This presentation premiered at WaterSmart Innovations

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Observed Long-Term Results of Multi-Stream Rotational Spray Heads and Associated Product Retrofits

Persistence of Distribution Uniformity and Other Improvements & Realized Water Savings

Kent Sovocool, Mitchell Morgan, and Michael Drinkwine

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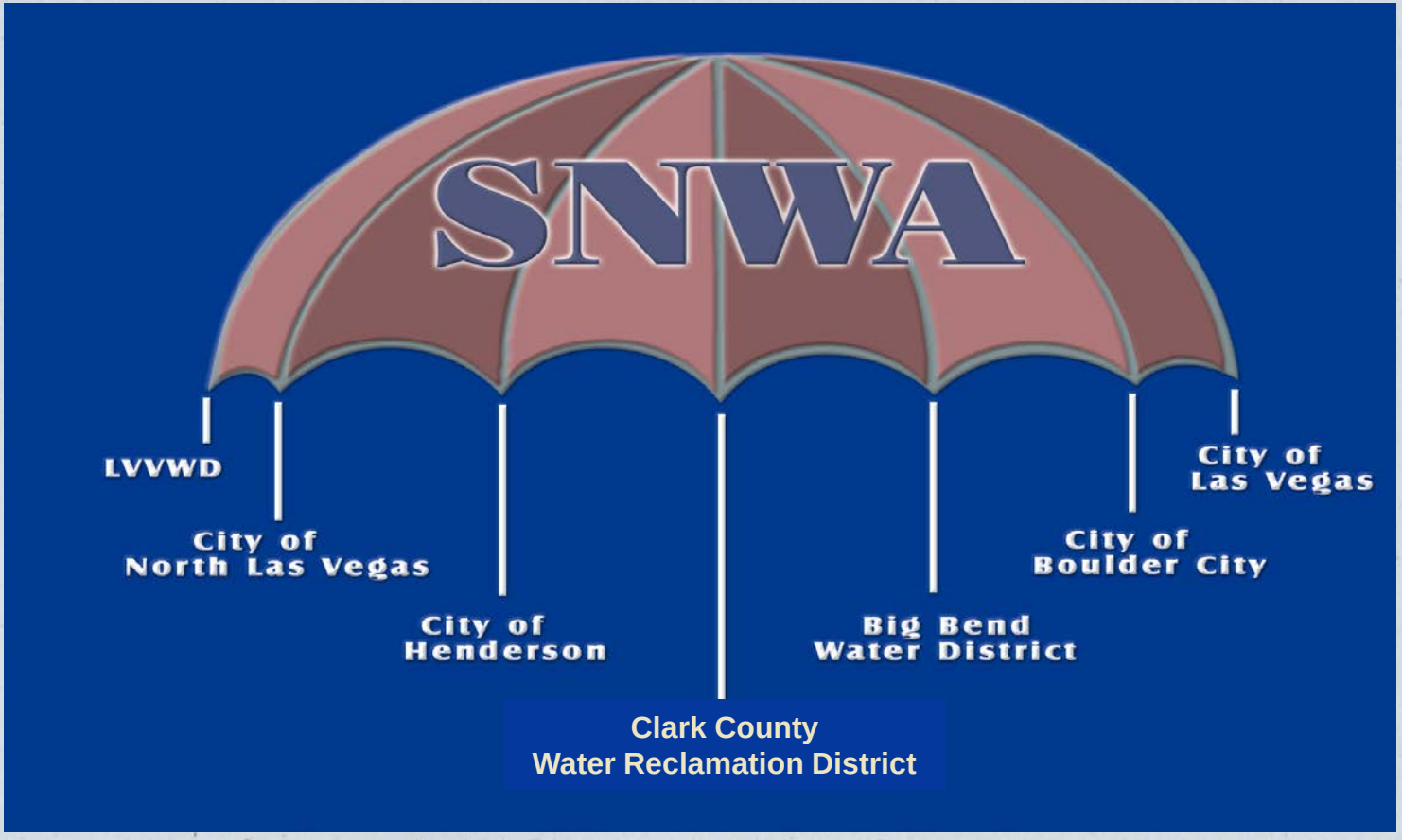
What is SNWA?



SNWA is the regional water wholesaler for the major municipal areas in Southern Nevada and is responsible for assuring adequate resources for these communities. Conservation is one of the major strategies employed to this end in addition to resource acquisition.

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Why a Field Study of MSRSHs?

- To date, there have been studies (many case studies) that support the improvements in DU, but generally small sample sizes and there is little data on what variables are important.
- Need for more systematic pre-/post retrofit testing.
- SNWA looking at rebating in future as well.
- Since more and more utilities are rebating, need **water savings** data in addition to DU improvement.
- Need to account for **behaviors too**!

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The Study

Two Phases

- **First Phase: Installations.** Demonstrated actual distribution uniformity improvements.

- **Second Phase: Monitoring.** How do customers water with the new technologies, do the DU improvements persist over time, and *how much water savings do they practically achieve?*

Rain Bird Rotary Nozzle

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Field Installations and Procedures (IA Audit Style)

- Record original settings (controller), get flow rates, stations info., etc.
- Perform Pre-installation DU – Lower Quarter Catch-can test.
- Install product.
- Perform Post-installation DU – Lower Quarter Catch-can test.
- Program a starting schedule.

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Installed Comparisons

- Hunter MP Rotators
- Hunter MP Rotators with Little Valves
- Rain Bird Rotary Nozzles
- Rain bird Rotary Nozzles with Little Valves
- Toro Precision Series
- Toro Precision Series with Little Valves
- Little Valves with Existing Components

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Phase 1 Highlights

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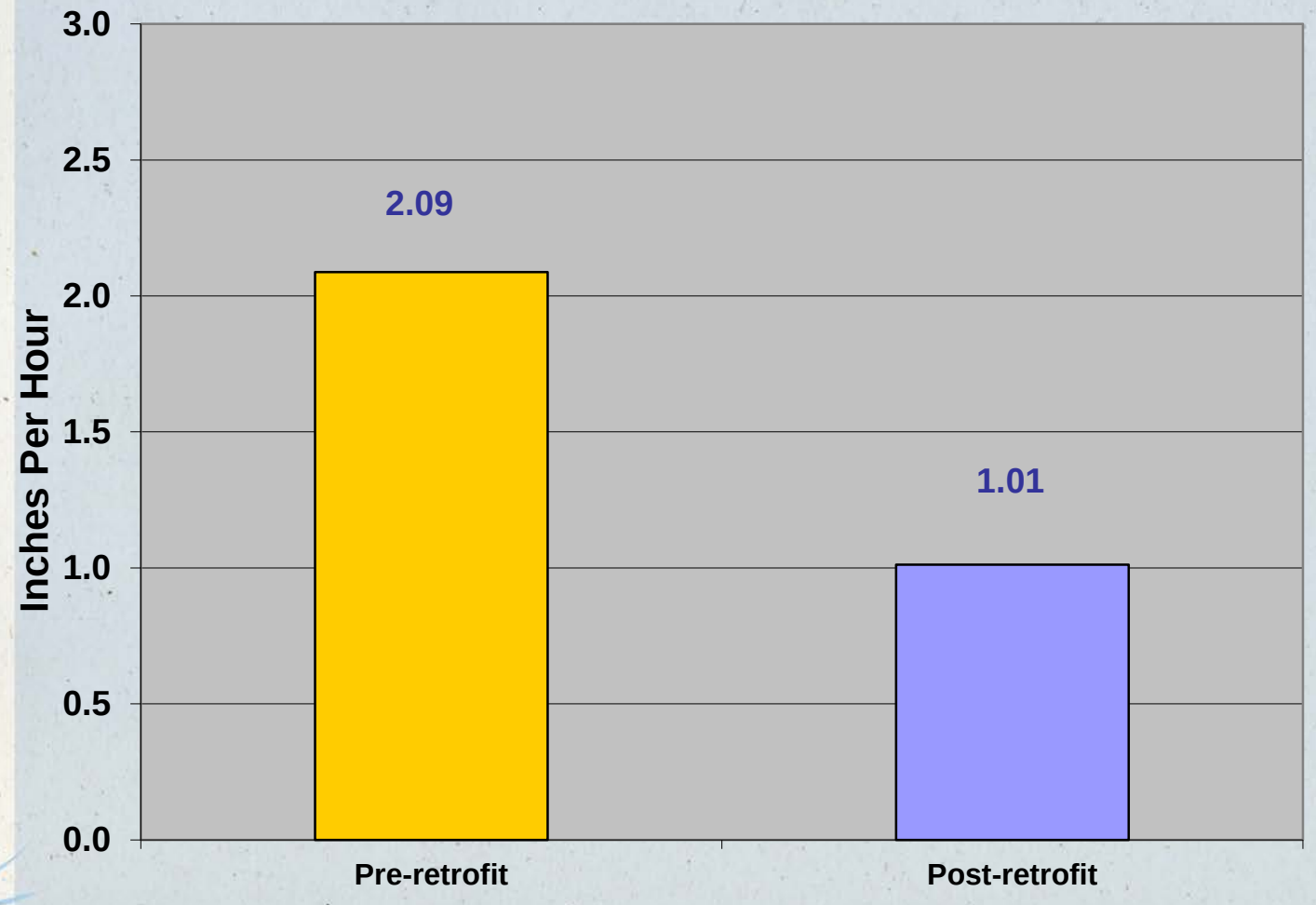
Overall Mean Precipitation Rates

***N* = 317, *p* < .000**

Highlighted *p* values lower than alpha level .05 indicate statistical significance throughout.



