WaterSense® Notice of Intent (NOI) to Develop a Draft Specification for Landscape Irrigation Sprinklers

I. Introduction

Residential outdoor water use in the United States accounts for nearly 9 billion gallons of water each day,[1] mainly for landscape irrigation. As much as half of this water is wasted due to evaporation, wind, or runoff, often caused by improper irrigation system design, installation, maintenance or scheduling. The U.S. Environmental Protection Agency's (EPA's) WaterSense program is addressing outdoor water efficiency by working with irrigation professionals and labeling efficient irrigation system control technologies. In addition to control technologies, EPA is indicating its intent to issue a draft specification for efficient landscape irrigation sprinklers with the issuance of this NOI.

High-efficiency irrigation sprinklers aim to deliver water more evenly to the landscape than traditional sprinklers and/or regulate outlet pressure to ensure a constant flow rate over a range of supply pressures. Allowing sprinklers to earn the WaterSense label will help further transform the irrigation market from traditional equipment to products that save water and better meet plant water needs.

According to the draft American Society for Agricultural and Biological Engineers and International Code Council (ASABE/ICC) 802-2014 *Landscape Irrigation Sprinkler and Emitter Standard*,[2] a sprinkler is a device consisting of a sprinkler body with one or more orifices (i.e., nozzles) to convert irrigation water pressure to high-velocity water discharge through the air, discharging a minimum of 0.5 gallons per minute (gpm) at the largest area of coverage available for the nozzle series when operated at 30 pounds per square inch (psi) or more with a full-circle pattern.

There are two main components that influence the efficiency of a sprinkler: the nozzle and the body. The nozzle provides the pattern of water emitted from the sprinkler and can be emitted in either a fan-like pattern (i.e., a spray nozzle) or by means of one or more moving streams [e.g., multi-stream, multi-trajectory (MSMT)], and influences the uniformity of how water is applied. The body of the sprinkler, which houses the nozzle, provides pressure regulation if applicable and can compensate for changes in inlet pressures. These two components are generally sold separately and are interchangeable between brands in some cases.

[1] Kenney, Joan F., et al. 2005. "Estimated Use of Water in the United States in 2005." *U.S. Geological Survey Circular*, 1344. U.S. Department of the Interior. Table 6, page 20.
[2] American Society for Agricultural and Biological Engineers and International Code Council (ASABE/ICC). 2014. Draft ASABE/ICC 802-2014 *Landscape Irrigation Sprinkler and Emitter Standard*. www.iccsafe.org/cs/standards/IS-IEDC/Pages/default.aspx.

II. Scope

WaterSense intends that the specification will apply to both high-efficiency nozzles and pressure-regulating bodies of landscape irrigation sprinklers. It is EPA's current intent to develop one specification that includes separate criteria for each component (i.e., a set of nozzle's criteria and a set of bodies' criteria). Each component will be independently certified and labeled separately and could either be purchased and used separately, or as a combination. If sold as a combination, both components must be WaterSense labeled.

EPA intends to limit this product category to nozzles and bodies that are used in landscape irrigation sprinklers, as defined by the draft ASABE/ICC 802-2014 *Landscape Irrigation Sprinkler and Emitter Standard*.[3] EPA intends to exclude micro irrigation emission devices—those that discharge water in the form of drops or continuous flow rates at less than 30 gallons per hour (gph) when operated at 30 psi—from this product category because they are mechanically different and have different performance attributes and applicable test protocols than landscape irrigation sprinklers. This effectively excludes drip emitters, drip line emitters, point-source emitters, and micro sprays. Bubblers, hose-end water products, or valve-in-head devices (i.e., sprinklers with an integral control valve intended to be operated from a remote location) are also excluded from this product category for similar reasons. This product category does not include sprinklers that are used exclusively within agricultural irrigation systems.

