons/year

Table A-5 compares the estimated water use for each calculation method. Staff chose the average among the four methods to estimate the water use per device. The baseline use is the weighted average of both compliant and noncompliant devices. 2,955 gallons per device is used for the remainder of the analysis. Embedded electricity is estimated using the value from the CASE Team report of 3,565 kWh/ million gallons.[115]

Average per Device Water Use Calculation:

(UC ANR + CALMAC + Smart Irrigation + CASE)/ 4 = average per device use

(3,124 + 2,608 + 3,462 + 2,626)/4 = 2,955 gal/yr

Embedded Electrical Energy Calculation:

Statewide Water Consumption x Embedded Energy per water consumption

834,918million gallons x 3,565 kWh/million gallons= 2,976GWh/yr

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114 Mayer, Peter, William DeOreo, et al, *Evaluation of California Weather Based "Smart" Irrigation Controller Programs*, 2009, pg. 86, http://ucanr.edu/sites/UrbanHort/files/99641.pdf.

115 Pike, Ed, and Daniela Urigwe, *Statewide Codes and Standards Enhancement (CASE) Team Response to Request for Proposals: Irrigation Spray Sprinkler Bodies*, pg. 64, September 18, 2017.

Table A-5: Baseline Water and Energy Use Residential Estimates

Calculation Method	Water Per Device (gal/yr)	Water Per Residence (gal/yr)	Statewide Water Use (Mgal/yr)	Embedded Electricity (GWh/yr)
UC ANR	3,124	112,476	655,508	2,337
CALMAC	2,608	93,900	547,248	1,951
Smart Irrigation	3,462	124,650	726,455	2,590
CASE Team	2,626	94,544	551,000	1,964

Source: California Energy Commission

Table A-6 Baseline Water and Energy Use

Application	Water Per Device (gal/yr)	Water Per Residence (gal/yr)	Statewide Water Use (Mgal/yr)	Embedded Electricity (GWh/yr)
Residential – Single Family	2,955	106,392	620,053	2,210
Residential - Multifamily	2,955	12,678	67,532	241
Commercial excluding Schools	2,955	N/A	186,839	666
Government	2,955	N/A	28,026	100
Total	N/A	N/A	902,450	3,217

Source: California Energy Commission

Compliant Water and Energy Use

The Irrigation Association estimated that 10 percent of current sprinkler spray bodies comply with the proposed pressure regulation standard.[116]

The University of Florida performed testing per the EPA WaterSense Specification for Spray Sprinkler Bodies and provided data to compare performance of products with and without pressure regulation. Staff reduced the data to provide the average output flow for spray sprinkler bodies with and without pressure regulating devices. The data are graphed in **Figure A-2.**

Staff calculated the water pressure at the spray sprinkler body by assuming 81 psi at the supply inlet and subtracting 10 psi for irrigation valve losses and 10 psi for pipe losses.

116 Mecham, Brent, Irrigation Association, *Spray Sprinkler Bodies Docket Number: 17-AAER-05,* pg. 45, September 18, 2017.

Staff updated the average water pressure and irrigation valve and pipe losses in response to stakeholder comments.

Water pressure at spray sprinkler body = Supply pressure – valve losses – pipe losses

61 psi = 81 psi – 10 psi – 10 psi

The water savings rate was calculated by determining the difference between the nonpressure-regulated flow rate and the maximum flow rate allowed by the proposed standard. The calculation was performed using performance values at a water pressure of 61 psi.

Water saving rate = (flow rate$_{NPR}$ –flow rate$_{compliant}$)/ flow rate$_{NPR}$

Water saving rate at 61 psi = (2.07 gpm-1.69 gpm)/2.07 gpm = 18.4%

Staff assumes no change in duty cycle when compliant products replace noncompliant products. Since the baseline usage per device is the weighted average use of both compliant and noncompliant devices, staff will calculate the water use for compliant and noncompliant devices using the savings rate found above and the compliance rate provided by the Irrigation Association.