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Overall Mean Per Station Flow Rates

***N* (Stations) = 504, *p* < .000**

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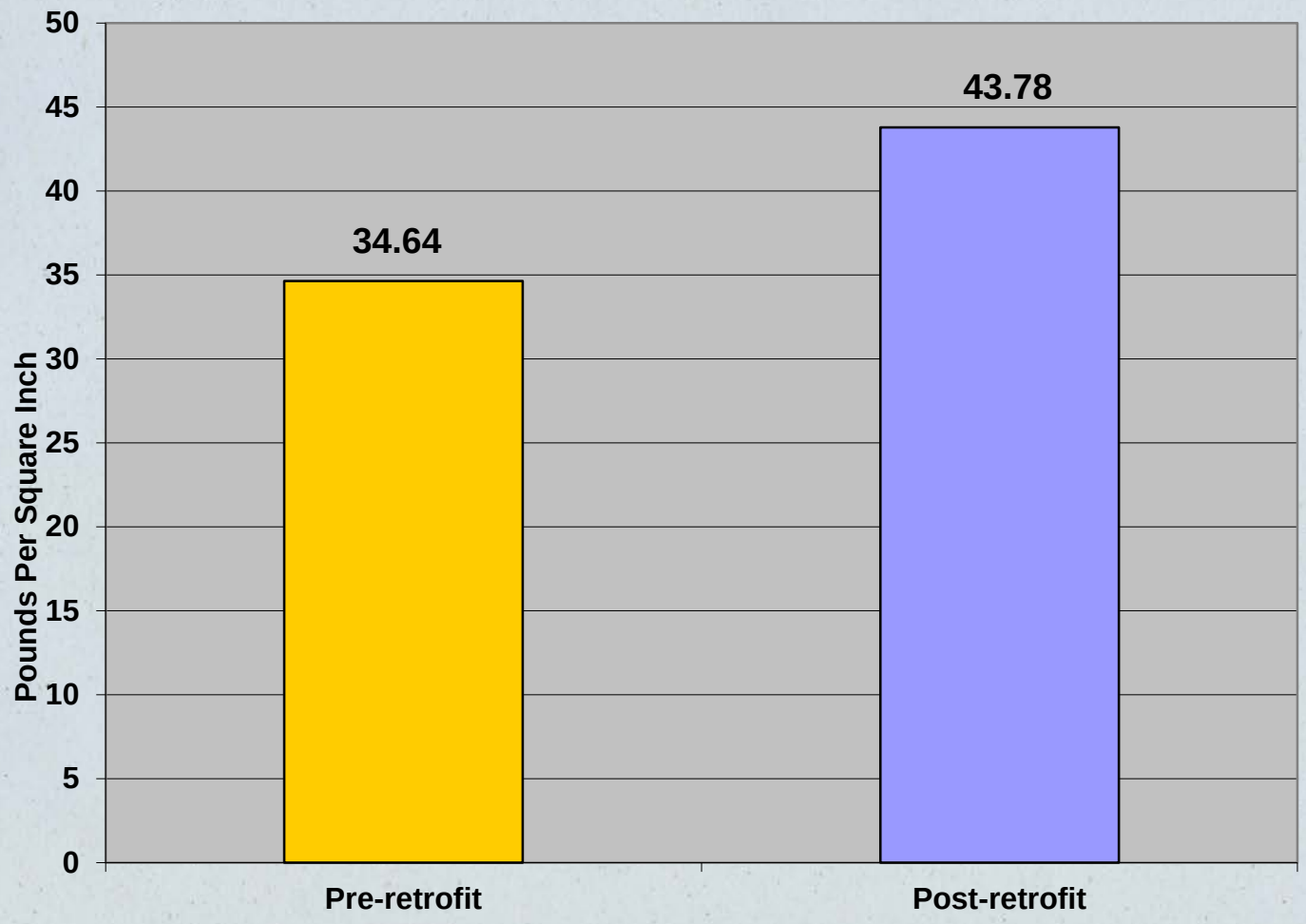
Overall Mean Operating Pressure

***N* (Stations) = 378, *p* < .000**



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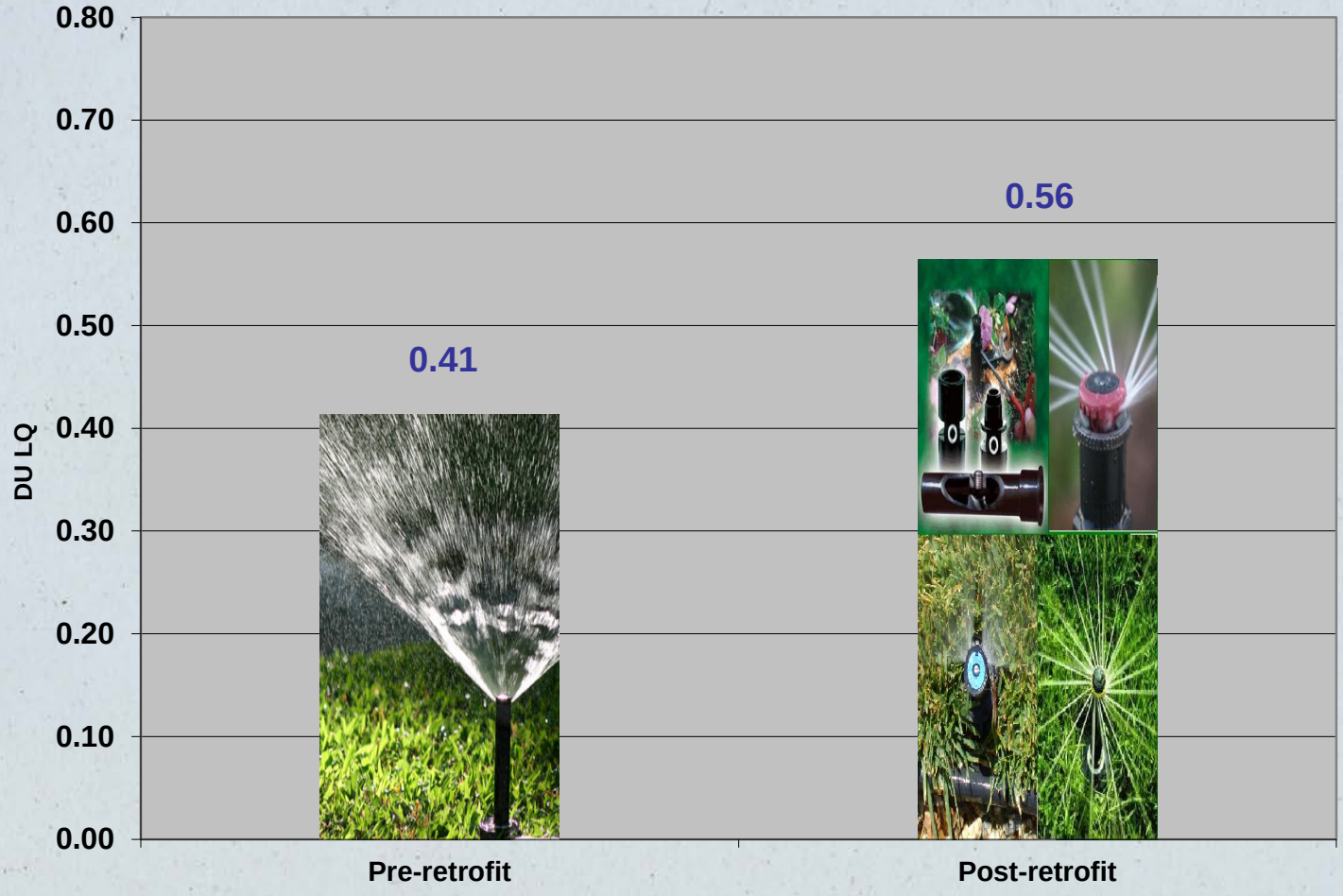
All Technologies Studied Comparison Lower Quartile Distribution Uniformity

***N* (Stations) = 378, *p* < .000**



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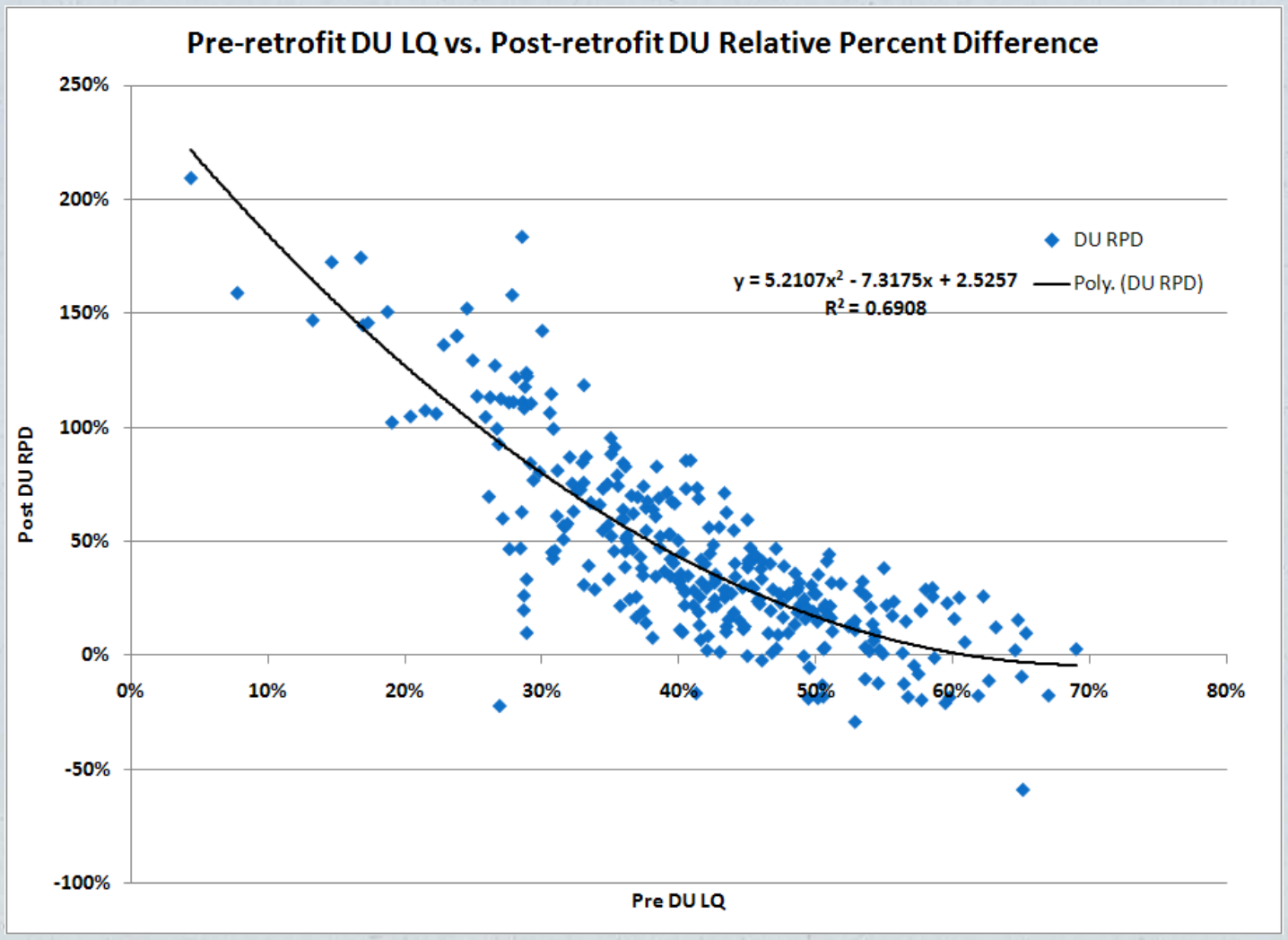
All Technologies: How might pre-retrofit DU influence how far improvements can go?



