DOCKETED

Docket Number:	17-AAER-08
Project Title:	Sprinkler Spray Bodies
TN #:	219239
Document Title:	California Investor Owned Utilities Comments Response to Invitation to Participate - Spray Sprinkler Bodies
Description:	N/A
Filer:	System
Organization:	California Investor Owned Utilities
Submitter Role:	Public
Submission Date:	6/16/2017 4:34:05 PM
Docketed Date:	6/16/2017

Comment Received From: California Investor Owned Utilities
Submitted On: 6/16/2017
Docket Number: 17-AAER-08

Response to Invitation to Participate - Spray Sprinkler Bodies

Additional submitted attachment is included below.

Landscape Irrigation Spray Sprinkler Bodies

Codes and Standards Enhancement (CASE) Initiative
For PY 2017: Title 20 Standards Development

Response to the California Energy Commission's Invitation to Participate Phase 2 Pre-Rulemaking
Irrigation Spray Sprinkler Bodies
Docket #17-AAER-08

June 16, 2017

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This document was prepared by the California Statewide Investor-Owned Utilities Codes and Standards Program and funded by the California utility customers under the auspices of the California Public Utilities Commission.
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Acknowledgements

The authors appreciate research contributed by Megan Prier, Hyphae Design Laboratory.

The authors also wish to express appreciation to Brent Mecham of the Irrigation Association (IA) for sharing his experience regarding IA test methods, test results, and other research; and staff at the Center for Irrigation Technology at Fresno State.

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1. Executive Summary

The Codes and Standards Enhancement (CASE) initiative presents recommendations to support the California Energy Commission's (Energy Commission or CEC) efforts to update California's Appliance Efficiency Regulations (Title 20) to include new requirements or to update existing requirements for various technologies. The four California Investor Owned Utilities (IOUs) – Pacific Gas and Electric Company (PG&E), San Diego Gas and Electric (SDG&E), Southern California Edison (SCE), and SoCalGas® – sponsored this effort (herein referred to as the CASE Team). The program goal is to prepare and submit proposals that will result in cost-effective enhancements to improve the energy and water efficiency of various products sold in California. The information presented here is a part of the CASE initiative to develop technical and cost-effectiveness information for potential appliance standards. The CASE Team is providing this information in response to the Energy Commission's Invitation to Participate Phase 2 Pre-Rulemaking for Irrigation Spray Sprinkler Bodies.

Landscape irrigation is an important topic for consideration because it is the single largest use of potable water in the residential sector and accounts for approximately half of total urban water usage in California (PPIC 2016). Across all sectors, residential and commercial landscape irrigation uses over one trillion gallons of water per year. The extraction and conveyance, potable water treatment, and distribution of landscape irrigation water requires more than 3 terawatt hours of embedded electricity per year. In light of California's recent drought emergency, landscape irrigation is a critical sector for consideration in Title 20 water efficiency standards.

The proposed test methods for pressure regulation in this document are based on ANSI ASABE/ICC 802-2014 test methods with a number of modifications based on the Irrigation Association (IA) Smart Water Application Technologies (SWAT) "Step Test" procedure including: 1) resetting the inlet pressure to zero between inlet test pressures; 2) testing at two different flow rates; 3) calculating summary data regarding deviation in outlet pressure from the manufacturer rating; and 4) including a minimum time for operation at each step. The proposed test methods for check valves are based on the SWAT Pop-up Sprinkler Head Check Valves Equipment Functionality Test Protocol version 2.3, with one modification based on ANSI ASABE/ICC 802-2014.

The CASE Team also encourages a requirement that manufacturers mark products so that the presence of pressure regulation and check valves are labeled on the device in a location visible after installation, consistent with ANSI ASABE/ICC 802-2014 section 304.1. In the case that the cap of the sprinkler body could potentially be removed and replaced with a cap from another sprinkler body, the same information should also be marked on the sprinkler body housing, beneath the sprinkler body cap.

The CASE Team encourages the Energy Commission to adopt standards that would address all spray sprinkler bodies sold in California, including replacement units and shrub adapters. Title 20 Standards would complement existing California regulations that address newly installed landscapes. The CASE Team did not identify economic or technical feasibility barriers to implementing spray sprinkler body standards during research and interviews with various market actors.

Despite the short payback period for more efficient products, establishing Title 20 Standards is critical to overcoming several barriers including historical stocking choices, lack of standards, lack of consumer education, and split incentives between landscape installers and property owners or tenants.

2. Background

2.1 Regulatory Background

California and the federal government have not established any direct regulations for spray sprinkler bodies. California AB 1928 (Campos 2016) updates prior legislation and requires the Energy Commission to establish performance standards and labeling requirements for spray sprinkler bodies[1] and other landscape irrigation products on or before January 1, 2019. The legislation also requires that the Energy Commission consider the Irrigation Associations' Smart Water Application Technology Program testing protocols. The CASE Team did not identify any state or federal requirements that would conflict with this mandate.

Installation requirements for landscape irrigation emission devices, such as spray sprinkler bodies, are included in the California Model Water Efficient Landscape Ordinance (MWELO) (California Title 23, Division 2, Chapter 2.7) (DWR 2015).[2] The MWELO has a requirement that irrigation emission devices comply with ANSI ASABE/ICC 802-2014, which contains anti-burst and integral pressure regulation requirements for spray sprinkler bodies. The MWELO also requires check valves to prevent drainage through sprinklers at low points when the irrigation system is turned off. The MWELO does not contain performance requirements for pressure regulation or check valves.

Title 20 Standards for spray sprinkler bodies would have a much broader reach than the MWELO, which primarily pertains to newly constructed landscapes and rehabilitated landscapes with a specified minimum size. Replacement units, which represent most product sales in California, are completely unregulated in the absence of a Title 20 standard.[3] In addition, homeowners and contractors are typically not required to obtain a permit when installing landscapes (e.g., backyards) after a new home is sold, and smaller landscapes will fall below the applicability threshold.

2.2 Utility and Other Incentive Programs

Many water utilities and municipalities provide rebates to both residential and commercial customers for water efficient irrigation emission devices. In California, common features for which rebates are available include internal pressure regulation for spray sprinkler bodies, drip irrigation conversion, high efficiency rotating spray nozzles, and spray sprinklers with integrated check valves. Rain Bird, a major manufacturer of irrigation equipment, compiled a list of rebate programs in over 80 jurisdictions for pressure regulation or check valves, many of which are offered through the California Water Service (Rain Bird 2015a, Rain Bird 2015b). Rebates are often issued per

[1] The legislation includes emission devices.
[2] Effective December 1, 2015. Regions that develop a joint local Water Efficient Landscape Ordinance (WELO) should implement their local WELO by February 1, 2016.
[3] Most products are sold in the unregulated replacement market rather than installed in new landscapes, because product lifetimes are significantly less than the expected lifespan of a building (such as, 30 years for a residential building).

qualifying device, and in some cases, they are bundled with broader programs. Furthermore, programs are often designed to replace older existing units since these units are not subject to water efficiency regulations. Once enacted, these incentive programs can complement the Title 20 Standards required by AB 1926, by encouraging early replacement of inefficient products with equipment that meets the potential standards.

The United States Environmental Protection Agency (U.S. EPA) is currently evaluating a potential WaterSense program for landscape irrigation spray sprinklers.[4] As part of the effort, U.S. EPA has sponsored testing to support the development of a test method and water savings specification for pressure regulated spray sprinkler bodies and has released a draft test method and specification (U.S. EPA 2016a and 2016b). Specific details regarding test methods are addressed in Section 5 of this document.

2.3 Model Codes and Voluntary Standards

Many government and non-government entities have made substantial progress establishing model building codes and voluntary standards that address water efficiency. Many of these existing codes and standards have been developed through rigorous public vetting processes with participation by key industry stakeholders. Table 1 below shows a variety of model codes and standards related to landscape irrigation emission devices. Please note that test methods developed by the Irrigation Association (IA) and the related draft WaterSense test method are discussed later in this document.

Table 1. Model Codes and Standards for Landscape Irrigation Spray Sprinklers

Model Code or Standard	Requirements
ANSI ASABE/ICC 802-2014 Landscape Irrigation Sprinkler and Emitter Standard (2014)	Addresses sprinkler (spray and rotor), bubbler, point-source and line-source drip emitter, and microspray landscape irrigation emission devices. Contains approximately 30 product specific test methods either directly or by reference to other standards. Contains approximately 10 mandatory product specific performance requirements. <u>Sprinkler and Bubbler Requirements</u> Section 302.6 requires that devices withstand pressure up to 150 percent of the maximum published operating pressure. Section 302.7 requires that devices with check valves prevent flow for elevation changes up to seven feet (3.0 psi). Section 302.8 requires integral pressure regulation for spray bodies, but does not contain a performance requirement. Section 303 contains test methods for check valve function, pressure regulation, flow rate, distance of throw, burst pressure, uniformity and missing nozzle flow reduction.