Noncompliant water use per device:

Noncompliant use = Baseline use / [(1-compliance rate) + (1-savings rate) x compliance rate)]

Noncompliant use = 2,955 gal/yr / [(1-10%) + (1-18.4%) x 10%)] = 3,011 gal/yr

Compliant water use per device:

Compliant use = (1-savings rate) x non-compliant use

Compliant use = (1-18.4%) x 3,011 gal/ yr= 2,457 gal/yr

Table A-7: Compliant Water and Energy Use

Application	Water Per Device (gal/yr)	Water Per Location (gal/yr)	Statewide Water Use (Mgal/yr)	Embedded Electricity (GWh/yr)
Residential – Single Family	2,457	88,436	515,406	1,837
Residential - Multifamily	2,457	10,539	56,135	200
Commercial excluding Schools	2,457	N/A	155,324	554
Government	2,457	N/A	23,299	83
Total	N/A	N/A	750,164	2,674

Source: California Energy Commission

Cost and Savings

Table A-6 lists the annual water and energy savings for the first year the proposed standards become effective. It also lists the water, energy, and monetary savings upon complete stock turnover to products compliant with the proposed standards in 2030.

Staff estimated and tabulated statewide savings in **Table A-8** using the results listed in **Tables A-6** and **A-7**. Staff assumptions, as well as sample calculations, are provided below.

Water savings per device = Non-compliant water use – compliant water use

Water savings per device = 554 gal / yr =3,011– 2,457

Water savings per residence = water savings per device x devices per residence

Water savings per residence = 19,951 gal /yr = 554 gal /yr x 36 devices

Statewide water savings = Baseline water usage – compliant water usage

Statewide water savings = 152,286 million gallons /yr = 902,450– 750,164

Statewide Energy Savings = Baseline Embedded Electricity – Compliant Embedded Electricity

Statewide Energy Savings = 543 GWh/yr = 3,217 GWh/yr – 2,674 GWh/yr

Table A-8: Water Savings and Energy Savings

Application	Water Savings Per Device (gal/yr)	Water Savings Per Location (gal/yr)	Statewide (Mgal/yr)	Embedded Electricity (GWh/yr)
Residential – Single Family	554	19,951	104,646	373
Residential - Multifamily	554	2,377	11,397	41
Commercial excluding Schools	554	N/A	31,515	112
Government	554	N/A	4,727	17
Total	N/A	N/A	152,286	543

Source: California Energy Commission

Table A-9 provides statewide monetary savings based upon the CA DWR data, which provided costs of residential water as $5.76 per 1000 gallons. The CASE Report provided the embedded electricity costs. Although the CASE team projects a yearly water delivery rate increase, staff chose to keep the water delivery rate flat since an increasing rate is not needed to show cost effectiveness.

Stock Water Delivery Savings = Statewide Water Savings x water delivery charge

Stock Water Delivery Savings = 152,286 M gal/yr x $5.76/1000 gal = $877.2/ yr

First year Water Delivery Savings = Stock Water Delivery Savings/Design Life

First year Water Delivery Savings =$877.2 M/10 yrs = $87.7M

Stock Embedded Energy Savings = Embedded Electricity x cost of electricity

Stock Embedded Energy Savings = 543 GWh/yr x $0.1431/kWh = $77.7 M/yr

Table A-9: Statewide Monetary Savings

	First Year			Stock Savings		
Application	**Water Delivery (M$/yr)**	**Embedded Electricity (M$/yr)**	**Total (M$/yr)**	**Water Delivery (M$/yr)**	**Embedded Electricity (M$/yr)**	**Total (M$/yr)**
Residential – Single Family	$60.3	$5.3	$65.6	$602.8	$53.4	$656.1
Residential - Multifamily	$6.6	$0.6	$7.1	$65.6	$5.8	$71.5
Commercial excluding Schools	$18.2	$1.6	$19.8	$181.6	$16.1	$197.7
Government	$2.7	$0.2	$2.9	$27.2	$2.4	$29.6
Total	$87.8	$7.7	$95.4	$877.2	$77.7	$954.9

Source: California Energy Commission

Staff surveyed manufacturer and retailer websites to determine the average retail price of sprinkler heads with and without pressure regulation. The results are presented in **Table A-10**.

Table A-10: Average Sprinkler Head Price

Stem (Pop-up height in inches)	Spray Body (No Nozzle)	Spray Body With Pressure Regulator	Spray body With Pressure Regulator and Check Valve
Gravity 2"	$3.92	N/A	N/A
2"	$2.03	N/A	N/A
4"	$1.76	$5.06	$6.33
6"	$6.10	$10.78	$11.52
12"	$10.23	$13.26	$15.96

Source: California Energy Commission

Table A-11 presents the incremental cost between a noncompliant and compliant product. Since staff could not find a compliant 2" gravity or 2" pop-up, the incremental costs for this product represent a compliant 4" pop-up installed with a flexible pipe adapter called a "funny pipe."