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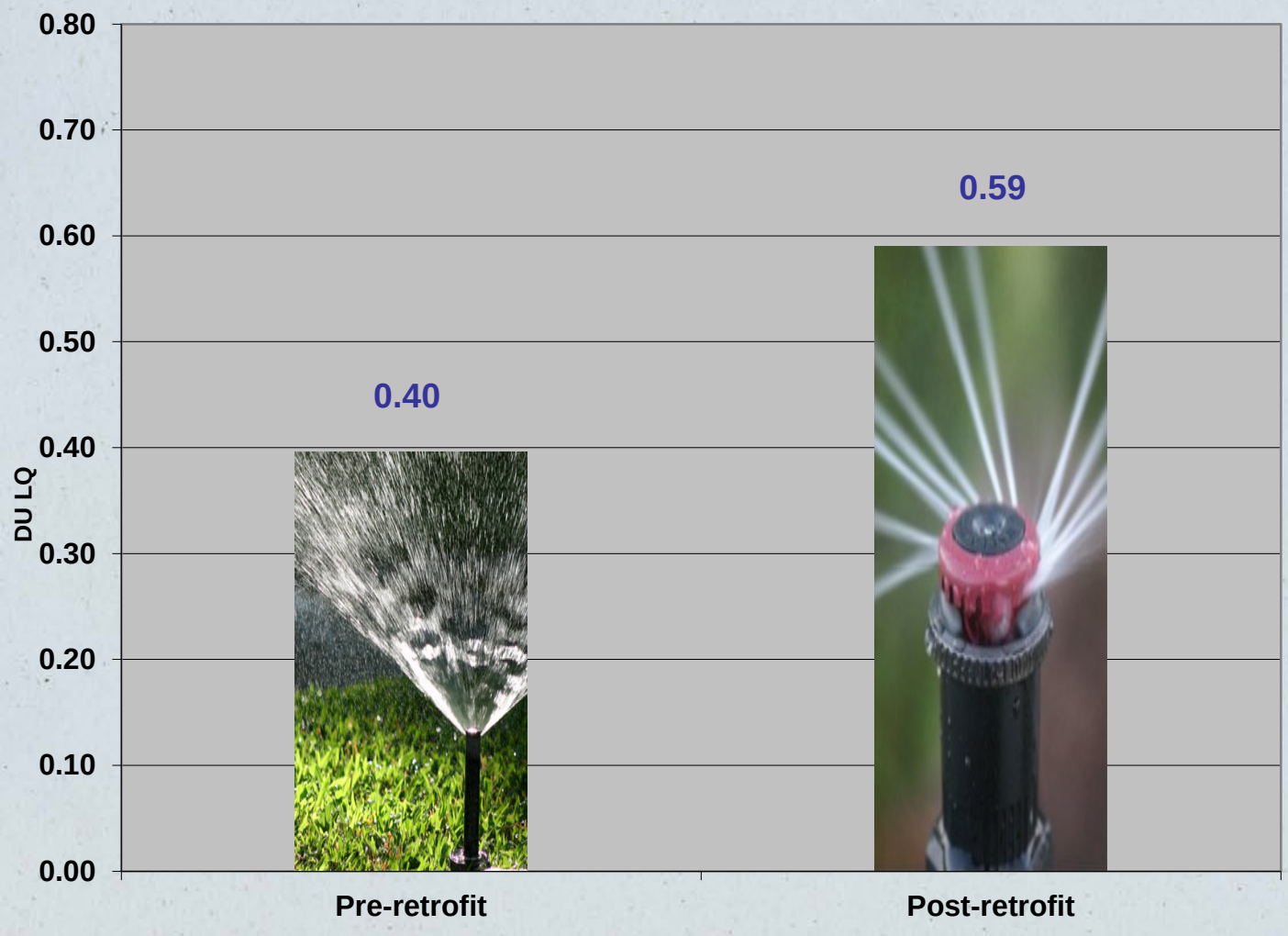
Hunter MP Rotators Lower Quartile DU

***N* = 73, *p* < .000**



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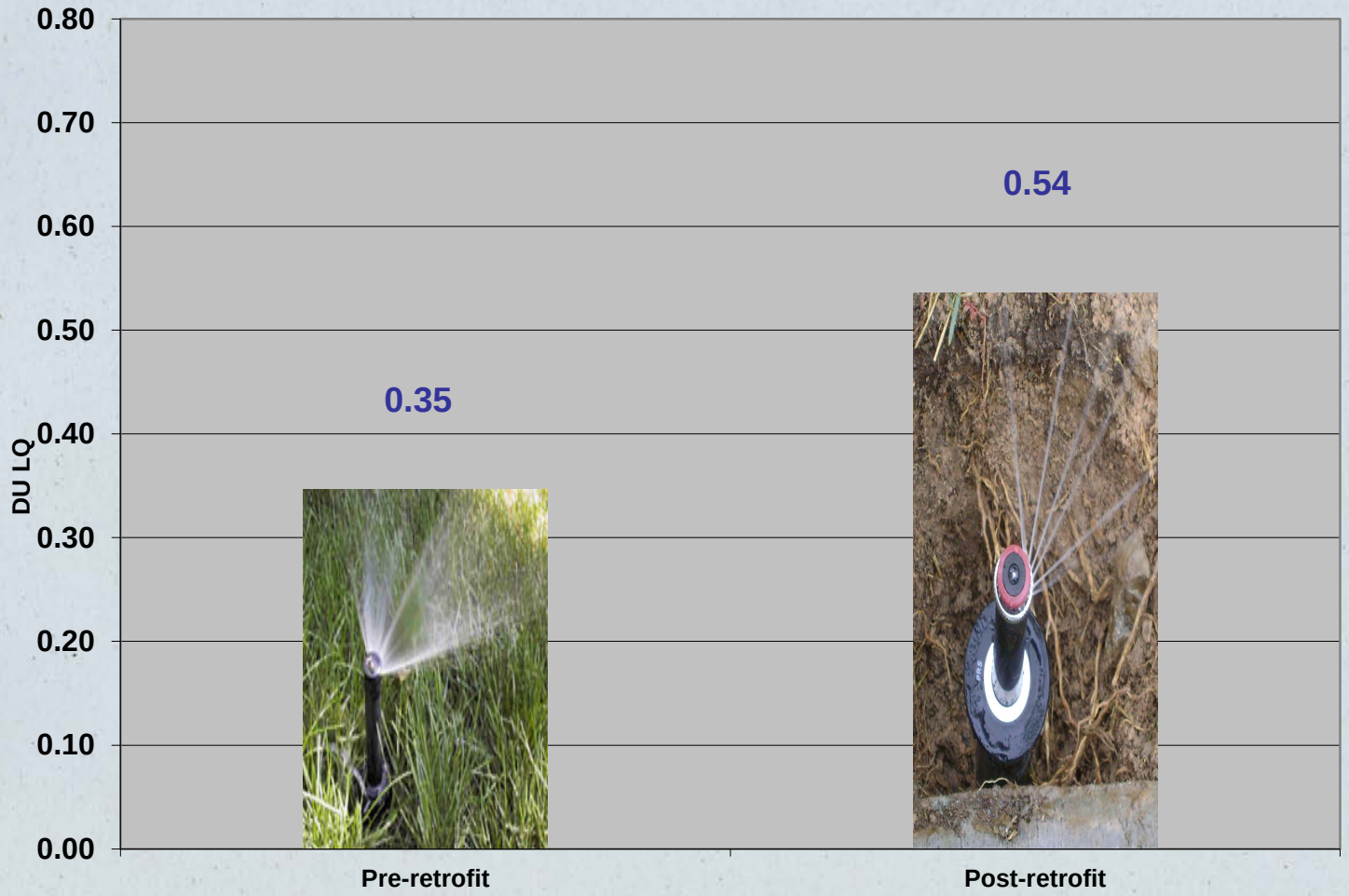
Hunter MP Rotators with Little Valves Lower Quartile DU

***N* = 34, *p* < .000**



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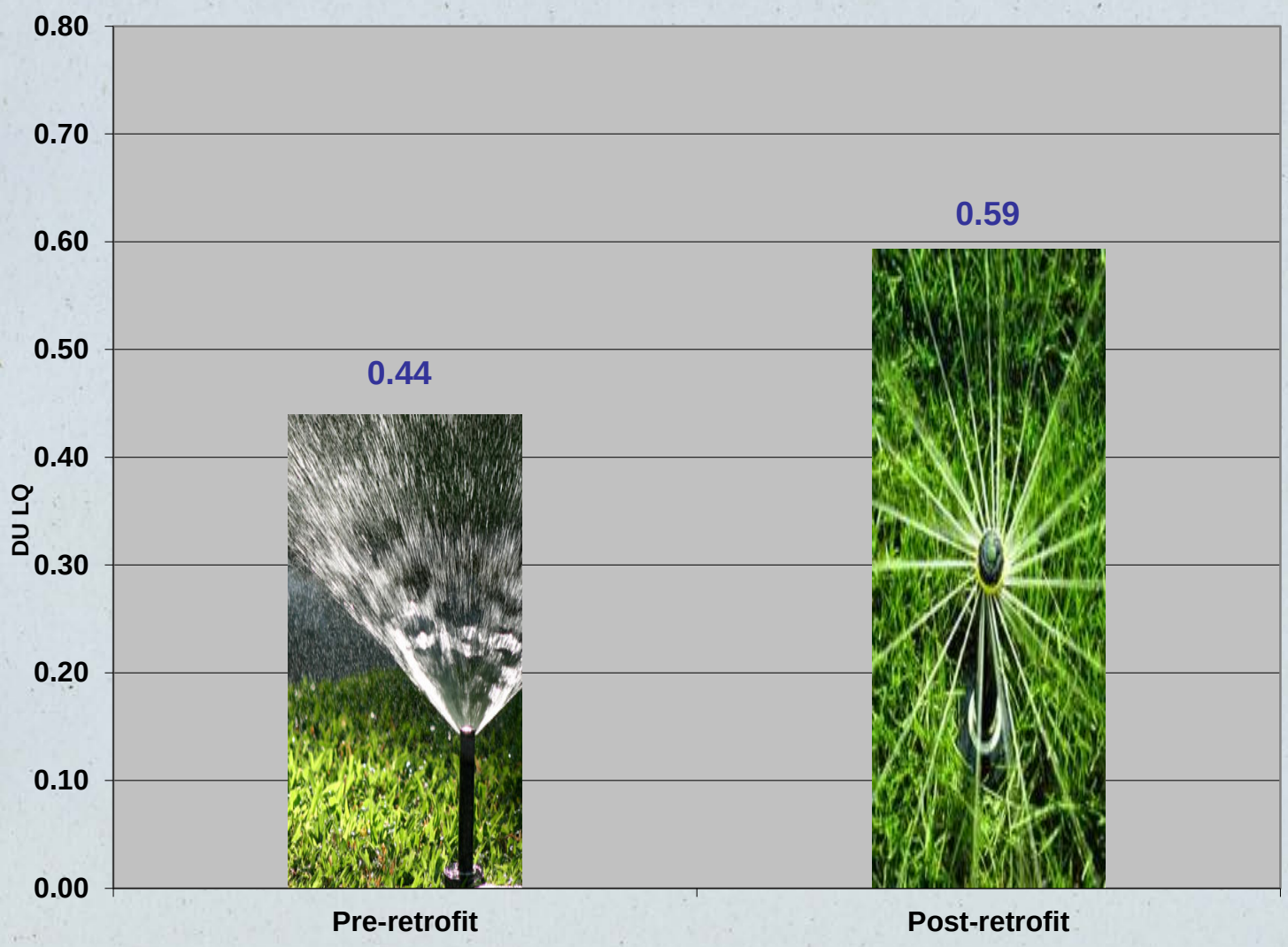
Rain Bird Rotary Nozzles Lower Quartile DU