III. Performance Measures for High-Efficiency Nozzles

For high-efficiency nozzles, WaterSense has identified distribution uniformity (DU) as the appropriate performance measure. DU, as defined by the draft ASABE/ICC 802-2014 *Landscape Irrigation Sprinkler and Emitter Standard*,[4] is the measure of the uniformity of irrigation water applied to a defined area. DU low quarter (i.e., DU_{LQ}) is typically the DU metric used in the field (i.e., measured in a landscape) and is defined as the ratio of the average of the lowest one-fourth of measurements of irrigation water to the average of irrigation water captured by collection devices, expressed as a dimensionless number with two decimal places.[5]

Theoretical Water Savings

When an irrigation system is scheduled appropriately, field DU_{LQ} measured in the landscape should be incorporated into the irrigation schedule to determine system runtimes, adjusting the amount of water applied to meet the needs of the driest portion of the landscape. The Irrigation Association's (IA's) Landscape Irrigation Auditor, 3rd Edition[6] recommends accounting for DU_{LQ} in the irrigation schedule according to Equations 1 and 2 below. These equations demonstrate how a change in DU_{LQ} impacts the amount of water scheduled to be applied in any given landscape:

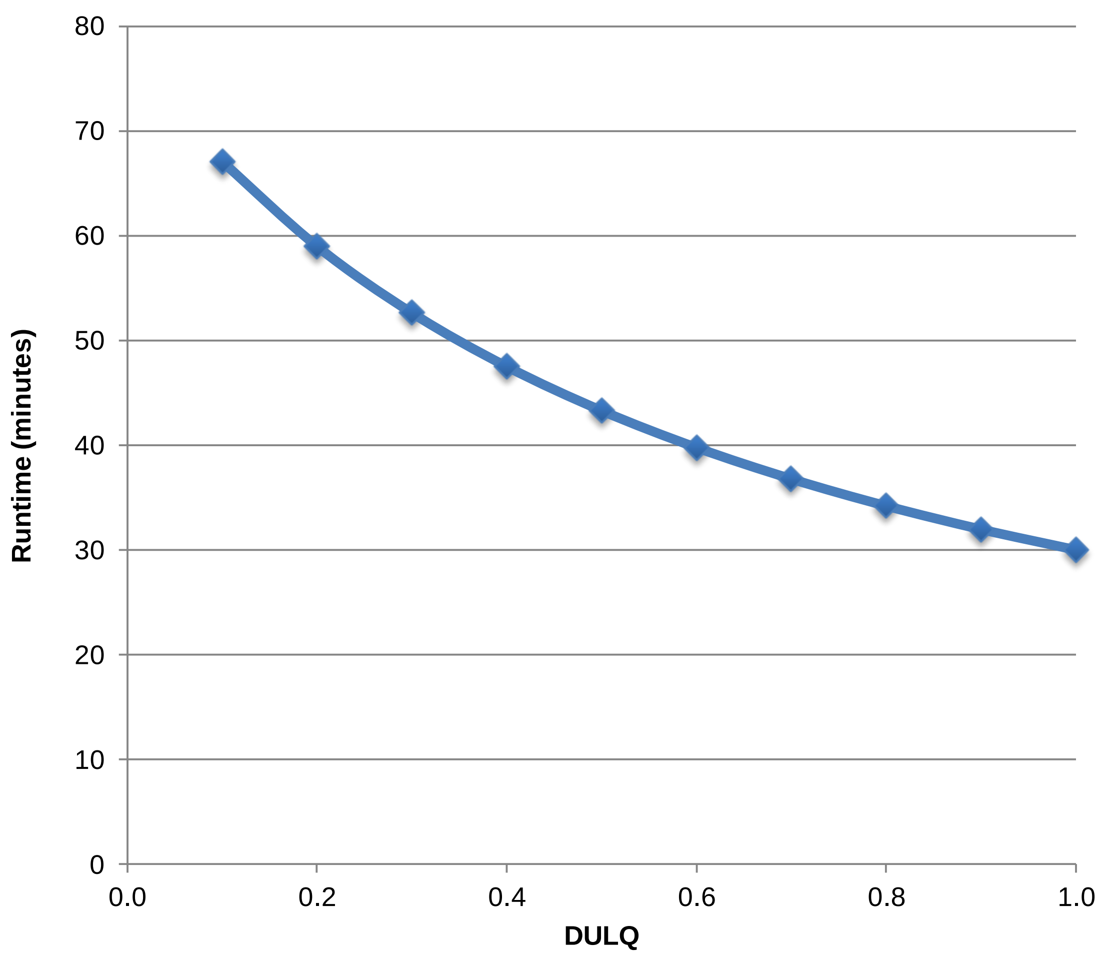
[3] Ibid.
[4] Ibid.
[5] Ibid.
[6] Irrigation Association (IA). 2013. Landscape Irrigation Auditor, 3rd Edition. Irrigation Association, Falls Church, VA.