Table A-11: Sprinkler Head Incremental Costs

Stem(Pop-up height in inches)	Spray Body With Pressure Regulator	Spray Body With Pressure Regulator and Check Valve
2"	$2.22	$3.16
4"	$3.30	$4.57
6"	$4.68	$5.42
12"	$3.03	$5.73

Source: California Energy Commission

Table A-12 lists the annual water and energy savings for spray sprinkler bodies once the proposed standard becomes effective. It also lists the design life, annual monetary savings, the incremental cost, and the life-cycle benefit of spray sprinkler bodies. Because water delivered to customers typically carries a fixed price, savings resulting from embedded electrical energy are not factored into staff calculations for monetary savings per unit. Staff chose the highest incremental cost of $4.68 for the 6" pop-up stem for the life-cycle benefit calculation. Since other types of spray sprinkler bodies have lower incremental costs, the life-cycle benefit calculation is conservative. Staff assumed a 3 percent discount rate to calculate the net present worth of the water savings. The incremental cost is subtracted from the net present worth of the savings to determine the life-cycle benefit.

Table A-12: Annual Water, Energy, and Monetary Savings

Design Life (years)	Water Savings (gal/yr)	Embedded Electricity Savings (kWh/yr)	Incremental Costs ($)	Average Annual Savings ($/yr)	Life-Cycle Benefit ($)
10	554	2.0	$4.68	$3.19	$22.55

Source: California Energy Commission

Average annual savings = water savings/year x water delivery charge

Average annual savings = 554 gallons/year x $5.76/1,000 gal= $3.19/year

Net present worth (NPW) of savings = Σ [(annual savings) / (1+discount rate) ^ year]

Table A-13: Net Present Worth Calculation Result by Year

Year	1	2	3	4	5	6	7	8	9	10	Total
Savings	$3.10	$3.01	$2.92	$2.84	$2.75	$2.67	$2.60	$2.52	$2.45	$2.38	$27.23

Source: California Energy Commission

Life-Cycle Benefit = Net present worth savings – Incremental Cost

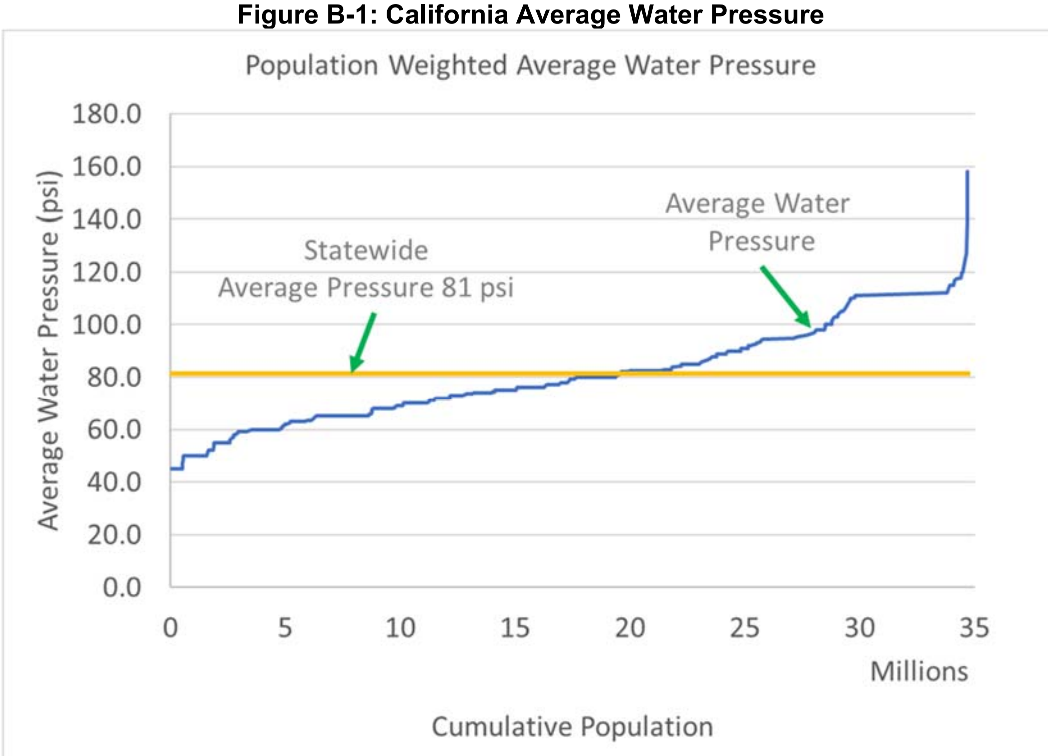
Life-Cycle Benefit = \$27.23 - \$4.68 = \$22.55