N = 67, *p* < .000



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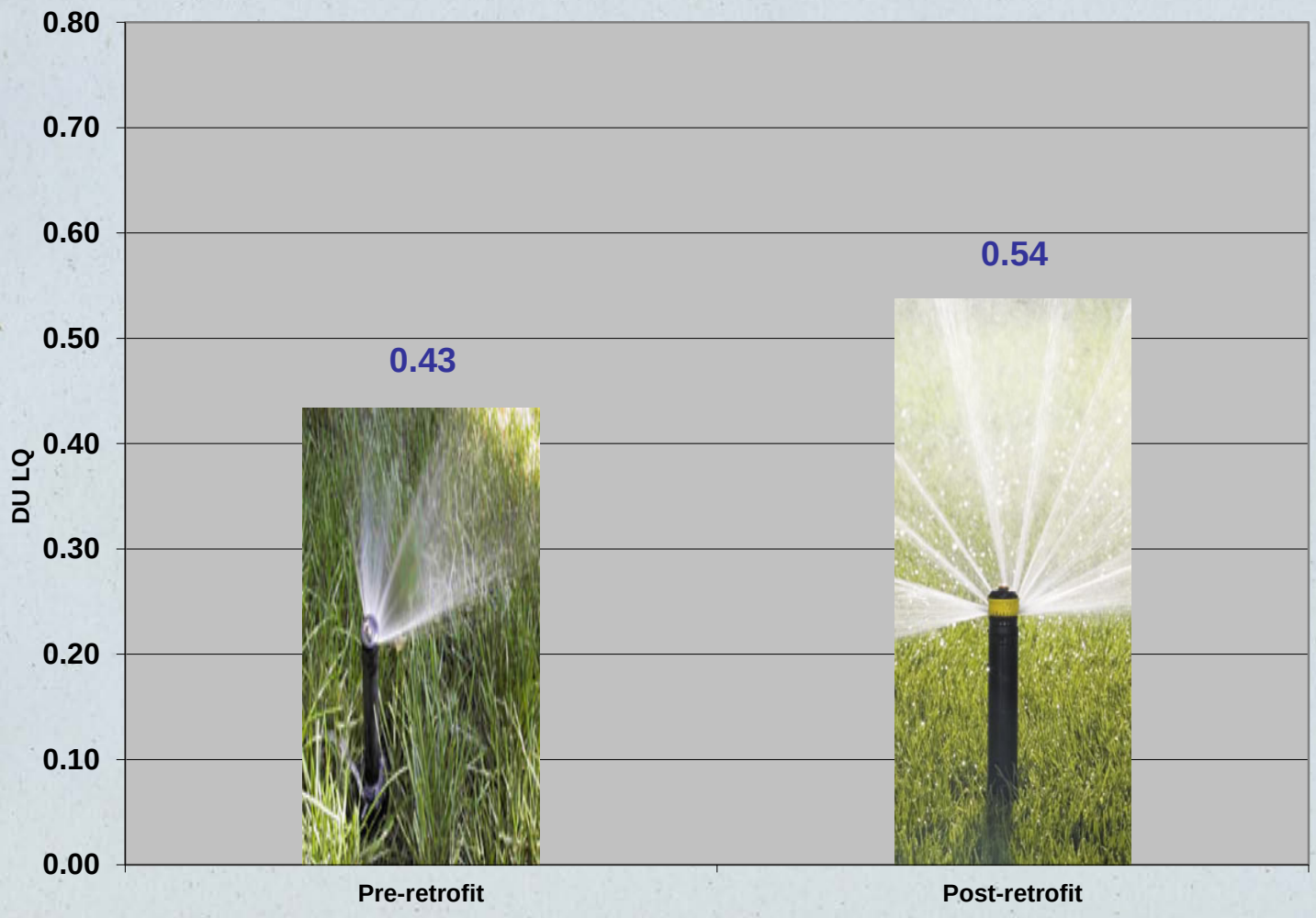
Rain Bird Rotary Nozzles with Little Valves Lower Quartile DU

***N* = 28, *p* < .000**



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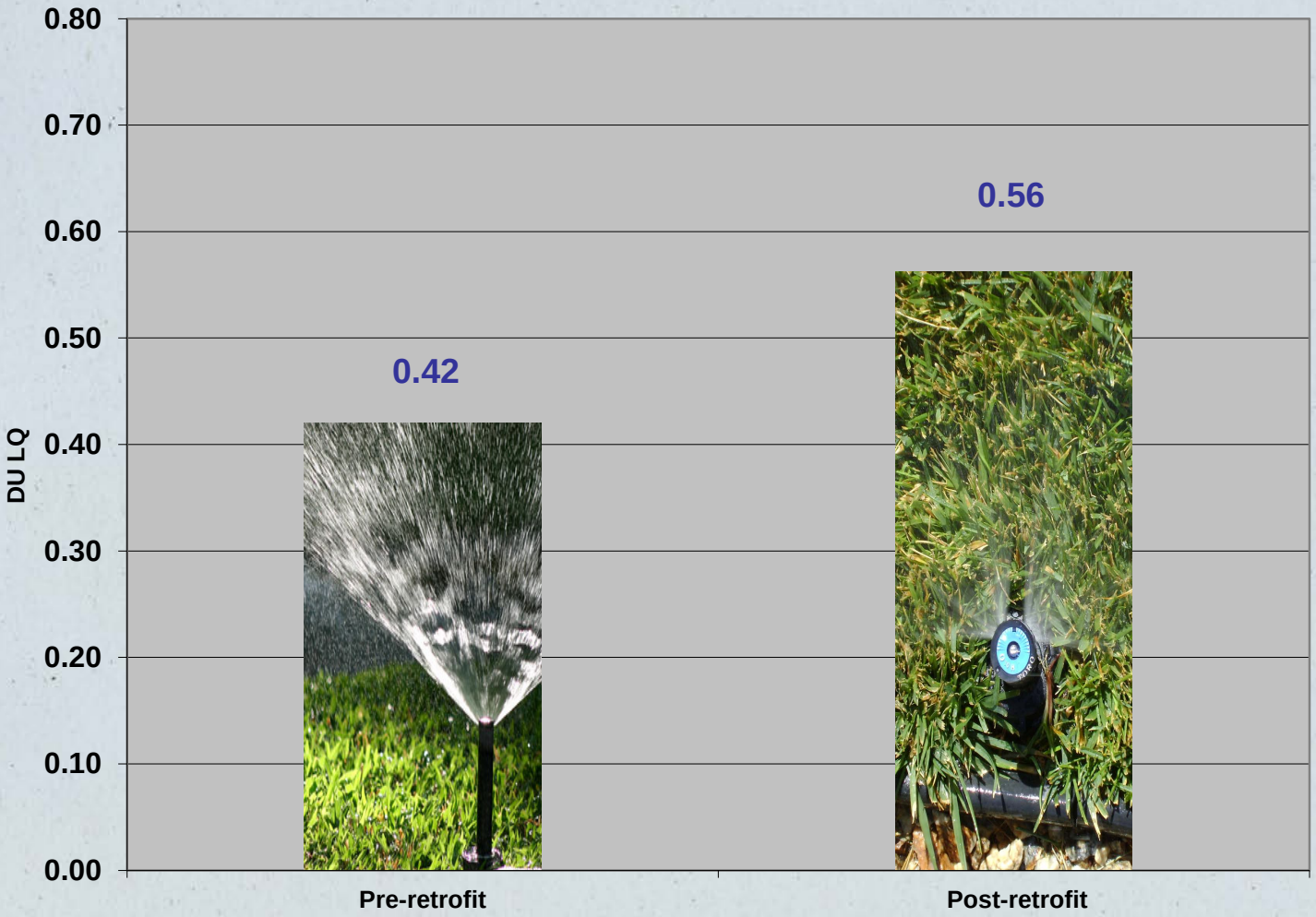
Toro Precision Series Lower Quartile DU

N **= 71,** ***p*** **< .000**



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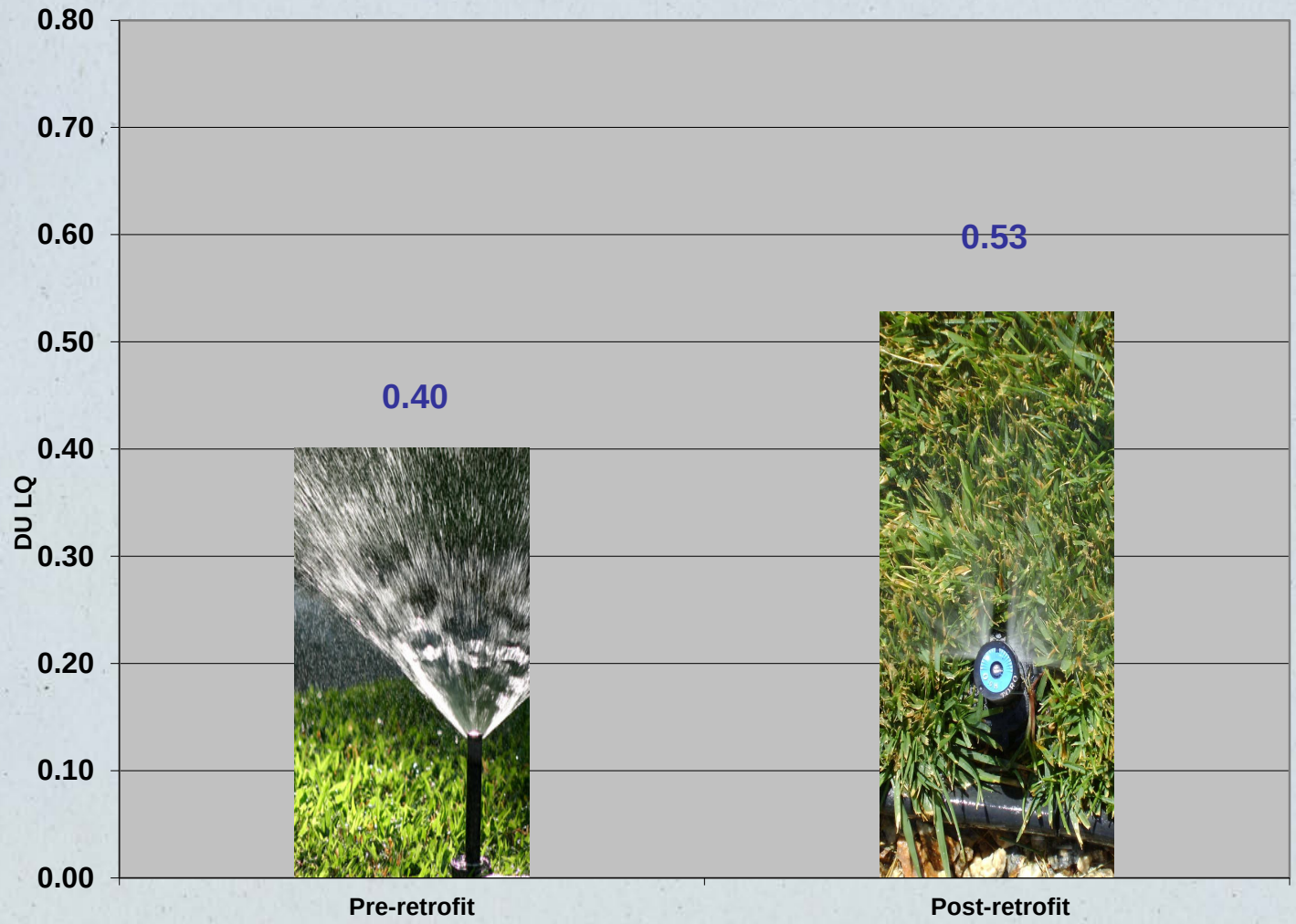
Toro Precision Series with Little Valves Lower Quartile DU