Equation 1. Scheduling Multiplier = $1/(0.386+0.614*DU_{LQ})$

Equation 2. Runtime[7] = (Scheduling Multiplier*60*Irrigation Depth)/(Application Rate)

As demonstrated by these equations, a landscape with more uniform water application or higher DU_{LQ} will require less water to be applied than one with less uniform water application or lower DU_{LQ} because the runtimes will be shorter. Figure 1 shows the relationship between DU_{LQ} and the irrigation system runtime, assuming an application rate of 1.5 inches per hour and an irrigation depth of 0.75 inches.

Figure 1. Effect of DU_{LQ} on Runtime



[7] Irrigation depth is reported in units of length and application rate in units of corresponding length per time.

Field Studies

WaterSense has only identified two field studies to date that have evaluated actual water savings of high-efficiency nozzles in the field. Two water utilities presented studies at the WaterSmart Innovations Conference in 2013 that examined the change in DU_{LQ} measured in the field and change in water use from retrofitting traditional spray nozzles in landscapes with nozzles that were advertised to have higher DUs[8]. The results from both studies showed an increase in DU_{LQ} post-retrofit but did not show the expected water savings despite changing post-retrofit schedules to reflect the lower application rates and increased DU_{LQs}. EPA plans to follow up with the study authors to assess if additional analyses can be conducted on the existing data to assess why an increase in field DU_{LQ} may not have resulted in expected water savings.

An additional study examined changes in DU_{LQ} from retrofitting landscapes with multi-stream, multi-trajectory (MSMT) nozzles but did not examine actual water use data pre- and post-retrofit. This study examined the impacts of 51 retrofitted sprinkler zones across 29 different sites with MSMT nozzles and found that, on average, DU_{LQ} increased from 0.44 to 0.70. While they did not directly measure water use during the study, they used the changes in DU_{LQ} to estimate water savings. This estimation predicted that retrofitting with MSMT nozzles would reduce irrigation by 31 percent.[9]

Laboratory-Measured DU_{LQ}

For products to be independently certified by a third party, WaterSense requires a repeatable and reproducible laboratory test protocol to measure performance attributes. Many manufacturers currently measure the DU of individual nozzles in a laboratory setting, but no standardized laboratory test protocol for DU existed until recently. Two DU test protocols were recently developed and are both in draft form. The draft ASABE/ICC 802-2014 *Landscape Irrigation Sprinkler and Emitter Standard*[10] includes a test method for application rate and pattern of a single sprinkler and subsequent calculation of DU_{LQ} from an arrangement of virtual sprinklers in a simulation model (Section 304.6). IA's Smart Water Application Technologies (SWAT) program has published a draft test protocol for high-uniformity spray sprinkler nozzles that includes a test for DU_{LQ}.[11] This protocol employs a field-type test with multiple sprinklers in several arrangements resulting in actual measured DU_{LQ}, as opposed to the modeled approach taken by ICC.