[4] U.S. EPA has issued a voluntary WaterSense New Home Specification (version 1.2) with a 65 percent lower quarter distribution uniformity requirement (as measured in the field), which may overlap with equipment-based labeling.

Model Code or Standard	Requirements
IAPMO Green Plumbing & Mechanical Code Supplement (2012)	Section 413.10 Sprinkler Head Installations. All installed sprinkler heads shall be low precipitation rate sprinkler heads. Section 413.10.1 Sprinkler Heads in Common Irrigation Zones. Sprinkler head installed in irrigation zones served by a common valve shall be limited to applying water to plants with similar irrigation needs, and shall have matched precipitation rates (identical inches of water application per hour as rated or tested, plus or minus five percent). Section 413.10.2 Sprinkler Head Pressure Regulation. Sprinkler heads shall 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). Section 413.10.3 Pop-up Type Sprinkler Heads. Where pop up type sprinkler heads are installed, the sprinkler heads shall rise to a height of not less than 4 inches (102 mm) above the soil level when emitting water. Section 413.11 Irrigation Zone Performance Criteria. Irrigation zones shall be designed and installed to ensure the average precipitation rate of the sprinkler heads over the irrigated area does not exceed one inch per hour as verified through either of the following methods: (a) Manufacturer's documentation that the precipitation rate for the installed sprinkler head does not exceed one inch per hour where the sprinkler heads are installed no closer than the specified radius and where the water pressure of the irrigation system is no greater than the manufacturer's recommendations. (b) Catch can testing in accordance with the requirements of the authority having jurisdiction and where emitted water volume is measured with a minimum of six catchment containers at random places within the irrigation zone for a minimum of 15 minutes to determine the average precipitation rate, expressed as inches per hour.
International Green Construction Code (IgCC) (2012)	Section 404.1.2.6 Sprinklers shall: Section 404.1.2.6.1. Have nozzles with matched precipitation rates. Section 404.1.2.6.5. If of the pop-up configuration, pop-up to a height of not less than four inches (101 mm). Section 404.1.2.6.6. Only be installed in zones composed exclusively of sprinklers and shall be designed to achieve a lower quarter distribution uniformity of no less than 0.65.
California Model Water Efficient Landscape Ordinance (July 9, 2015)	The MWELO contains numerous requirements. Below are several examples related to spray sprinkler bodies: Section 491 Definitions: "check valve" or "anti-drain valve" means a valve located under a sprinkler head, or other location in the irrigation system, to hold water in the system to prevent drainage from sprinkler heads when the sprinkler is off. Section 492.7(a)(1)(C): If water pressure is below or exceeds the recommended pressure of the specified irrigation devices, the installation of a pressure regulating device is requirement to ensure that the dynamic pressure

Model Code or Standard	Requirements
	at each emission device is within the manufacturer's recommended pressure range for optimal performance. Section 492.7(a)(1)(S): Check valves or anti-drain valves are required on all sprinkler heads where low point drainage could occur. Appendix D – Prescriptive Compliance Option Section 5.C - Pressure regulators shall be installed on the irrigation system to ensure the dynamic pressure of the system is within the manufacturers recommended pressure range. Section 5.E - All irrigation emission devices must meet the requirements set in the ANSI standard, ASABE/ICC 802-2014 "Landscape Irrigation Sprinkler and Emitter Standard."
WaterSense Draft Spray Sprinkler Body Specification Version 1.0 (November 17, 2016)	WaterSense proposed a draft voluntary standard and test method for pressure regulated spray sprinkler bodies in late 2016. The standard would require that products regulate pressure to keep flow within specific limits. The test method would require testing each product at four inlet pressures to determine pressure to the nozzle and flow rate from the nozzle.

2.4 Impetus to Pursue Water and Energy Efficiency

2.4.1 State Water Policy Goals

Water is essential to supporting and sustaining the environmental, economic, and public health needs of the state. The continuing risk of severe future droughts, shifts in regional climate patterns, and the state's population growth are leading to concerns about the sustainability of ever-growing demands on a limited (and shrinking) water supply. Since water security is critically important to the state, improving water efficiency is a well-established statewide policy goal. For instance, legislation enacted in 2009 (Senate Bill X7-7, Steinberg 2009) established the goal of achieving a 20 percent reduction in urban per capita water use in California by 2020.

In addition, the California Public Utilities Commission (CPUC) has also directed the IOUs to pursue water efficiency activities, such as rebate programs and codes and standards advocacy, as part of their energy management portfolios to reduce the amount of energy associated with water use. As discussed in Section 2.4.4, a significant amount of energy is used to fulfill California's water supply needs.

2.4.2 Stringent Water Efficiency Standards Will Reduce the Need for Costly Water Supply Development

Establishing more stringent water efficiency standards is a cost-effective intervention for reducing California's water demand. It may be the most cost-effective intervention when compared to solutions that aim to increase and maintain reliable water supplies. For instance, projects such as

ocean water desalination, dams, or new water conveyance cost billions of dollars.[5] The water efficiency standards presented in this document, on the other hand, will reduce Californians' expenditures on water and energy bills while supporting manufacturers and builders that offer high efficiency devices. Additionally, in contrast to large-scale water supply projects, efficient water use is expected to result in significant environmental benefits as discussed in Section 9.

2.4.3 Long-Term Energy Efficiency Initiatives

California has several long-term polices in place to enhance energy efficiency, curb greenhouse gas (GHG) emissions, and reduce demand on energy resources and the electricity grid. This section briefly describes some of the many policies adopted across the state in recent years.

The Global Warming Solutions Act of 2006 (AB 32), requires California to reduce its GHG emissions to 1990 levels by 2020 — a reduction of approximately 15 percent below emissions expected under a "business as usual" scenario (CARB 2015). Implementation of AB 32 is laid out in the "Climate Change Scoping Plan," last updated in May 2014. One of the key elements of the scoping plan is expanding and strengthening energy efficiency programs, including Title 20, and improving the efficiency of water use as described further below. To date, California is on target to meet the goals of AB 32 (CARB 2014). In response, Governor Brown issued Executive Order B-30-15 on April 29, 2015, which establishes a California greenhouse gas reduction target of 40 percent below 1990 levels by 2030 (CA Executive Order No. B-30-15). The Executive Order calls for the most aggressive greenhouse gas reductions policy in national history. This goal was subsequently adopted into state law via SB 32 (Pavley 2016).

On October 18, 2007, CPUC published Decision 07-10-032, which created a framework for long-term strategic planning of energy efficiency and other demand-reducing programs (CPUC 2007a). Through Decision 07-10-032, CPUC adopted the state's zero net energy (ZNE) goals, which calls for all new residential and commercial construction in California to be ZNE by 2020 and 2030, respectively. These ZNE goals have encouraged the Energy Commission to adopt more stringent energy efficiency standards for appliances and buildings in California over the past few years. The state's building and appliance energy efficiency standards have saved Californians $74 billion in energy costs since 1977 (CARB 2014).

In his inaugural address on January 5, 2015, Governor Brown proposed the goal of doubling the efficiency of existing buildings by 2030, along with increasing renewable energy use and decreasing fossil fuel consumption in the transportation sector by 50 percent (Brown 2015). California SB 350 (De León 2015) calls for annual targets for statewide energy efficiency savings and demand reduction that will achieve a cumulative doubling of statewide energy efficiency savings in electricity and natural gas by January 1, 2030, furthering California's commitment to energy efficiency.

In addition to the state's energy efficiency policies, the IOUs have a long history of implementing residential and commercial energy efficiency programs to spur market transformation towards energy efficient technologies. The IOUs' Statewide CASE Initiative has also had a significant impact on the adoption of various appliance and building efficiency standards both in California and

[5] Though it can produce a reliable source of water, desalination is a very expensive and energy-intensive technology. It also has an impact on the local aquatic environment, as well as electric consumers and ratepayers, since energy is the largest single cost for a desalination plant (Pacific Institute 2013). Further, upgrading infrastructure for water conveyance and storage can cost tens of billions of dollars.

nationally, which have led to substantial energy and water savings, as well as meaningful GHG and cost reductions for the state.

2.4.4 Water-Energy Nexus

The term "water-energy nexus" refers to the interdependent relationship between water use and energy use in California. The relationship between water, energy, and GHG emissions helps to further justify additional water efficiency standards. An Energy Commission study found that nearly 20 percent of electricity use and 30 percent of non-power plant-related natural gas use in California is associated with water pumping, treatment, heating, and disposal (CEC 2006).[6] California consumes about 2.9 trillion gallons of water per year for urban uses (Christian-Smith et al 2012).[7] According to Christian-Smith, Heberger & Allen 2012, these 2.9 trillion gallons of water correspond to approximately 26.4 terawatt hours (TWh) of embedded electricity, though the CASE Team analysis uses a lower assumed value (2012). Additionally, water is required to produce electricity. If electricity demand increases, so does the demand for water (California Sustainability Alliance 2013).