***N* = 22, *p* < .000**



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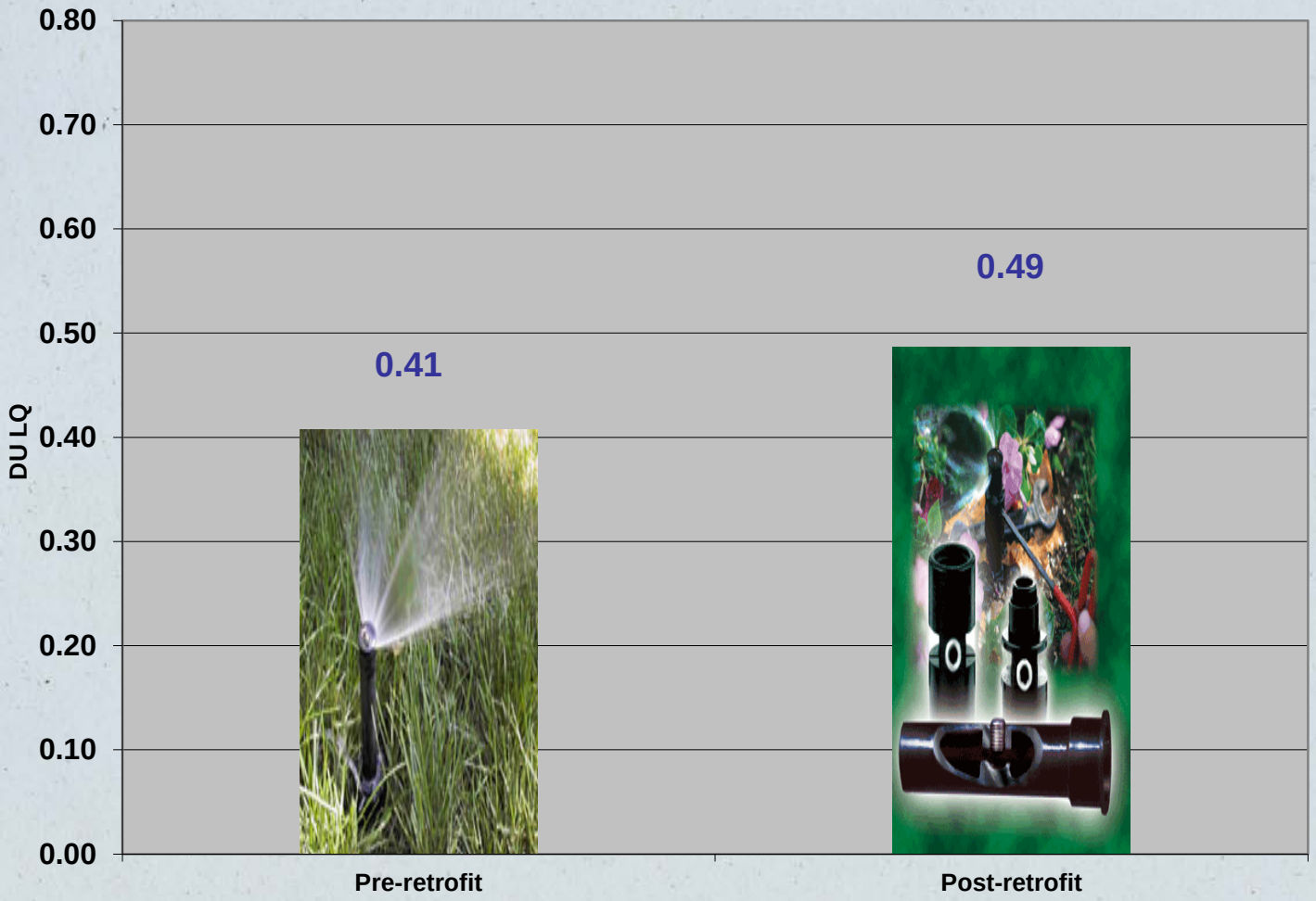
Little Valve with Existing Components Lower Quartile DU

***N* = 22, *p* < .004**



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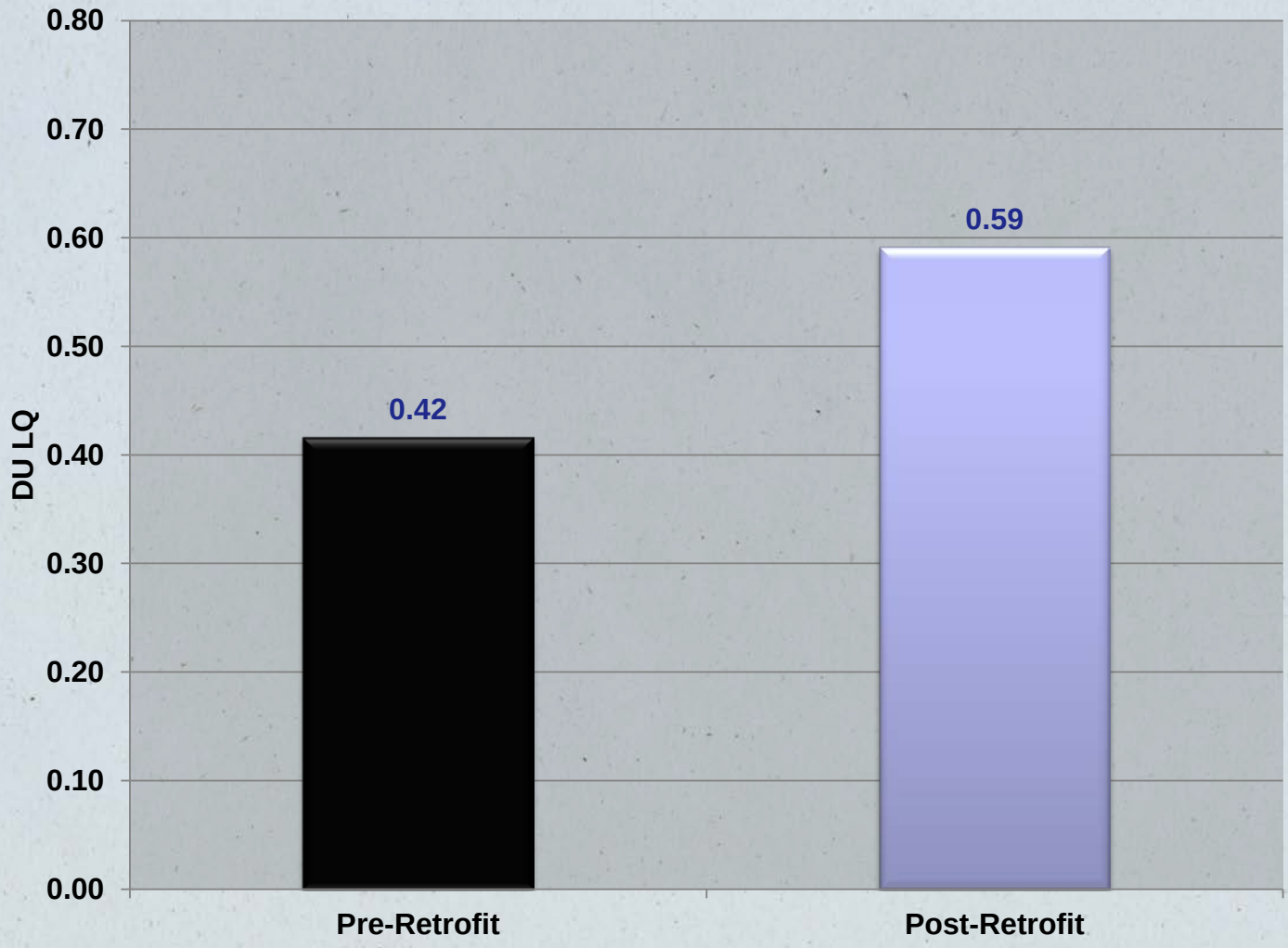
All MSRSHs (Hunter MP and Rain Bird Rotary) Lower Quartile DU

***N* = 140, *p* < .000**



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Phase 1 Findings

- All of the sprinkler head improvements technologies appear to work. The average improvement in DU was 0.17 (a relative improvement of 40%) for MSRSHs. For all technologies it was 0.14 (33% relative improvement).

- There may be a diminishing returns effect in any simple head retrofit in that the higher the pre-retrofit DU, the less relative improvement was obtained. Going beyond 0.60 DU values, at least in Southern Nevada, is difficult.

- The improvement for the Toro Precision series Spray was statistically similar to the Rain Bird and Hunter MSRSHs products.

- The Little Valve product by itself is capable of imparting DU improvement (about 0.08). The concept though of “stacking” it with another technology, does not “further” raise DU.

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Phase 1 Findings

- Though using these improved technologies certainly does not guarantee any given turf area with pop-ups will make the WaterSense® New Home requirements (design is critical), not using such technologies probably makes it much harder to make the spec requirement.