Appendix B:
Water Pressure Discussion

California Water Pressure Data and Calculation

The California Department of Water Resources (DWR) collects data from over 300 urban water suppliers that provide water to over 34 million of California's 38 million residents as part of its Urban Water Use Efficiency program.[117] Staff compiled the data provided by DWR to determine the population weighted, average water pressure for the state. Figure B-1 shows a plot of the average water pressure versus the state population. Staff selected this data to provide an estimate of the state's average water pressure since the data was provided by the water suppliers and represents most of the state's population. Commission staff confirmed the DWR data is appropriate for this use with DWR staff.[118]

Figure B-1: California Average Water Pressure



Source: California Energy Commission with DWR Data

117 California Department of Water Resources, Urban Water Use Efficiency Program, available at: https://www.water.ca.gov/Programs/Water-Use-And-Efficiency/Urban-Water-Use-Efficiency.

118 Phone conversation with Todd Thompson (DWR) June 12, 2018.

Static and Dynamic Water Pressure

Stakeholders requested that Commission staff clarify whether water pressure is a dynamic or static value when used to calculate water savings.[119] Static water pressures are measured when there is no flow within the plumbing system. Dynamic water is the static water pressure minus the pressure losses due to the restrictions in the plumbing system. Since flow rates may be high during irrigation, staff will use the dynamic pressure to represent the water pressure at the spray sprinkler bodies and to calculate water savings.

Staff reviewed irrigation design manuals for estimates of static and dynamic water pressures. Staff found industry assumes about a 20 psi difference between static and dynamic pressures when the system has a static pressure of 80 psi.[120] Staff updated the analysis to assume a 20 psi difference between static and dynamic water pressure.

Pressure Reducing Devices

Stakeholders requested that the Commission study the use of valves, water pressure regulators[121] and backflow preventers[122] and their effect on the water pressure found at the spray sprinkler body.

Plumbing and Irrigation Valves

Water pressure will be reduced due to the restrictions imposed by plumbing and irrigation valves. Staff reviewed the irrigation valve specification sheets to estimate the pressure drop across the valves.[123] Staff estimates a 5 psi dynamic loss based upon this information.

Water Pressure Regulators

Water pressure regulators limit the water pressure to prevent excessive pressures. The devices are required by the California Uniform Plumbing Code (UPC) where water

119 Brent Mecham, Irrigation Association, Comments at the Staff Workshop on Appliance Efficiency Regulations for Spray Sprinkler Bodies, March 14, 2018, Transcript, pg. 35, Docket 17-AAER-08.

120 Rain Bird Corporation, *Landscape Irrigation Design Manual*, pg. 6-7, 2001, Hunter Industries, *Residential Sprinkler System Design and Installation Guide*, pg. 5, 2018.

121 Brent Mecham, Irrigation Association, Comments at the Staff Workshop on Appliance Efficiency Regulations for Spray Sprinkler Bodies, March 14, 2018, Transcript, pg. 36, Docket 17-AAER-08.

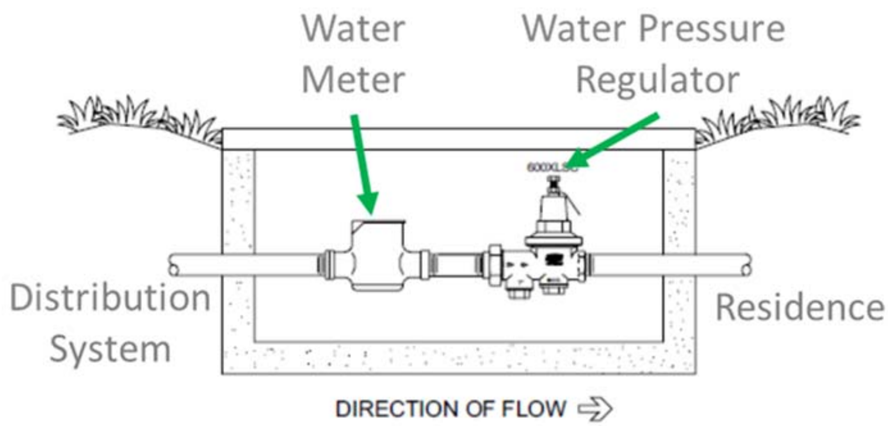
122 Chris Dundon, Contra Costa Water District, *CCWD Comments Low Water Pressure*, Docket # 17-AAER-08, pg. 2, March 19, 2018.