As noted earlier, the California Climate Change Scoping Plan recognizes that this water-energy nexus has significant potential implications for achieving climate change avoidance goals since the embedded energy in water results in GHG emissions (CARB 2008). The plan calls for the establishment of indoor and outdoor water efficiency standards, and water recycling initiatives to help achieve California's GHG reduction goals. Specifically, the plan (Volume I p. C-132) calls for the Energy Commission and other state agencies to adopt standards including Appliance Efficiency Standards and Landscape Water Standards. The CASE Team also notes that climate change is likely to increase the frequency and severity of California's drought cycles. Thus, water efficiency standards are also a vital step towards adaptation in response to climate change.

3. Product Description

Irrigation emission devices are used to dispense irrigation water to a landscape at specific rates, patterns, and distances. A variety of types of emission devices are currently available on the market, and different types are used for different landscape applications. Irrigation emission devices can be classified into five main categories: spray sprinklers (or sprays), rotor sprinklers (or rotors), bubblers, drip irrigation emitters, and microspray. This document focuses on spray sprinkler bodies, but information on the other devices and their applications can be found in Appendix A: Additional Product Information.

3.1 Spray Sprinklers

According to the ANSI ASABE/ICC 802-2014 standard, sprinklers are defined as irrigation emission devices that convert irrigation water pressure to high velocity water discharge and

[6] Water-related energy uses include energy consumed by water agencies for water collection, extraction, conveyance, treatment, distribution prior to use (potable water), and treatment and disposal after use (wastewater). It also includes energy used by the end-user after the water agency has delivered water, such as energy used to pump and heat water on site.

[7] Urban uses include outdoor and indoor residential water use; water used in commercial, institutional, and industrial applications; and unreported water use, which is primarily attributed to leaks.

discharge a minimum of 0.5 gallons per minute (gpm). Spray sprinklers, a subset of sprinklers, are designed to continuously apply water over a landscape in a fixed pattern.

A spray sprinkler consists of a sprinkler body, which contains all the internal parts integral to the function of the sprinkler, as well as a spray sprinkler nozzle. The nozzle determines the radius (e.g., 8 foot, 10 foot, etc.) and pattern (e.g., full-circle, half-circle, quarter circle, rectangular strip) in which the water is sprayed. Nozzles are often marketed and sold separately from spray sprinkler bodies, and they are typically interchangeable between various spray sprinkler bodies. Nozzles can also be replaced without changing the spray sprinkler body. Spray sprinklers that are used with traditional nozzles (i.e., nozzles that do not rotate, but spray water in a fixed pattern) are typically used for relatively small landscape areas. Typically, the recommended operating pressure for these devices is 30 psi with a water throw range of about four to 20 feet (Rain Bird 2001).

Spray sprinkler bodies can also be used with newer rotating pattern spray nozzles (also known as rotator or rotary nozzles), which fit onto traditional spray sprinkler bodies, but spray streams of water in a rotating pattern using the rotational energy provided by the flow of water through the device (see Appendix A: Additional Product Information for a description of rotors, a different sprinkler product where rotational energy is commonly provided by gears in the body and long throw rates are typical). Spray sprinkler bodies with rotary nozzles can be used for slightly larger landscaped areas, since these nozzles generally have a higher radius of throw than fixed pattern nozzles. Therefore, spray sprinkler bodies used in this application have a higher recommended operating pressure of 40 to 45 psi, as compared to the 30 psi recommended operating pressure for spray bodies used with fixed pattern spray nozzles.

Some spray sprinklers, called shrub-style sprinklers, can be permanently mounted above ground to water areas with high ground cover. Due to safety and aesthetic concerns associated with shrub-style sprinklers, spray heads that pop up from the ground when in use are much more common. These pop-up spray heads are available in heights from two to 12 inches. Four and six-inch units are common; conversely, two and three-inch heights are not common.[8]

Typically, pop-up spray bodies consist of the following components:

- Riser – extends a predetermined height above ground for watering and retracts back into the spray body when watering is completed.
- Spring – extends and retracts the riser.
- Wiper seal – seals the gap between the riser and the spray body to prevent leakage and keep debris out of the spray body.
- Body – outer housing in which the above components are contained.
- Cap – screws on to hold internal components inside sprinkler body. Can often be removed to allow access to interior sprinkler body components.

Additionally, more advanced spray bodies include additional components to achieve water savings. These include:

[8] Two- and three-inch units may lack sufficient space for installation of integral pressure regulation. Four-inch units can substitute for these shorter units.

- Pressure regulation – reduces the water pressure inside the sprinkler body to an optimal specified value, usually 30, 40 or 45 psi. Uniform flow rate is maintained at different inlet water pressures via the use of a pressure regulator integrated into the stem of the sprinkler body. 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. This feature is especially useful in landscapes where the water supply pressure exceeds the recommended sprinkler operating pressure (which commonly occurs).

- Check valve – eliminates drainage in irrigation systems when not in operation, otherwise water will tend to drain from supply lines through low points. Check valves can be integral to the sprinkler body or installed on site as an add-on.

- Missing nozzle flow reduction feature – reduces or stops water flow from the sprinkler when a nozzle or riser is missing or damaged.

Without pressure regulation, the flow rate and radius of water emitted by the sprinkler nozzle will typically increase as the inlet water supply pressure to the spray head increases. A small number of manufacturers market certain nozzles or nozzle screens with claims that they provide pressure compensation. Though a pressure compensator can reduce outlet pressure to some degree, it typically cannot maintain a constant outlet pressure like a pressure regulator can.[9] Additionally, some nozzles allow for the radius of the water throw to be adjusted by turning a radius adjustment screw at the top of the nozzle. Reducing the radius in this manner will also serve to decrease the pressure at the nozzle, which may help a knowledgeable user adjust for high pressures in their landscape. This feature is unlikely to help an unskilled homeowner or yard maintenance worker, and likely will not correct for misting and overspray when operating at a higher than rated pressure. In addition, due to its imprecise nature, relying on a radius adjustment nozzle is not preferable to integral spray body pressure regulation. Figure 1 below shows typical spray head components, which are normally made of plastic. Spray heads made with brass components are available, but uncommon for new product sales and may be limited to replacement units for legacy landscapes.

[9] For example, regarding the 1800 PCS nozzle pressure compensating screen, Rain Bird states that: "With a pressure compensator, outlet pressure will be reduced, but will fluctuate as the inlet pressure changes. A pressure compensator cannot maintain outlet pressure at a constant rate. A pressure regulator establishes and maintains a constant outlet pressure of 30 psi (2.1 bar) as long as the inlet pressure at the spray head is greater than 30 psi (2.1 bar)." http://www.rainbird.com/landscape/products/sprayBodies/1800PCS.htm

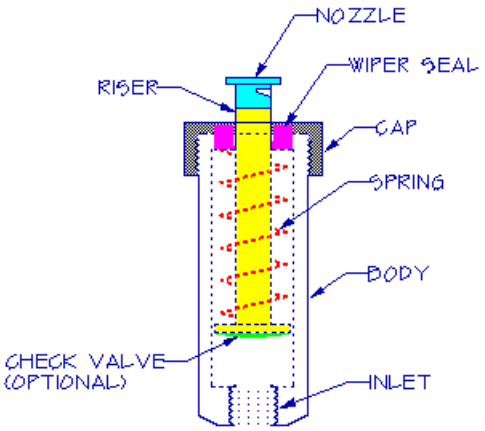

Figure 1. Parts of a traditional pop-up spray sprinkler

Source: Irrigation Tutorials. http://www.irrigationtutorials.com/selecting-a-sprinkler-head/

WaterSense estimated that pressure regulated spray sprinklers can achieve 22 percent water savings for landscapes with a 60-psi water supply inlet pressure to the irrigation system (U.S. EPA 2016b). In addition, in 2014 the Metropolitan Water District of Southern California (MWD) awarded Rain Bird with a grant for the "Project PRS" study conducted by the University of Arizona, College of Agriculture and Life Sciences. The study found that spray sprinklers with integral pressure regulation result in significant water savings compared to non-regulated spray sprinklers when inlet pressure exceeds 30 psi (Brown and Gilbert 2015).