- The results here are impressive and robust. They do not however necessarily match the levels of improvement sometimes advertised (and found in some studies).

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Phase 2 Results

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Final Audits

A subset of the study sites were available to do a final round of irrigation audits to determine the perseverance of initial findings.

- 18 Properties
- 32 Audits

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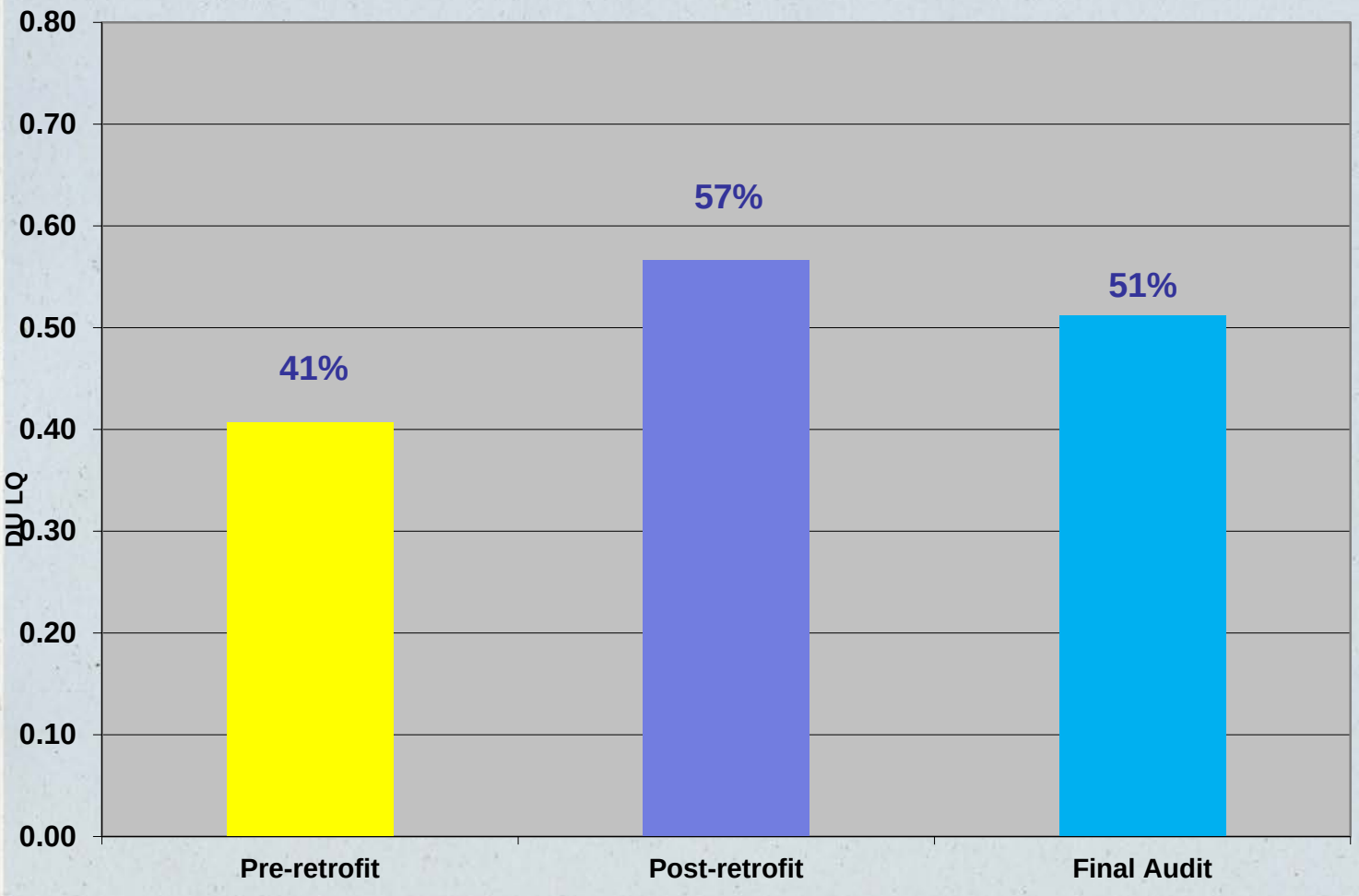
Persistence of DU Improvements

Some degradation of DU from Post to Final

N = 32, p < .000



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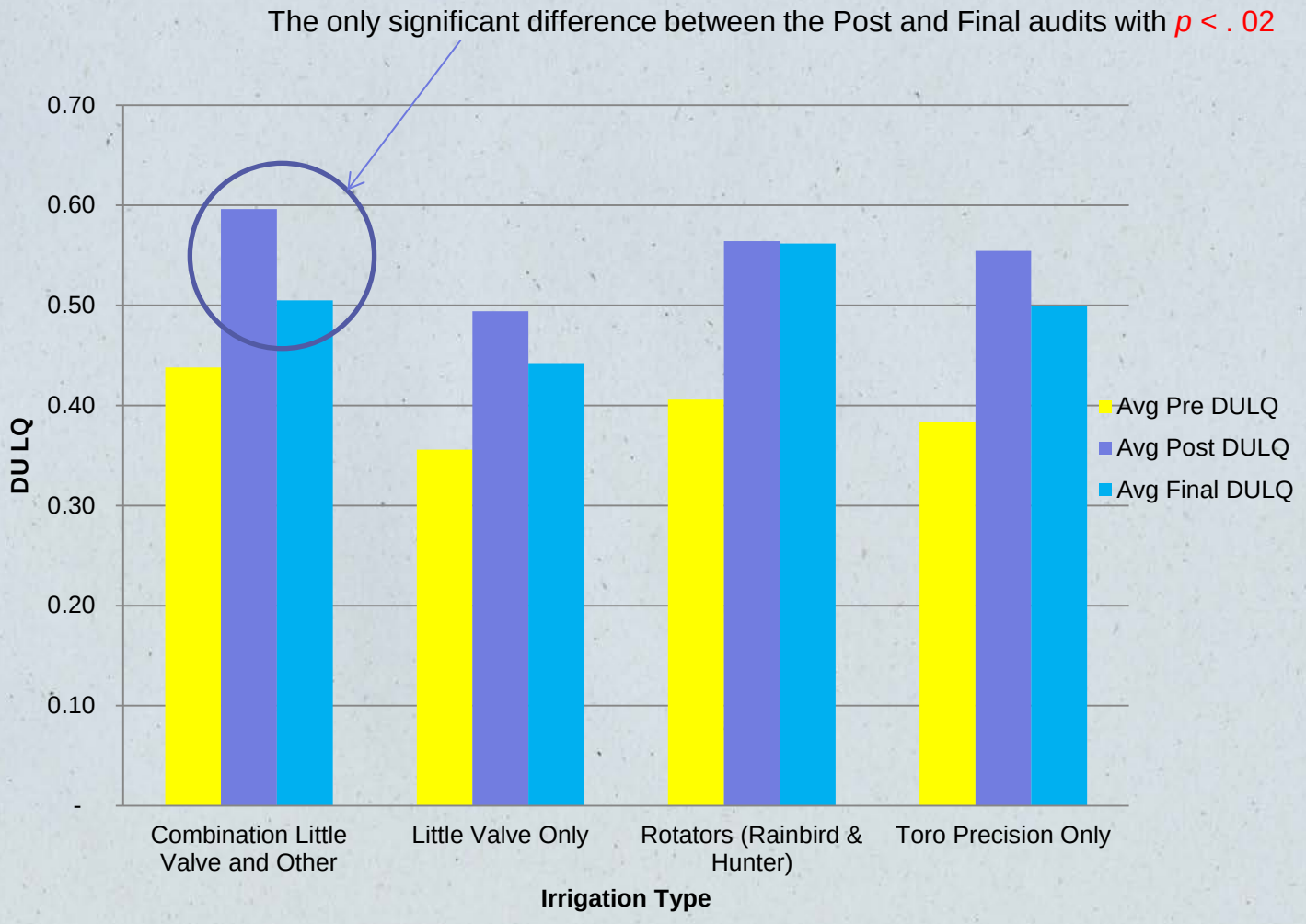
Lower Quartile DU by Irrigation Type



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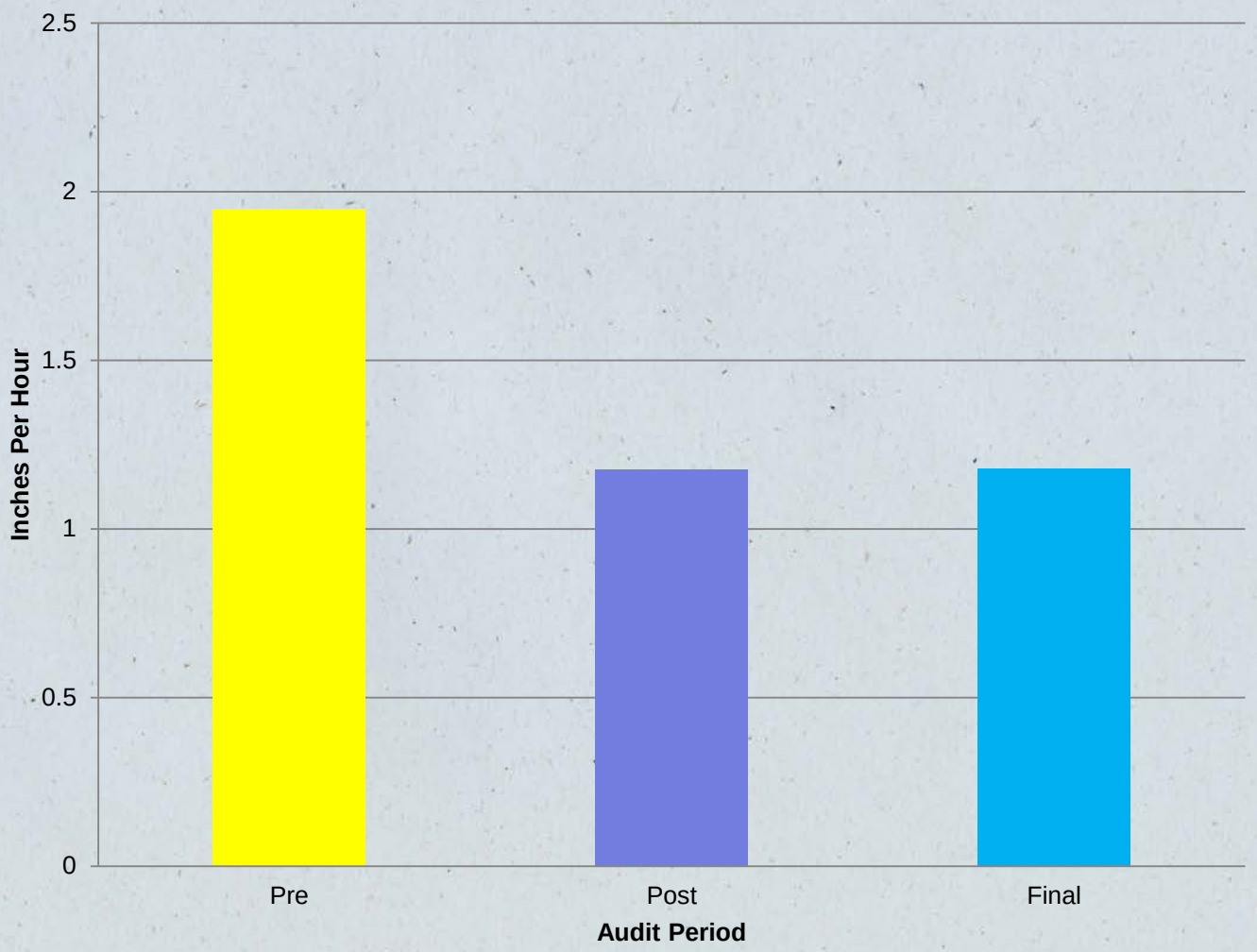
Persistence of Precipitation Rates