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[8] Eugene Water & Electric Board. 2013. Reducing Peak Hour Demand With Nozzle Retrofits: Three Year Evaluation Paper presented at WaterSmart Innovations Conference. Las Vegas, NV. October 3, 2013.
Socovool, K., Morgan, M., and M. Drinkwine. 2013. Observed Long-Term Results of Multi-Stream Rotational Spray Heads and Associated Product Retrofits. Paper presented at WaterSmart Innovations Conference. Las Vegas, NV. October 3, 2013.

[9] Solomon, K. H., et al. 2007. "Performance and Water Conservation Potential of Multi-Stream, Multi-Trajectory Rotating Sprinklers for Landscape Irrigation." *Applied Engineering in Agriculture*, ISSN 0883-8542. http://nurserysprinklers.com/media/resources/MP_ASABE_Paper.pdf

[10] ASABE/ICC. *op. cit.*, Page 2

[11] IA. June 2013. *High-Uniformity Spray Head Sprinkler Nozzles: Equipment Functionality Test*. Testing Protocol Version 2.0. www.irrigation.org/SWAT/Draft_Protocols/Spray_Head_Sprinkler_Nozzles/.

WaterSense is considering the adoption of the ASABE/ICC test method into a draft specification for a number of reasons. First, the ASABE/ICC test method was developed as a laboratory test to limit the variability of results and increase reproducibility between laboratories. Additionally, the method has been developed through a standards-setting process following well-established American National Standards Institute (ANSI) procedures. Many manufacturers have indicated their intent to comply with the standard, meaning that they will complete the test method for uniformity as part of that process.

Relationship Between Laboratory-Tested DU_{LQ} and Field DU_{LQ}

As explained above, according to industry best management practices, the DU_{LQ} measured in the field should be accounted for in the irrigation schedule, thereby decreasing runtimes with higher field DU_{LQ}. WaterSense anticipates that products with higher laboratory DU_{LQ} will result in irrigation systems with higher field DU_{LQ}, when those systems are properly designed and installed. However, the relationship between these two parameters (i.e., field DU_{LQ} and laboratory-tested DU_{LQ}) needs to be established in practice. WaterSense does not currently have the necessary data to document this relationship. Next steps regarding the establishment of this relationship are included in Section VI and Appendix A below.

Performance Threshold

Assuming a relationship between field DU_{LQ} and laboratory-tested DU_{LQ} can be established, a performance threshold based on laboratory-tested DU_{LQ} will need to be developed. This will require that a number of products undergo testing to the selected test protocol to provide a range of performance data. Based on the range of performance data, WaterSense will select an appropriate minimum threshold for DU_{LQ} threshold in one of two ways:

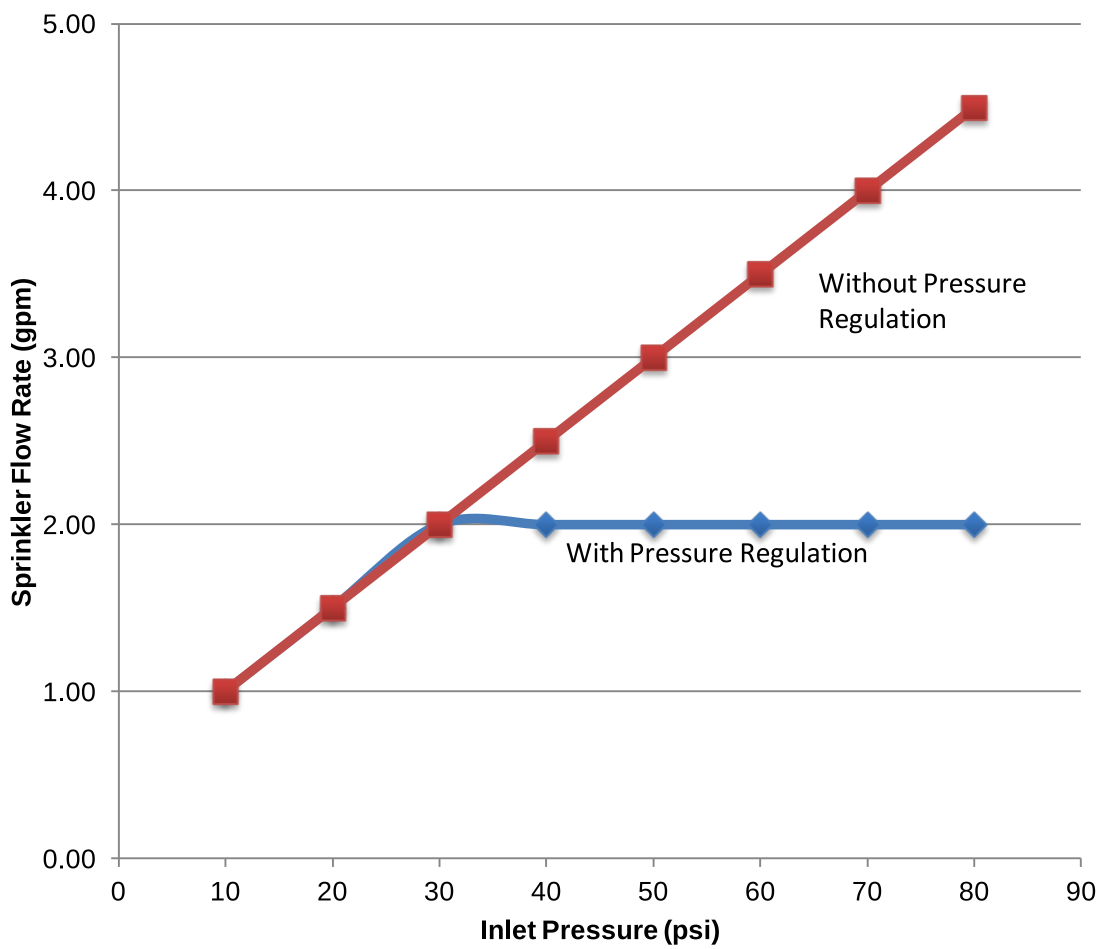
1. Top-Tier Approach: WaterSense would review the performance data for a wide range of products and determine a “top tier” with respect to DU_{LQ}. For example, WaterSense might view the range of performance data and place a threshold at the top 20 percent of product DU_{LQ} results.

2. Increase-From-Baseline Approach: In this approach, WaterSense would determine an average DU_{LQ} of traditional spray nozzles. WaterSense would then set a threshold for some increase in DU_{LQ} from that baseline to determine the threshold for “high-efficiency” nozzles. For example, if a baseline DU_{LQ} was determined to be 0.55, WaterSense might place a threshold at 30 percent above that at a $DU_{LQ\ of}$ 0.72.

IV. Performance Measures for Pressure-Regulating Bodies

Pressure-regulating sprinkler bodies are designed to provide a relatively constant flow rate across a range of expected inlet pressures (see Figure 2). A constant flow rate at varying pressure results in a predictable and constant precipitation rate and uniform application of water by preventing disruption of the sprinkler pattern that can be caused by excessive supply pressure.

Figure 2. Idealized Effect of Sprinkler Pressure Regulation on Flow Rate



In addition, pressure-regulating bodies can reduce flow when a sprinkler is damaged and flows at an excess rate. In the case of damage, pressure regulation will reduce the flow rate, thereby reducing the total water wasted. However, the primary function of pressure regulation is to minimize excess water use associated with excessive supply pressure.

Water Savings

Although pressure-regulating sprinkler bodies can result in higher water savings depending upon supply pressure when compared to non-regulated sprinkler bodies, WaterSense has not identified any studies to date documenting nor quantifying such water savings. Furthermore, WaterSense does not currently have sufficient data on average irrigation system supply pressure, which are needed to estimate potential water savings.

When a sprinkler is damaged, water savings occurs due to the inherent reduction in pressure and flow rate provided by the product. However, this benefit is in addition to the water savings achieved under normal operation. The extent of water wasted due to broken sprinklers is unknown due to a lack of data regarding the frequency of broken sprinklers and associated circumstances.