3.1.1 Shrub Sprinklers

As described above, shrub sprinklers are irrigation emission devices that are permanently mounted above ground. Shrub sprinklers are created by attaching spray sprinkler nozzles directly on to a riser pipe with the use of a shrub adapter, which is a device allowing use of spray sprinkler nozzles with a riser or pipe rather than a spray sprinkler body. Shrub sprinklers are much less common than spray sprinkler heads, because they protrude from the ground and are only suitable for areas without foot traffic to avoid equipment damage and potential tripping hazards. Most irrigation professionals recommend using shrub sprinklers only in applications where there are no other options.[10]

Typically, shrub adapters are simple devices which fit fixed or rotating spray nozzles to one-half inch threaded risers. Shrub adapters with integral pressure regulation are available and provide irrigation water at a constant pressure (typically 30 psi) for a range of inlet supply pressures. Figure 2 shows examples of non-pressure regulating and pressure regulating shrub adapters.

[10] "Irrigation Tutorials - How to Select the Best Spray-type Sprinkler" http://www.irrigationtutorials.com/faq/spraybackground.htm

Toro 570S Shrub Adapter
(for male threaded spray nozzles)

Orbit Shrub Adapter
(for female threaded spray nozzles)

Rain Bird PA-8S-PRS Pressure Regulated Shrub Adapter (30 PSI)

Hunter PROS-00-PRS40 Pressure Regulated Shrub Adapter (40 PSI)

Figure 2. Non-pressure regulated and pressure regulated shrub adapters

4. Market Analysis

4.1 Market Structure

The three largest manufacturers of landscape irrigation equipment in the California market are Rain Bird, Hunter, and Toro. All three of these companies offer a variety of residential and commercial landscape irrigation emission device equipment, including standard spray sprinkler bodies and those with the water saving features as described in Section 3. Additionally, each of these manufacturers market specialty products. For example, Toro markets an extensive line of drip irrigation equipment as well as a pressure compensating spray nozzle, Hunter offers a large variety of pressure compensating bubblers, and Rain Bird was among the first large manufacturers to develop a pressure regulating rotor body.

Aside from the three manufacturers described above, there are several other manufacturers that produce landscape irrigation emission device equipment that is sold in California. For spray sprinklers, these manufacturers include Orbit, Hydro-Rain, K-Rain, Irritrol, Weathermatic, and Signature. The market focus of these manufacturers ranges from professional level products (e.g., Irritrol and Signature) to do-it-yourself residential products sold in retail stores (e.g., Orbit).

Landscape irrigation emission devices are distributed through several outlets, including direct sales from manufacturers to homebuilders or other large volume purchasers, sales from large irrigation

product distributors, such as Ewing Irrigation and SiteOne Landscape Supply (formerly John Deere Landscapes) and retail sales (e.g., Home Depot, Lowe's, or online retailers), which are common suppliers for do-it-yourself repairs and remodels. Many irrigation contractors use irrigation product distributors. Therefore, distributors have a significant influence on which products reach the mainstream market. Brand, price, performance, added features, and ease of use and installation play a role in which products distributors choose to stock. Some manufacturers have localized distribution channels that utilize wholesale distributors to deliver a tailored distribution strategy for different regions. Wholesale distributors may work with builders, contractors, water utilities or retail stores. Sales representatives for the wholesaler can offer personalized messaging to interested customers. Wholesalers also tend to target markets with high sales or markets that have an appetite for the specialty products they carry. In addition to large manufacturers and distributors, small businesses also play a role in the spray sprinkler body market. Many irrigation contractors that buy wholesale spray sprinklers and provide them to end use consumers are price-conscious small businesses.

The CASE Team interviewed representatives from six major irrigation manufacturers and distributors, which provided useful information for this document. Most major manufacturers indicated that scaling up the production of pressure regulated spray bodies to comply with a potential standard would take only a few months.

4.2 Market Share of Qualifying Products

4.2.1 Current Market Share

The CASE Team reviewed data from a variety of sources to obtain information about the availability of spray sprinkler bodies that contain integral pressure regulation and check valves, and therefore may comply with a Title 20 standard. Based on this research, the CASE Team found that qualifying products are widely available. All nine of the manufacturers listed in Section 4.1 that produce spray sprinklers offer at least one model of pressure regulating spray sprinkler body, and many manufacturers offer multiple models.[11] For instance, the California Water Service lists 32 different models from four different manufacturers with both pressure regulation and check valves (California Water Service 2015).[12]

Table 2 below lists a sampling of the pressure regulated spray sprinkler bodies available on the California market.[13] The table also includes products with both check valves and pressure regulation. Integrated check valves are typically not available on six or 12-inch pop-up spray sprinkler bodies with side inlets, but if desired, these sizes are also available as bottom inlet models which can support integrated check valves. Almost all spray sprinkler manufacturers market standard shrub adapters as well. Additionally, Toro, Rain Bird, and Hunter offer 30 psi pressure regulated shrub adapters, and Hunter also offers a 40-psi pressure regulated shrub adapter.

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[11] A few manufacturers, including Signature, Toro, and Rain Bird, also offer spray heads with a missing nozzle flow reduction feature.

[12] This list does not indicate whether the products have all been tested and could meet the proposed Title 20 standard. In addition, this list does not include all products marketed as containing pressure regulation.

[13] Though fewer products are available with 40 psi and 45 psi ratings, nozzles rated for use at 40 or 45 psi are typically also rated for use with 30 psi spray sprinkler bodies.

Table 2. Sampling of Spray Sprinkler Offerings by Manufacturer

Manufacturer	30 psi Pressure Regulated Spray Sprinkler Bodies	40+ psi Pressure Regulated Spray Sprinkler Bodies	Spray Bodies with Pressure Regulation and Check Valve*
Hunter	Pro Spray PRS30	Pro Spray PRS40 (40 psi)	Pro Spray PRS30 CV, Pro Spray PRS40 CV (14')
Rain Bird	1800-PRS, RD1800 P30	1800-P45, RD1800 P45 (45 psi)	1800 SAM PRS, 1800 SAM P45, RD1800-S-P30, RD1800-S-P45 (14')
Toro	570Z PR		570Z PR COM (10')
Irritrol	I-PRO PR		I-PRO PR-CV (14')
Orbit	Eco-Spray		
Hydro-Rain	HRS 200 PC		HRS 200 PC
K-Rain	PRO-S PR		
Signature	63XD		63XE (10')
Weathermatic	LX PRS		LX PRS30-CV (9.5')

*Check valve rating in parentheses where available.

4.2.2 Future Market Adoption of Qualifying Products With and Without Standards

The CASE Team anticipates that Title 20 Standards will lead to the installation of more efficient irrigation equipment across California. Without Title 20 Standards, the market adoption of sprinkler spray bodies with integral pressure regulation might increase somewhat due to the MWELO, which requires ANSI ASABE/ICC 802-2014 compliant landscape irrigation emission devices in new landscapes. In addition, due to the drought and other factors, water prices are increasing in some areas around the state, which may increase incentives for purchasing products with water saving features. However, the CASE Team does not believe that the drought emergency converted the market to primarily using pressure regulated sprinkler spray bodies and check valves. Potential market barriers, such as historical stocking decisions, lack of customer information regarding expected savings, and the lack of performance standards for pressure regulated sprays, limit the natural market adoption of pressure regulated spray sprinkler bodies. Another potential barrier is split incentives between installers and property owners, especially when property owners are not educated about potential water savings. Installers may be under pressure to install the system with the lowest initial cost and generally are not responsible for paying water bills.

5. Test Methods

5.1 Current Test Methods

This section summarizes ANSI ASABE/ICC 802-2014, the IA's SWAT, and the draft WaterSense test methods as related to potential spray sprinkler body standards.

5.1.1 Pressure Regulation

ANSI ASABE/ICC 802-2014 Section 303.5 contains a test procedure for spray sprinkler body pressure regulation. The procedure requires the following:

- Spray sprinkler body outlet pressure is tested as inlet pressure is increased in increments of five psi up to 20 psi above the manufacturer-stated rating, and is then tested in 10 psi increments.
- Descending pressure changes are tested starting at the highest value and then decreasing through the same pressures as the first part of the test.
- Test is conducted with a 1.5 gpm nozzle.
- A minimum of five spray bodies must be selected from a batch of 25 units.
- The water supply temperature is limited to 78 °F (22.5 °C).
- Test duration must be a minimum of three minutes.

ANSI ASABE/ICC 802-2014 also requires recording inlet and outlet pressure, though it does not require summarization of test results and does not contain a performance benchmark.

The SWAT Turf and Landscape Irrigation Equipment Pressure Regulating Spray Head Sprinklers Equipment Functionality Test Version 3.0 (May 2012) contains a series of procedures related to spray sprinkler body testing. For example, the "Continuous Test" requires testing of pressure regulation over a continuous range of increasing and then decreasing pressures similar to ANSI ASABE/ICC 802-2014, section 303.5. Additionally, the SWAT protocol requires a "Low Flow" test with 12-foot radius half circle (12h) spray nozzles (e.g., this would result in a water application rate of 1.3 gpm for conventional Hunter 12h nozzles and 0.5 gpm for the Hunter MP Rotator nozzle set for 12h coverage), and a "High Flow" test with 15-foot radius full-circle (15c) spray nozzles (e.g., this would result in a water application rate of 3.76 gpm for Hunter 15c nozzles).