They remained the same with $N = 32$, $p > .98$



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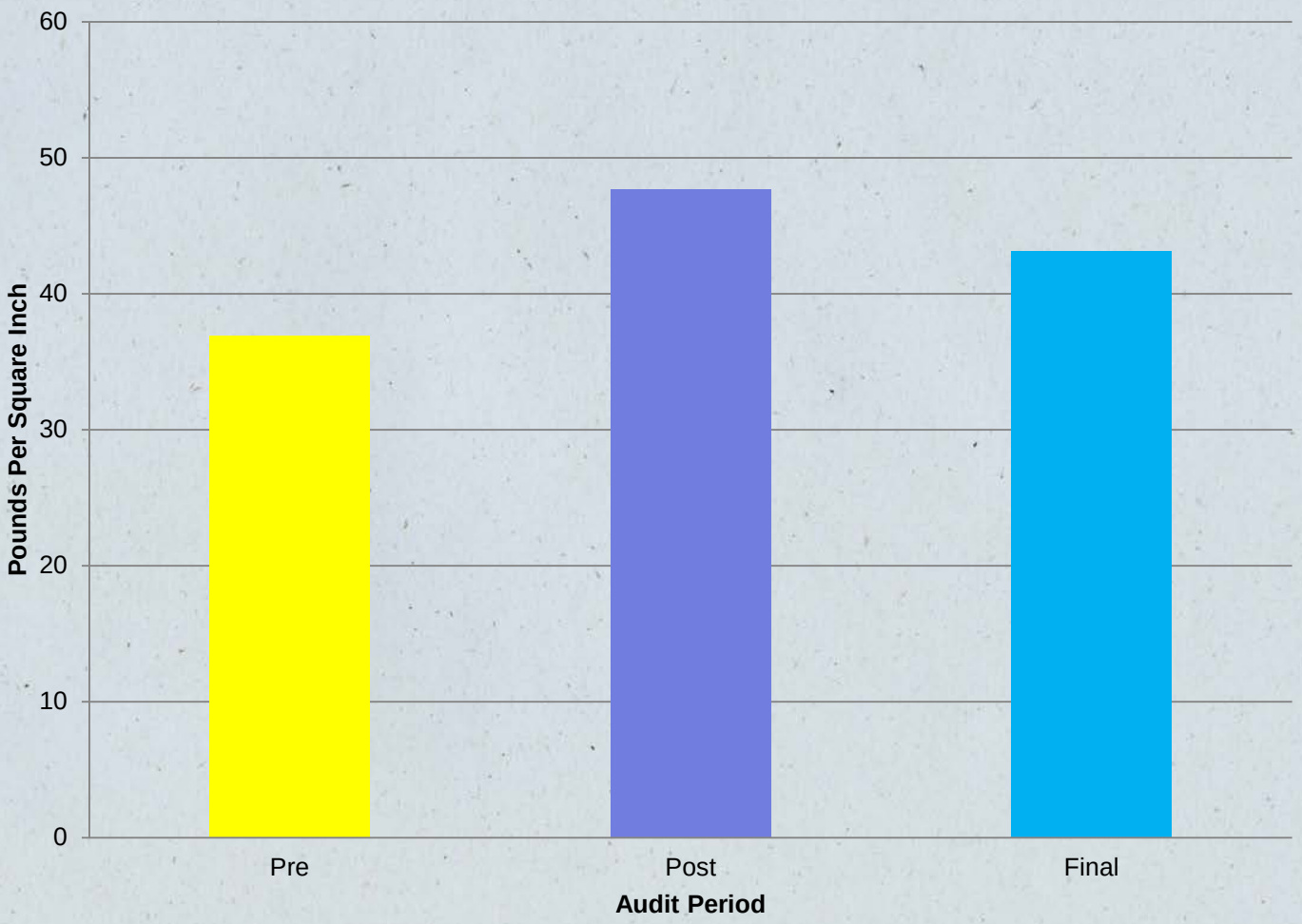
Persistence of Pressure Rates

Some pressure rate decrease with *N* = 32, *p* < .00



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Post-retrofit Installation Phase Monitoring Results

- 138 Sites have a complete pre- and post-retrofit consumption records.
- All properties were retrofitted in 2009 or 2010 so we have 2 – 3 complete years of post-installation consumption records.
- A comparison of the average pre-installation with the average post installation should reveal any savings associated with the retrofits.

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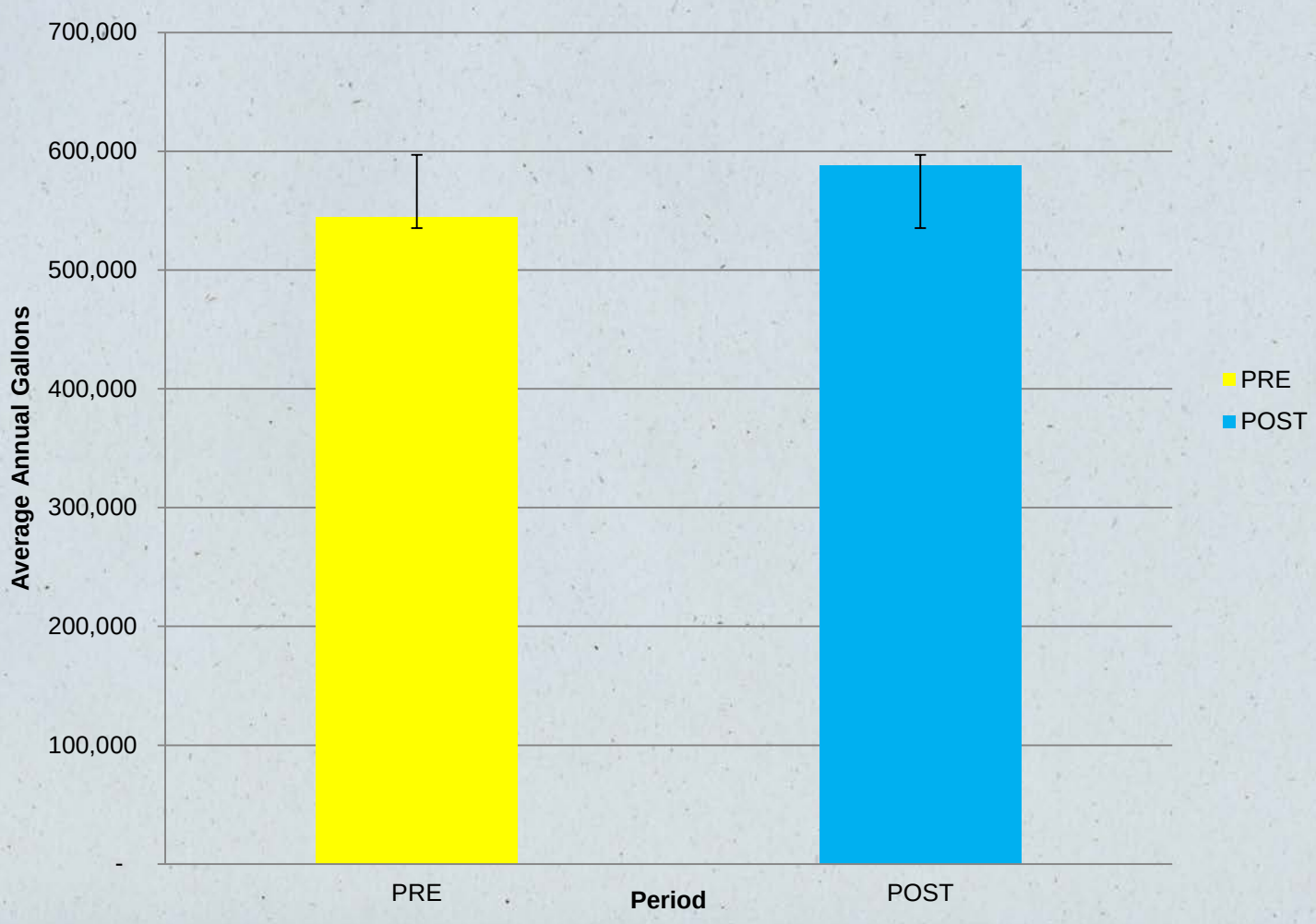
Average Annual Consumption Pre- vs. Post-retrofit

T-test of Dependent Samples *N* = 138, *p* < .002

Note: all error bars indicate standard deviation.