Laboratory-Measured Pressure Regulation

For products to be independently certified by a third party, WaterSense requires a repeatable and reproducible laboratory test protocol to measure performance attributes. Many manufacturers currently measure pressure regulation of individual bodies in a laboratory setting, but no standardized laboratory test protocol for pressure regulation existed until recently. Two pressure regulation test protocols have recently been developed and are both in draft form. The draft ASABE/ICC 802-2014 *Landscape Irrigation Sprinkler and Emitter Standard*[12] includes testing of both pressure regulation and flow rate. The pressure regulation test (Section 304.5.2) provides a procedure to measure outlet pressure in response to a defined range of inlet pressures with a standardized orifice at 1.5 gpm. IA's SWAT program has published a draft protocol for pressure-regulating spray heads.[13] This test is specific to only spray head sprinklers (i.e., sprinklers with a non-rotating stem or turret). The test measures pressure downstream of the pressure regulator but upstream of the nozzle across a range of inlet pressures at a "low" flow rate (i.e., 12-foot, half-circle spray nozzle) and a "high" flow rate (i.e., 15-foot, full-circle spray nozzle).

For a number of reasons WaterSense is currently considering the use of the ASABE/ICC pressure regulator test method. First, the method has been developed through a standards-setting process following well-established ANSI procedures. Second, the proposed standard includes all the test methods WaterSense is considering for inclusion in the specification.

Performance Threshold

In order to set a performance threshold for a tested product, an allowable range in sprinkler outlet pressure across a range of inlet flow rates (i.e., allowable performance variation) is required. WaterSense anticipates setting a performance threshold for pressure-regulating bodies by developing an acceptable outlet pressure variance across a range of inlet pressures.

V. Outstanding Questions

WaterSense welcomes feedback on all aspects presented in this NOI but is seeking specific input on the following outstanding questions:

[12] ASABE/ICC. *ibid.*, Page 4
[13] IA. May 2012. *Pressure-Regulating Spray Head Sprinklers: Equipment Functionality Test*. Testing Protocol Version 3.0. www.irrigation.org/SWAT/Draft_Protocols/Pressure_Regulating_Spray_Heads.aspx.

1. Is the proposal of labeling nozzles and bodies separately appropriate for this product category?

2. Regarding the performance measure for high efficiency nozzles, is the top-tier approach or increase-from-baseline approach more appropriate for identifying the performance threshold for DU?

3. Regarding pressure regulation, is a sprinkler's ability to maintain a constant outlet pressure over a range of inlet pressures an appropriate measure of performance for pressure-regulating spray bodies? Is it appropriate to include a performance measure that specifies the sprinkler body's ability to decrease flow when a nozzle is damaged or missing?

4. Is the required orifice flow rate of 1.5 gpm in the ASABE/ICC test method for pressure regulation adequate to characterize the performance of a family of sprinkler nozzles that covers a range of wetted radii and patterns?

VI. Next Steps and Schedule

With respect to both high-efficiency nozzles and pressure-regulating bodies, WaterSense needs to select performance test protocols and ensure they are both repeatable and reproducible. This will require that a range of products undergo the associated test at multiple laboratories (i.e., round-robin testing). The datasets produced as a result of round-robin testing will be used to set performance thresholds. Additionally, WaterSense needs to further evaluate the relationship between field DU and laboratory-tested DU. This will involve gathering and analyzing existing data that contribute to this relationship and/or conducting a well-designed field study. Additional details are included in Appendix A.

The timeline for developing a draft specification is largely dependent upon the progress made in selecting and finalizing repeatable and reproducible protocols, as well as the resolution of the outstanding questions and data needs described above and in Appendix A.

All interested parties are encouraged to submit written information and comments regarding any of the concepts or issues presented in this NOI. Additionally, WaterSense is requesting any additional data or water savings studies with respect to high-efficiency nozzles and/or pressure-regulating bodies, as requested in Section V or to support the research proposal presented in Appendix A. Please submit all comments and data to watersense-products@erg.com by July 28, 2014. WaterSense will consider this information as it prepares to engage with stakeholders to answer the outstanding questions and conduct research necessary to fill data gaps. All feedback will be taken into consideration as WaterSense prepares to develop draft a specification for high-efficiency nozzles and pressure-regulating bodies.