In addition, the SWAT protocol contains a "Step Test" for pressure regulation. The protocol requires depressurizing the testing apparatus before each test run. The operator then increases pressure and stabilizes at the appropriate inlet pressure. The operator records the inlet and outlet pressures and summary values and calculates mean, standard deviation, and coefficient of variation values. The test is conducted with 12h spray nozzles. The Step Test method may more closely represent real world behavior for landscape irrigation systems than ANSI ASABE/ICC 802-2014, section 303.5 or the Continuous Test, assuming that spray sprinkler bodies are not subject to pressure swings.

The SWAT also contains a "Stability Test" to evaluate flow of spray heads at 20 psi above the manufacturer-advertised regulated pressure rating over a period of 30 minutes. The test is conducted with 12h nozzles.

The U.S. EPA WaterSense program is currently developing a test method based on ANSI ASABE/ICC 802-2014 and the SWAT Step Test (US EPA 2015) and has released a draft test method (U.S. EPA 2016a). Relevant observations from this effort are highlighted in Section 5.2.

5.1.2 Check Valves

The SWAT Pop-up Sprinkler Head Check Valves Equipment Functionality Test Protocol Version 2.3 (June 2014) contains several relevant test methods for check valves. Section 5.3.1 requires a test to verify that no visible weeping or formation of drops occurs over a one-hour period at 75 percent of the manufacturer's declared cracking pressure (i.e., the point at which the check valve begins to allow the flow of water to the spray sprinkler nozzle). Section 5.3.2 requires testing to determine whether check valves have a cracking pressure within 10 percent of the manufacturer's specified value (both "up" cracking pressure as water pressure is raised and "down" cracking pressure as water pressure is lowered). The protocol also tests for leakage with the spray sprinkler body oriented at 0, 15, 30 and 45 degrees from vertical. Section 5.3.3 requires long-term set tightness by testing over a 24-hour period. Section 5.4 specifies an endurance test of 2,500 cycles. The protocol requires that check valves undergo the endurance test, and then they are tested under sections 5.3.1, 5.3.2, and 5.3.3. The protocol also includes methods for determining pressure loss (section 5.2) and resistance to damage (section 5.1.1).

ANSI ASABE/ICC 802-2014, section 303.5.1 addresses check valve testing with a one-paragraph overview of testing for determining check valve cracking pressure. It also specifies that the cracking pressure will be determined after a 60-minute period during which no drainage occurs.

5.1.3 Anti-Burst

ANSI ASABE/ICC 802-2014 section 305.5 also contains an anti-burst test method for sprinkler bodies. Section 305.5.5 requires that each test sample shall withstand a hydrostatic pressure of 1.5 times the maximum published operating pressure, but not less than 150 psi for one minute without permanent distortion or leakage exceeding 10 milliliters per minute.

5.2 Proposed Test Methods

5.2.1 Pressure Regulation

The CASE Team proposes testing requirements that are similar to ANSI ASABE/ICC 802-2014 with several modifications to the pressure regulation test based on the SWAT Step Test:

- Testing would be required at two different flow rates consistent with the SWAT Step Test procedure: 1.5 gpm (in accordance with ANSI ASABE/ICC 802-2014) and 0.75 gpm, which may be more representative of some multi-stream, multi-trajectory nozzles as well as traditional nozzles covering a relatively small irrigated area, such as a 10-foot radius quarter circle or eight-foot radius half circle nozzle. Note that stakeholders recommended that U.S. EPA include two flow rates when developing a WaterSense test method. U.S. EPA originally noted its intent to adopt this recommendation (U.S. EPA 2015), although more recently they have indicated that they are reconsidering whether to use one or two test flow rates (U.S. EPA 2016b).
- The test would include a requirement for the calculation of summary data regarding deviations in outlet pressure and flow from the manufacturer's rating.

- The test would retain the ANSI ASABE/ICC 802-2014 pressure levels at which testing must occur and add a required minimum time for operation at each inlet test pressure. Testing for the U.S. EPA shows that product performance is non-linear and the highest flow rate can occur at any point between the low end and the high end of the product operating range. U.S. EPA is currently considering the pressures at which testing will occur.
- The test would require that inlet test pressure is reset to zero between each test pressure. This step is not required by ANSI ASABE/ICC 802-2014. However, U.S. EPA has found that omitting the "reset" step can change the test results (US EPA 2016b).
- The overall testing burden is expected to be low due to the limited number of spray sprinkler body products in the market and the short duration of the test procedures proposed by the CASE Team.
- The draft WaterSense test method would use a needle valve to control flow rates through the spray sprinkler body instead of a nozzle as specified by IA SWAT. The CASE Team will review this aspect of the final WaterSense test method and any public comments once available.

The CASE Team also proposes that the standards require manufacturers to test and list, test results using the IA Stability Test and provide this information to the Energy Commission. The duration of the proposed Title 20 test method may be very short compared to longer run times in the field. A test and list requirement would enable the Energy Commission to determine whether future revisions to the regulatory compliance test method and/or standard are needed to accurately reflect performance in the field. The CASE Team does not believe that the test and list requirement would impose a significant burden on manufacturers.

The proposed test methods would require that pressure taps comply with ASME PTC 19.2 and would require that any required flow metering devices comply with ASME PTC 19.5. These methods are referenced in ANSI ASABE/ICC 802-2014, section 303.5.3. While ASME PTC 19.2 is referenced in 303.5.2, it is not referenced in the IA Stability Test. In addition, ASME PTC 19.5 is not referenced in the ANSI ASABE/ICC 802-2014 (section 303.5.3) and may be useful for verifying that the flow rate of the tested nozzle falls within allowable parameters.

The CASE Team also notes the importance of measurement accuracy, especially for flow rate given that pressure regulated products generally achieve flow rates within five percent to ten percent of nominal flow rate ratings (U.S. EPA 2016b). Flow appears to be inherently more difficult to measure with accuracy. However, the procedures utilized by the University of Florida (which are stricter than the proposed WaterSense test method) would allow for flow rate measurement within two percent of actual value and pressure measurement within less than one percent of the actual value at 1.5 gpm (Dukes 2017).[14] This level of accuracy is highly desirable. The CASE Team is also researching instrument calibration standards and intervals and whether any general laboratory certifications (ISO, etc.) establish relevant calibration practices.

[14] Resolution of at least 0.01 gpm and accuracy of +/- 1% plus 0.005 gpm would lead to testing results within 2% of true flow rate value at 1.5 gpm (0.3% plus 1% plus 0.7%). Pressure measurement with an accuracy of +/- 0.1% of full scale value and resolution of 0.0035% full scale would lead to test results within 0.6% of true pressure value at 30 psi.

5.2.2 Check Valves

The CASE Team proposes a testing requirement similar to the IA SWAT protocol sections 5.3 and 5.4 for determining cracking pressures under several scenarios. Note that Annex A does not specify a minimum hold time before determining the pressure at which no drainage through the spray sprinkler body occurs. As such, the CASE Team proposes a mandatory 60-minute hold time based on ANSI ASABE/ICC 802-2014, section 303.5.1.

5.2.3 Anti-Burst

The CASE Team proposes requiring testing in accordance with ANSI ASABE/ICC 802-2014 section 305.5 anti-burst requirements.

6. Marking and Labeling Requirements

The CASE Team proposes a labeling requirement based on ANSI ASABE/ICC 802-2014, section 304.

6.1 Current Marking and Labeling Requirements

DWR recently revised the MWELO to include provisions from ANSI ASABE/ICC 802-2014 for landscape irrigation emission devices installed in newly constructed landscapes. ANSI ASABE/ICC 802-2014 contains marking and labeling requirements for spray sprinklers, which are listed below:

The following features shall be marked on the device in a location visible after installation:

- Check valve feature for sprinklers that include an integral check valve (section 304.1.7);
- Pressure control or pressure compensation feature for sprinkler bodies and bubblers that include these features (section 304.1.8).

The following information shall be made publicly available to the end user either in the product literature, on the product website, on the product packaging, or on the product itself:

- Manufacturer name;
- Nominal size of tubing or fittings to connect to the device;
- Nozzle series, if applicable;
- Device installation, operation and maintenance instructions;
- Presence of integral flow shut-off (missing nozzle) capability;
- Design pop-up height in inches and points of measurement used to establish the height;
- Flow rate at the minimum, recommended, and maximum operating pressure in units of gallons per minute. Where the flow rate varies depending on the nozzle or outlet selected, a range or table of flow rates shall be provided as an alternative;
- Distance of throw at the minimum, recommended, and maximum operating pressure in units of feet. Where the distance of throw varies depending on the nozzle selected, a range or table of distances rates shall be provided as an alternative;

- Spray pattern and range of adjustability;
- Design trajectory angle in units of degrees;
- Pressure at which a check valve cracks (i.e., no longer holds back water) as determined in units of feet of water column;
- Application rate at the minimum, recommended and maximum operating pressure in units of inches per hour, or a range or table where rate varies with nozzle selected; and
- Target spray sprinkler body regulation pressure to the nozzle in units of pounds per square inch.