123 Orbit, *Valve Specification (57223, 57224, 57321)*, available at https://www.orbitonline.com/site_files/manuals/Anti-Siphon%20Valve%20Specification.pdf, Orbit, *Valve Specification(57100, 57101, 57105)*, available at: https://www.orbitonline.com/site_files/manuals/200%20Series%20valves%20chart.pdf, Rain Bird Corporation, *CP/CPF Valve Manual*, http://www.rainbird.com/sites/default/files/media/documents/2017-06/man_CP-Valves_en.pdf and http://www.rainbird.com/sites/default/files/media/documents/2017-06/man_DAS-Valves_en.pdf.

pressure within a building exceeds 80 psi.[124] Staff determined that pressure regulators were first required by the 1988 UPC.[125]

Staff believes many single family homes do not have pressure regulators installed. Pressure regulators were not required prior to 1988 and homes built after 1988 would have to have had a water pressure over 80 psi at the time of construction to have a pressure regulator installed. Therefore, staff did not propose any adjustments to the assumed average water pressure based on the presence of a pressure regulator.

Figure B-2: Water Pressure Regulator Installation Location



Source: Zurn Industries

Backflow Preventers

Backflow preventers are devices installed to prevent the flow of contaminants such as sewage or graywater into the drinking water system. California Code of Regulations, Title 17 specifies when a backflow preventer must be installed. They are not typically required for single family residences unless there a risk of contamination from a cross connection to a non-potable source of water.[126] Since back flow preventers are not required at single family homes they would not affect the irrigation water pressure.

California plumbing code does not requires a back flow preventer to separate fire sprinkler system from the water distribution system as long as the sprinkler system follows the National Fire Protection Association codes and is compatible with potable water requirements.[127] Since backflow preventers for fire sprinkler systems would not be

124International Association of Plumbing and Mechanical Officials, 2016 California Plumbing Code, Chapter 6, Section 608.2.

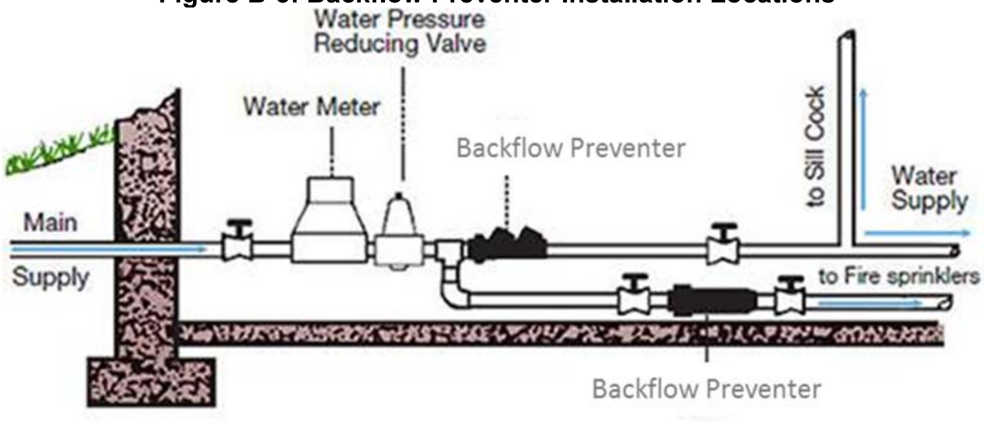
125 California Code of Regulations, Title 24, Part 5, 1988 State Uniform Plumbing Code, Section 5-1007, Water Pressure, Pressure Regulators and Pressure Relief Valves.

126 California Code of Regulation, Title 17, Section 7584 to 7605, *Drinking Water Supplies*.

127 International Association of Plumbing and Mechanical Officials, 2016 California Plumbing Code, Chapter 6, Section 612.3.8.

installed in the path of the irrigation system they will not affect the water pressure or the water savings estimates.

Figure B-3: Backflow Preventer Installation Locations



Source: Watts Water Technologies, Inc.