Appendix A: Research Proposal for Landscape Irrigation Sprinklers

I. Research Objectives

In order to move forward with the development a specification for landscape irrigation sprinklers, WaterSense has two fundamental requirements: the products must provide demonstrated water savings and, if savings are demonstrated, there must be a mechanism to measure and verify associated product characteristics. The following research objectives and approach help accomplish these goals.

Research Objectives for High-Efficiency Nozzles

- To determine if the selected protocol to test DU_{LQ} in the laboratory is repeatable and reproducible.
- Evaluate in the laboratory the range of performance for products on the market.
- Determine if there is a relationship between DU_{LQ} tested in a laboratory setting and DU measured in the field.

Research Objectives for Pressure-Regulating Bodies

- To determine if the selected protocols to test pressure regulation and a reduction in flow under a damaged or missing nozzle scenario are repeatable and reproducible.
- Once a protocol(s) for the above performance measures are determined to be repeatable and reproducible, determine the performance threshold that defines an effective pressure-regulating body.

II. Approach

WaterSense proposes the following approach to meet the research objectives:

Research Approach for High-Efficiency Nozzles

- Phase 1: WaterSense proposes this phase include both round-robin testing of the selected test protocol and, in parallel, gathering and analyzing existing data that helps determine the relationship between laboratory-tested DU_{LQ} and field DU_{LQ}.
    - Round-robin testing will include at least three laboratories testing a predetermined number of products, including both high-efficiency nozzles and traditional nozzles. Results will be compiled and analyzed to examine test protocol repeatability and reproducibility.

- Regarding the collection and analysis of existing data, WaterSense is specifically seeking data during the NOI phase that will help determine if there is a relationship between laboratory-tested DU_{LQ} and field DU_{LQ}. WaterSense will need to determine if the relationship between the two can be established based on the data received, or if Phase 2 will need to be implemented.

- Phase 2: If a relationship between laboratory-tested DU_{LQ} and field DU_{LQ} cannot be developed by existing data, then a well-designed field study will be developed to examine this relationship. The scope and design of the field study will be informed by the data analysis conducted in Phase 1.

Research Approach for Pressure-Regulating Bodies

- Conduct round-robin testing with at least three laboratories testing a predetermined number of products. Results will be compiled and analyzed to examine test protocol repeatability and reproducibility.

- Determine the variation in outlet pressure of current products across a range of inlet pressures. These data will inform the decision of an allowable variation to be included as the performance threshold in a WaterSense specification.

- Determine the ability of a sprinkler body to decrease flow under a damaged or missing nozzle scenario. These data will inform the threshold for required flow reduction when a nozzle is damaged or missing.

Appendix B: References

American Society for Agricultural and Biological Engineers and International Code Council (ASABE/ICC). 2014. Draft ASABE/ICC 802-2014 *Landscape Irrigation Sprinkler and Emitter Standard*. www.iccsafe.org/cs/standards/IS-IEDC/Pages/default.aspx.

Eugene Water & Electric Board. 2013. Reducing Peak Hour Demand With Nozzle Retrofits: Three Year Evaluation Paper presented at WaterSmart Innovations Conference. Las Vegas, NV. October 3, 2013.

Irrigation Association (IA). May 2012. *Pressure-Regulating Spray Head Sprinklers: Equipment Functionality Test*. Testing Protocol Version 3.0. www.irrigation.org/SWAT/Draft_Protocols/Pressure_Regulating_Spray_Heads.aspx.

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Kenney, Joan F., et al. 2005. “Estimated Use of Water in the United States in 2005.” *U.S. Geological Survey Circular*, 1344. U.S. Department of the Interior. Table 6, page 20.

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