6.2 Proposed Marking and Labeling Requirements

The CASE Team proposes the adoption of the marking and labeling requirements listed above, in accordance with ANSI ASABE/ICC 802-2014. Since qualifying sprinkler spray bodies must include integral pressure regulation and check valves, these features must be clearly marked on the device in a location visible after installation. In the case that the cap of the sprinkler body could potentially be removed and replaced with a cap from another sprinkler body, the same information should also be marked on the sprinkler body housing, beneath the sprinkler body cap.

Additionally, the CASE Team recommends that the Energy Commission consider a distinctive marking for units that comply with a Title 20 performance standard, since units could be labeled as pressure regulating under ANSI ASABE/ICC 802-2014 without meeting a performance standard. In addition, units labeled as meeting ANSI ASABE/ICC 802-2014 check valve requirements may not have undergone the testing required under the Title 20 standards. The Energy Commission may also wish to require that manufacturers mark the date of manufacture (see Section 8.3).

7. Water & Energy Usage

7.1 Efficiency Metrics

According to the MWELO, irrigation efficiency is defined as the amount of water beneficially used by plants divided by the amount of water that is applied (DWR 2015). Inefficient products apply more water than is theoretically necessary to meet plant water needs due to water losses from the product or system. Greater irrigation efficiency can be expected from well-designed and maintained systems in addition to using more efficient products.

7.2 Per Unit Water Use

<u>Flow Rate During Operation</u>

Non-pressure regulating sprinkler spray bodies have significantly higher nominal flow rates at higher inlet pressures. The theoretical relationship between water flow rate and water pressure for an unobstructed pipe and orifice can be described by a simplified version of Bernoulli equation (see

Figure 3 based on WaterSense 2015)[15]. The CASE Team notes that while actual flow rates for spray sprinklers are correlated with water pressure as predicted by the Bernoulli equation, the change in flow rate for a given change to the inlet pressure would be less than the hypothetical change predicted by the Bernoulli equation due to obstructions in the sprinkler spray body and potentially also friction.

Figure 3. Bernoulli equation relationship between relative water pressure and relative flow

Equation 1: Simplified Bernoulli Equation

$$\frac{Flow_{PR}}{Flow_{NR}} = \sqrt{\frac{P_{PR}}{P_{NR}}}$$

$Flow_{NR}$ = Flow with no pressure regulation
$Flow_{PR}$ = Flow with pressure regulation
P_{NR} = Sprinkler pressure at the nozzle with no pressure regulation
P_{PR} = Sprinkler pressure at the nozzle with pressure regulation
Assumptions: no change in elevation, no obstacles and frictionless flow

Equation 2: Theoretical Water Savings Based on Bernoulli Equation

$$Water\ Savings\ Fraction = \frac{Flow - Flow_{PR}}{Flow} = 1 - \sqrt{\frac{P_{PR}}{P}}$$

Examples: If P = 70 psi, P_{PR}=30 psi, Water Savings = 34%
Note: actual savings will be less than theoretical due to baffles and screens within the flow stream

Pressure regulating devices regulate nominal flow rate at higher inlet pressures and typically have a smaller variance of mean flow rate from the manufacturer's nominal flow rate when compared to non-pressure regulating devices.

Misting, Evaporation, and Wind

Irrigation devices will waste water via wind drift, misting, and evaporation when operated at pressures that exceed the intended sprinkler operating pressure. At higher pressures, water droplet size decreases, which increases susceptibility to wind drift and evaporation (CUWCC 2014). The amount of wind drift and evaporation also depends on climatic conditions, time of day, and length of irrigation run-time (Zazueta 2011).

Baseline Water Use from Drainage When Not in Operation

Additionally, some water will be lost through drainage when the landscape irrigation system is in not in operation and not equipped with check valves. The portion of the landscape irrigation supply pipeline that is higher in elevation than the lowest spray sprinkler head can drain completely to the

[15] The CASE Team assumes a constant nozzle orifice size so that changes in flow rate are proportional to changes in velocity and a constant elevation. The Bernoulli equation is based on a theoretical frictionless, unobstructed flow.

elevation of the lowest spray sprinkler head when the irrigation system is not in operation. Check valves prevent this from occurring.

8. Standards Implementation Issues

8.1 Infrastructure issues

The CASE Team is not aware of any infrastructural issues that would represent a barrier to implementation of a potential standard. Spray sprinkler bodies with integral pressure regulation and check valves are readily available. As noted earlier, the California Water Service lists 32 different models from four different manufacturers with both pressure regulation and check valves (California Water Service 2015).[16] Qualifying products can be installed with no additional materials or labor.

8.2 Stakeholder Positions

Numerous stakeholders have vetted a recommendation that the Energy Commission adopt Title 20 Standards for this product. For instance, the Independent Technical Panel (ITP) convened by the Department of Water Resources has included a recommendation in its "Report to the Legislature on Landscape Water Use Efficiency" (April 2016) that recommends the adoption of California appliance energy efficiency standards requiring pressure regulation and check valves (ITP 2016). The proposal does not include specific code language. The membership of the ITP is shown below in Table 3.

Table 3. Independent Technical Panel Members

Name	Representation	Organization
Peter Estournes	Business	Gardenworks, Inc., Santa Rosa
Penny Falcon, P.E.	Retailer	Los Angeles Department of Water and Power
David W. Fujino, Ph.D.	Academia	UC Davis, CA Center for Urban Horticulture
William Granger	Retail Water Provider	City of Sacramento
Lisa Maddaus, P.E.	At large	Maddaus Water Management
Edward R. Osann	Environmental	Natural Resources Defense Council
Jeff Stephenson	Wholesaler	San Diego County Water Authority

Furthermore, the CASE Team reviewed numerous public comments on the ITP's report with a focus on stakeholders likely to have an interest in sprinkler products. Though the CASE Team did not review every public comment, those that were reviewed supported adoption of Title 20 standard. Several examples are listed below:

- The Municipal Water District of Orange County (MWDOC) fully supports this recommendation and has found that that the absence of pressure regulation in irrigation

[16] This list does not indicate whether the products have all been tested and could meet the proposed Title 20 standard. In addition, this list does not include all products marketed as pressure regulating.

systems is widespread, contributing to a significant amount of water being wasted. They have also found that low-head drainage is common, especially in hilly areas, which results in wasted water and excess time to recharge an empty irrigation system. MWDOC believes that the proposed recommendation will result in solutions to prevent low head drainage and water loss due to excess pressure, and that the savings will accrue in both new systems and existing systems, as the proposed recommendation is a manufacturing standard for all new sprinkler bodies (MWDOC 2016).

- The California Landscape Contractors Association (CLCA), a nonprofit trade association of approximately 2,000 licensed landscape contractors, supports the recommendation and suggests an implementation deadline of January 1, 2018 (CLCA 2016).
- The Irrigation Association (IA), which represents 1,500 members in the irrigation industry, supports the recommendations. The IA includes large irrigation equipment manufacturers including Hunter, Orbit, Toro and Rain Bird, several smaller manufacturers, distributors, retailers, and a variety of other companies and organizations. The IA was involved in the development of ANSI ASABE/ICC 802-2014 and encourages referencing that standard in the development of a Title 20 standard (IA 2016).
- The Association of Professional Landscape Designers (APLD), which primarily represents residential landscape designers, but also includes contractors and landscape architects who provide design services for commercial, industrial and institutional landscapes, supports the recommendations (APLD 2016).
- The Contra Costa Water District (CCWD) expressed an interest in addressing low quality sprinkler heads sold in big box stores (CCWD 2016).

The comment from CCWD expressed a desire to improve the quality of sprinkler heads available to consumers. Due to the required testing and the addition of the anti-burst, pressure regulation, or check valve features, a sprinkler head that complies with Title 20 standards will likely have a higher quality standard than those most commonly sold today, which addresses this concern.

The CASE Team is not aware of significant opposition to standards. For instance, the Senate Rules Committee found that no person or organization opposed the AB 1928 (Campos 2016) requirement to adopt mandatory standards for spray sprinkler bodies and other landscape irrigation products (Senate Rules Committee 2016). In addition, the CASE Team held conference calls and meetings with six manufacturers and distributors. No one indicated that a Title 20 standard for pressure regulation would present any technical or economic feasibility issues,[17] and several stressed the importance of a well-designed and installed landscape irrigation system (see Appendix A: Additional Product Information for complementary measures).

8.3 Compliance Issues

The CASE Team recommends that the Energy Commission set a compliance date of twelve months based on the amount of time needed to complete manufacturing scale up and labeling of qualifying products. Some manufacturers informed the CASE Team that they are equipped to quickly scale up existing production lines for pressure regulated products, while in other cases a change to the

[17] The CASE Team informal outreach to manufacturers and distributors did not include check valve requirements, which were added to the scope of the CASE response later based on the ITP recommendation.

configuration of manufacturing lines would be required to scale up production. The CASE Team is not aware of any need to consider a compliance date longer than 12 months to scale up production and stock supply channels with compliant products. Compliance testing should not impact manufacturers' ability to meet the compliance deadline set by the Energy Commission.[18] The anti-burst requirement would not impose any new significant burden on manufacturers since they must already meet this requirement by December 1, 2015, under the MWELO.[19]

The Energy Commission should also consider requiring consistent marking of products with the date of manufacture. The CASE Team understands that some manufacturers mark individual units with the manufacturing date in order to validate warranty claims, while others do not. Marking the box in which multiple units are packaged appears to be a common industry practice, which may be helpful in some cases, but not sufficient when products are sold individually.[20]

The CASE Team expects that finding out whether products sold through retail channels meet the standard can be readily determined by examining retail stock and checking online sales offerings against qualifying products in the Energy Commission's Modernized Appliance Efficiency Database System (MAEDBS), as well as through similar procedures for other retail products regulated by the Energy Commission.

Sales from wholesale distributors to contractors may be less publicly visible, and the CASE Team recommends several approaches to address this sales channel. The first is outreach and education. The next approach is the verification of products offered for sale through distributor websites and/or other sources.

In addition, the CASE Team recommends coordinating with the MWELO compliance audits and/or CALGreen inspections of new installations. Contractor installations of equipment obtained through wholesalers may be more prevalent for new installations than for replacement of broken units, and thus these inspections and audits would provide another option to verify compliance.[21] Since ANSI ASABE/ICC 802-2014 (Section 304.1) requires the labeling of pressure regulation and check valve features on devices in an area visible after installation, auditors conducting MWELO third-party audits should be able to verify at least the presence or absence of integral pressure regulation and check valves.[22] DWR guidance is recommended to highlight that audits and local agency compliance checks should verify that spray bodies meet Title 20 Standards and that the models installed are consistent with the models that would be listed in the Energy Commission's MAEDBS system of compliant products.

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[18] The CASE Team estimates that pressure regulation product testing can be conducted relatively quickly without delaying a manufacturer's ability to comply. Our understanding is that testing procedures should take less than one day per product after equipment set-up. In addition, there are a limited number of models on the market since each spray body model can be used with a wide range of nozzles from the spray body manufacturer and typically from other manufacturers as well.

[19] In theory, a manufacturer could offer a product for sale only for the replacement market to avoid compliance with the MWELO, but in practice the CASE Team is not aware of any technical differentiation or market differentiation between replacement units and units for new landscaped areas.

[20] While the box may be dated based on date of packaging instead of date the unit is manufactured, this difference should be small since manufacturers have an incentive to package and ship promptly to avoid carrying excess inventory.

[21] The CASE Team assumes that a home or property owner, or a maintenance technician is likely to replace a broken unit that they will purchase that unit through a retail sales channel, but a contractor is much more likely to hire a professional to design and install an entirely new landscape.

[22] Encouraging building code officials to harmonize landscape irrigation requirement in CALGreen (Title 24, Part 11) will also be beneficial.

9. Environmental Impacts

Several additional environmental benefits are expected from potential standards. First, as noted earlier, water conservation will lead to several significant environmental benefits. Secondly, reductions in excess irrigation will reduce runoff that can contain sediment, pesticides, and fertilizers, thereby reducing discharges of these pollutants to receiving water bodies, sanitary sewers, and storm water collection systems. Additionally, the measure may improve plant health and reduce weeds by reducing over-irrigation.

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Appendix A: Additional Product Information

Nozzles and Distribution Uniformity

As mentioned in Section 3, spray sprinklers utilize nozzles to determine the pattern and radius of the sprinkler's water throw. Nozzles are available in a variety of throw patterns including arcs ranging from 90 to 360 degrees, squares, and strip shapes. Some nozzles also allow for the radius of the water throw to be adjusted by turning a radius adjustment screw at the top of the nozzle, allowing for even greater flexibility. Nozzles are also often interchangeable to increase the sprinkler body longevity and allow for greater flexibility in landscape applications. Nozzles from one manufacturer can also be matched with spray bodies from another manufacturer.

Rotary (or rotator) nozzles are also becoming increasingly available. Rotary nozzles fit onto sprinkler spray bodies, and rather than spraying water in a fixed spray pattern, rotary nozzles spray water more slowly and more uniformly in multiple higher outlet pressure rotating streams. Rotary nozzles generally have a higher radius of throw than traditional sprays, and they also have a higher recommended operating pressure of 40 to 45 psi, as compared to the 30-psi recommended operating pressure for traditional spray nozzles. To reduce potential runoff, rotary nozzles feature a lower precipitation rate than traditional spray nozzles, and thicker water streams from rotary nozzles allow for greater wind resistance than traditional sprays. Figure 4 below shows the spray pattern of a tradition spray nozzle as compared to that of a rotary nozzle.

Figure 4. Traditional spray nozzle (left) vs rotary nozzle (right)[23]

The CASE Team recognizes the potential benefit of a nozzle standard, but this document t does not contain a recommendation for a nozzle standard due to the current lack of a generally accepted metric and test method for spray nozzle operational efficiency.

Distribution uniformity (DU) is currently referenced in standards, such as ANSI ASABE/ICC 802-2014. DU is measured with catch cans that collect spray water. This metric is used in design calculations to ensure that sufficient water is applied to ensure that all areas of a landscape receive sufficient irrigation. Low DU is sometimes used as a proxy for wasted water due to runoff and deep

[23] Source (left): http://ak.picdn.net/shutterstock/videos/3793262/preview/stock-footage-garden-irrigation-spray-system-watering-planted-flowerbed.jpg
Source (right): http://www.waterirrigation.co.uk/media/catalog/category/12_1.png

percolation from high water application spots that exceed plant needs. However, research has found varying results in terms of actual water savings from improved DU, which may be due in part to the ability of soil to redistribute water based on site specific conditions (CUWCC 2014). In addition, DU does not address overspray, evaporation, or drift. Recent research has also shown that interference between different sprinklers may occur, which is not captured by DU testing of individual nozzles (Zoldoske and Mecham 2015). Thus, some of the key mechanisms for water loss of sprinkler systems are not covered currently by any known test method.

U.S. EPA originally intended to establish a WaterSense program for nozzles based on DU. However, U.S. EPA subsequently found that DU lab measurements may not correlate with DU in the field, and they received comments that DU may not be an effective metric for determining water savings. "Based on the lack of field studies demonstrating savings and the public comments received discouraging WaterSense from basing savings on theoretical calculations based on DU, U.S. EPA has decided to put specification development for high-efficiency nozzles on hold. WaterSense continues to collect data and would be interested in collaborating with the industry on field studies or other research that would assess tangible savings, develop consensus around a new performance measure, or demonstrate DU as a viable performance measure for high-efficiency nozzles" (U.S. EPA 2015).

Thus, development of a metric and test method for nozzle operational efficiency is an additional future study opportunity for a potential future Title 20 standard. Ideally, a landscape operational efficiency metric for nozzles would address uniformity of water distribution as well as drift, evaporation, overspray and potential interference between sprinklers. The IA has developed a testing protocol "Smart Water Application Technologies (SWAT) Spray Head Sprinkler Nozzles Performance Characteristics" (March 2015) that is intended to address nozzle operating efficiency. No product testing results are currently listed on the IA website. Currently sprinkler nozzles are tested in still air. Ideally a future standard would also test this equipment under controlled air velocity conditions to test for drift. The CASE Team also notes that system design would likely affect the level of water savings achieved in the field from an improved nozzle.

Quantifying the ability of soil to redistribute water laterally as noted above is another area for potential further study. For instance, sandy soils have less capacity to hold and laterally redistribute water from high water application areas to low water application areas than soils with more clay content. This factor will influence the potential benefit of improved application uniformity.

Rotor Sprinklers

Unlike sprays, which apply a fixed pattern of water over a landscape, rotors apply water to a landscape by means of one or more rotating streams. In rotor sprinklers, the rotor body itself or the internal parts of the rotor body may rotate, unlike the fixed bodies of spray heads. Impact rotors were the first type of rotor technology developed. They operate by rotating a sprinkler arm, which causes the sprinkler body and corresponding water stream to rotate. Impact rotors make a familiar clicking sound as they rotate across a landscape. Due to the imprecise motion of impact rotors, their loud noise, and the possibility of dirt lodging into the large, open cavity of the rotor casing during irrigation, impact rotors have diminished in popularity in comparison to newer, gear-driven rotors. In gear-driven rotors, water that moves through the sprinkler turns a set of gears which rotates the nozzle, thus rotating the water stream across the landscape. Gear-driven rotors

are smaller and have a lower profile than impact rotors. They are also quieter and require less maintenance. Figure 5 below shows an impact rotor compared to a gear-driven rotor.

Figure 5. Impact rotor (left) vs gear-driven rotor (right)[24]

Like sprays, rotors are commonly offered in the pop-up variety. Although cheaper rotors are sold with one preinstalled nozzle, many rotors are also offered with interchangeable nozzles that determine the radius and flow rate of the rotor's water throw. Compared to sprays, rotors typically operate at a higher recommended pressure of 30 to 100 psi (depending on the model). They are also most often used in larger landscapes due to the larger radius of water throw offered by the rotors (15 to 100+ feet). The water throw radius of many rotors can be adjusted by turning a radius reduction screw, and many models offer arc adjustment from 20 to 360 degrees. Rotors tend to have fewer available features than sprays, but check valves are available for rotors. A couple manufacturers also offer a pressure regulating rotor body, but this feature is not widely available. Additionally, several water suppliers offer rebates for the installation of rotors based on expected water savings.

Bubblers

Bubblers are irrigation emission devices used to apply irrigation water directly to plant's root zone. They flood the soil, discharging greater than 6.3 gallons per hour as defined under ANSI ASABE/ICC 802-2014. They are typically installed in landscapes designed for specialty applications, such as irrigating trees, flower beds, vegetables, and shrubs. Standalone bubblers are generally screwed directly onto a half-inch riser pipe, but bubbler nozzles are also available, which are threaded to fit onto spray head bodies. The watering distance for bubblers is much smaller than that of spray or rotors (only up to approximately three feet). Pressure compensating bubblers are

[24] Source (left): http://store.RainBird.com/media/catalog/product/cache/1/image/9df78eab33525d08d6e5fb8d27136e95/a/g/ag5maxipaw_actionclose up_2.jpg
Source (right): https://www.orbitonline.com/site_files/feed/products/600/55069_action2_600.jpg

also available which modulate water output for a range of input pressures, but pressure regulation for bubblers can also be achieved by matching a bubbler nozzle with a pressure regulating spray body. Figure 6 below shows two different types of bubblers: 1) flood or umbrella bubblers which flood a small area, and 2) stream bubblers in which water is shot out away from bubbler body.

Figure 6. Flood or umbrella bubbler (left) and stream bubbler (right)[25]

Drip Irrigation

Drip emitters are a type of microirrigation device intended to discharge a small uniform flow rate of less than or equal to 6.3 gallons per hour when operated at 30 psi (ANSI ASABE/ICC 802-2014). Drip irrigation systems are generally designed to operate in a pressure range of 10 to 30 psi (NMSU 2011), as opposed to spray and rotor sprinkler systems, which operate at or above this level. (For landscapes with water supply pressures above 30 psi, a pressure regulator should be installed on the drip irrigation system valve to avoid damage to system components.)

Compared to sprinklers, properly designed and maintained drip irrigation systems can save water by reducing evaporation, runoff, and deep drainage since the irrigation water is slowly applied more closely to the plant root system. However, drip irrigation systems may also require more careful maintenance than sprinkler systems.

Drip emitters include line-source emitters and point-source emitters. Due to the variety of types of drip irrigation, it can be used for most types of plant applications. Drip irrigation may also be desirable in situations where waterborne diseases are a concern, such as in edible crop production, since it keeps irrigation water near the root zone of the plant and does not spray irrigation water into the air or onto plant leaves, fruits, or vegetables like sprays or rotors would.

Line-source Drip Emitters

Drip irrigation systems are typically built using flexible polyethylene tubing. Unlike sprays or rotors, which may have trouble watering landscape plots with irregular shapes or dimensions, the flexibility of drip tubing allows for installation in a variety of geometries. In line-source drip emitter tubing, drip emitters are placed in the tubing walls at spaced intervals. Line-source drip

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[25] Source (left): http://irrigationrepair.com/images/diyimages/flood_bubbler.jpg
Source (right): https://s-media-cache-ak0.pinimg.com/736x/d8/9c/5f/d89c5fc04c803ea6ecf54fdc574bfa05.jpg

emitters are typically used in applications where plants are evenly spaced, such as gardens or orchards. For residential and commercial applications, typical in-line emitter spacing intervals are 12, 18, and 24 inches, and typical water emission flow rates range from 0.5 to one gallon per hour. Line-source drip emitters include rigid drip line tubing, as well as thin and flexible drip tape, which is less durable and often replaced after a couple growing seasons (often used for agricultural applications).

Pressure compensating drip line emitters are also available, which aim to provide a uniform water flow rate across a range of inlet pressures. Even without pressure compensating emitters, most drip systems will have some degree of pressure reduction since the long pipe length and small pipe diameter of drip tubing will naturally reduce water pressure. Figure 7 below shows a drip line emitter, drip tape line-source drip emitter, and point-source drip emitter.

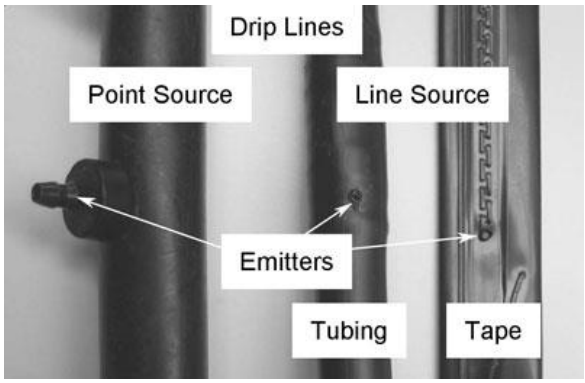

Figure 7. Types of drip emitters
Source: **http://aces.nmsu.edu/pubs/research/agmech_eng/rr-773/welcome.html**

Point-source Drip Emitters

Point-source drip emitters emit water at a single point and are often used to irrigate irregularly spaced plants such as trees and bushes where drip line might be insufficient. Typical water emission flow rates range from 0.5 to 4 gallons per hour. Point-source emitters can be punched directly into polyethylene tubing with attached barbs or they can be threaded onto tubing. Types of point-source drip emitters are show in Table 4 below.

As with drip line emitters, pressure compensating point-source emitters that maintain a constant flow output for a range of inlet pressures are also available. Pressure compensation is useful for ensuring that irrigation water is applied evenly. However, it is not recommended for flat landscapes with very low water pressure, such as landscapes that use low-pressure gravity fed irrigation from on-site water barrels.

Table 4. Types of Point-Source Emitters

Point-Source Emitter Type	Example Product
Turbulent flow path emitters, which route water through a complex water path to reduce flow rate and minimize clogging.	Netafim BD
Take apart or flag emitters, which have an open flow path. Although they are more likely to clog than turbulent flow emitters, they are a low-cost option which works well at very low pressures.	Toro E-2
Diaphragm emitters, which contain a flexible diaphragm which helps to adjust for varying water pressures.	DIG PC Drip Emitter

Opportunities for potential drip emitter standards

While this document does not contain recommended standards for drip and line emitters, they could be considered for a future Title 20 standard based on ANSI ASABE/ICC 802-2014 or other standards. For instance, ANSI ASABE/ICC 802-2014 requires that product flow rates, as a function of inlet pressure, fall within +/- 7 percent of manufacturer published values. The standard also contains a requirement for devices with pressure regulation. Similar types of requirements could also be studied for other microspray devices.

Microspray

Another type of irrigation emission device that is gaining popularity is the microspray. Like a blend between traditional spray sprinklers and drip irrigation, these devices are designed to operate at lower pressure and emit irrigation water near plant's root zone. Microsprays are typically marketed for agricultural uses and not commonly used for landscape irrigation. If agriculturally-focused microspray incentives or standards are applied to this product, then the residential landscape market would likely also see impacts.

Landscape Irrigation Audits

The CASE Team also received feedback during the development of this document regarding the importance of proper landscape irrigation system design and post-installation audits to verify proper design and installation. The CASE Team recognizes the importance of verifying proper irrigation system design and installation to complement equipment standards. Several organizations provide training that includes this topic and U.S. EPA WaterSense includes a list of certified professionals on their website.[26] The CASE Team also notes that the draft ITP report recommends several opportunities to strengthen the MWELO irrigation audit requirements for new landscapes. In addition, local jurisdictions have authority to adopt the ITP recommendations and/or other regulations under their authority to achieve equal or greater water savings than the MWELO.

[26] http://www3.epa.gov/watersense/outdoor/cert_programs.html#audits