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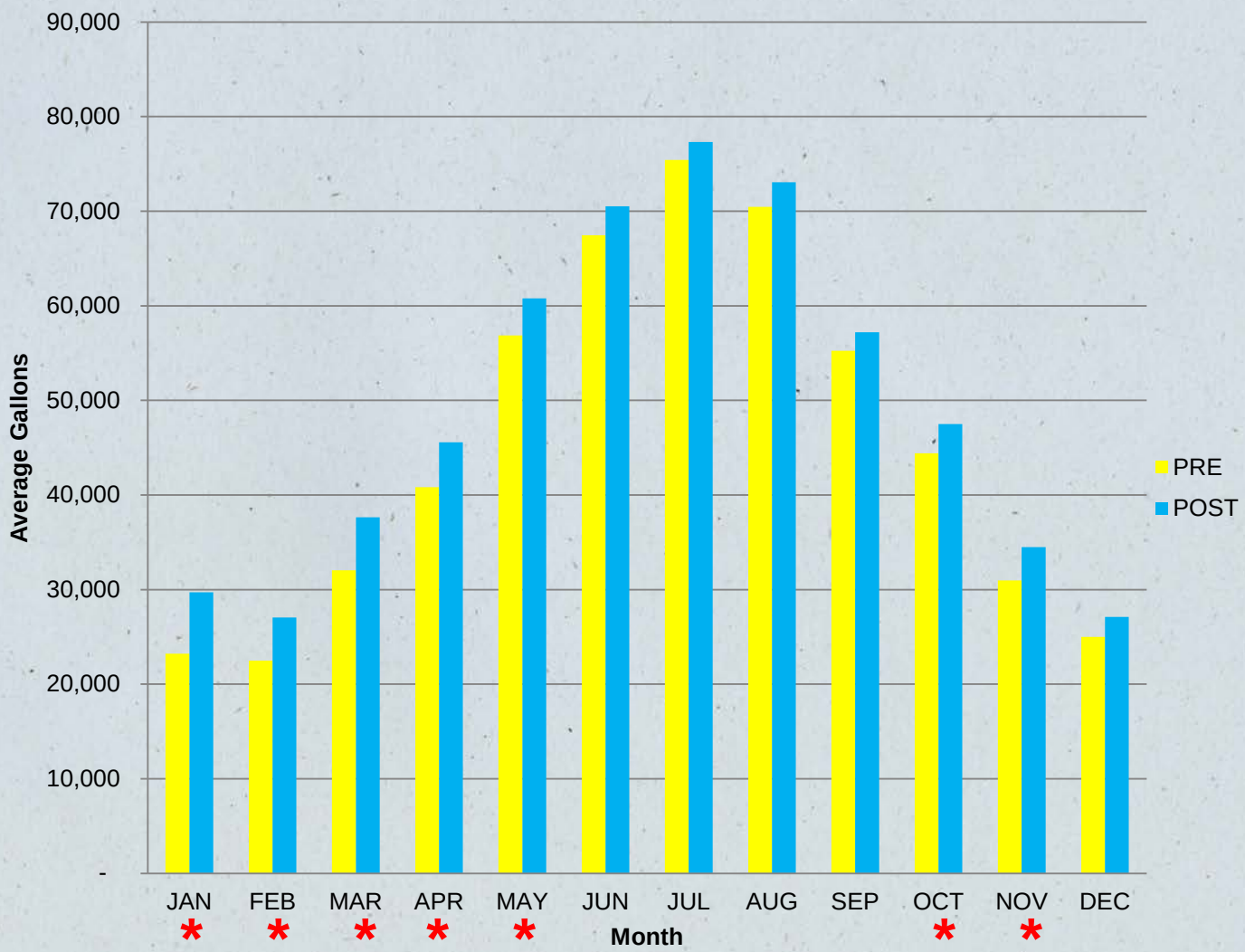
Pre- vs. Post-retrofit by Month

T-test for Dependent Samples, *N* = 138

*** indicates statistically significant months**



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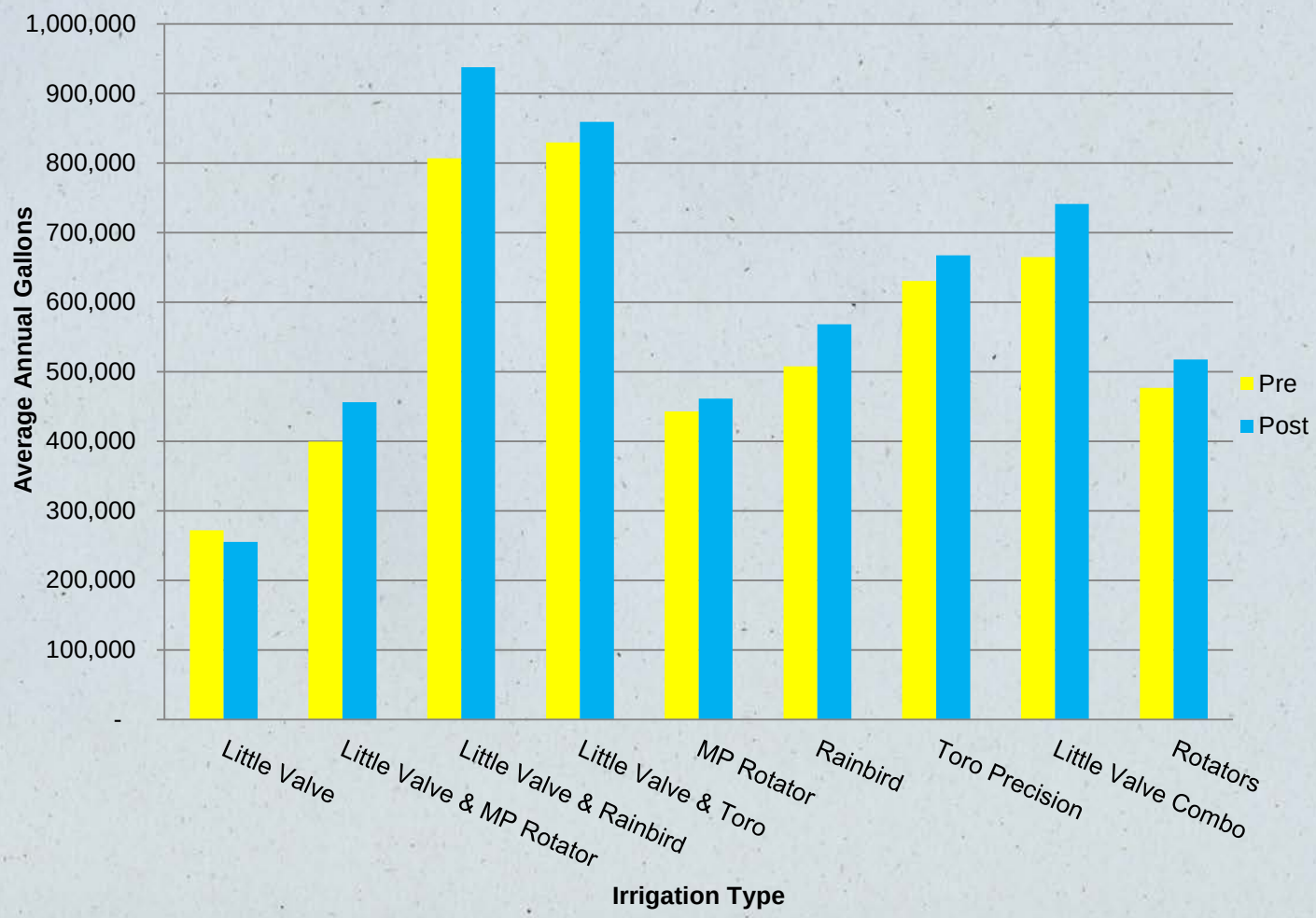
Average Annual Consumption Pre vs. Post-retrofit by Irrigation Type

With all *p* > .05 results are not statistically significant for any type



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Comparison Group

A comparison group of non-retrofitted properties was examined to compare against subset study sites consumption.

To get a good match we made careful selections with the following criteria:

- Overall pre-install date water use (within +-1 %)
- Closest overall match month-to-month
- Closest match to parcel size
- 74 study sites and matching comparison sites made it through the selection process

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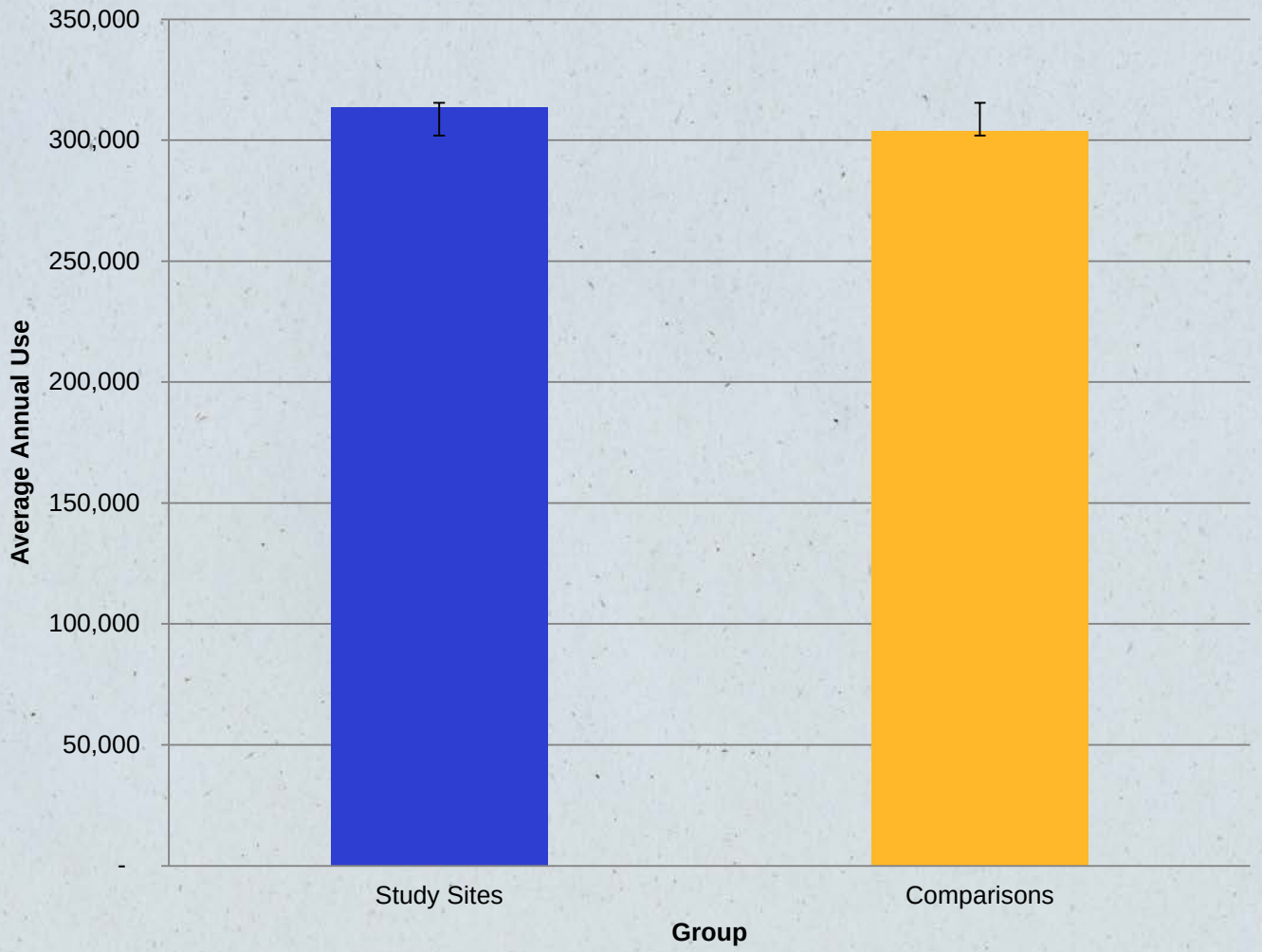
Pre-retrofit Average Total Use Comparison

3 – 4 years, with *N* = 74, *p*>.72



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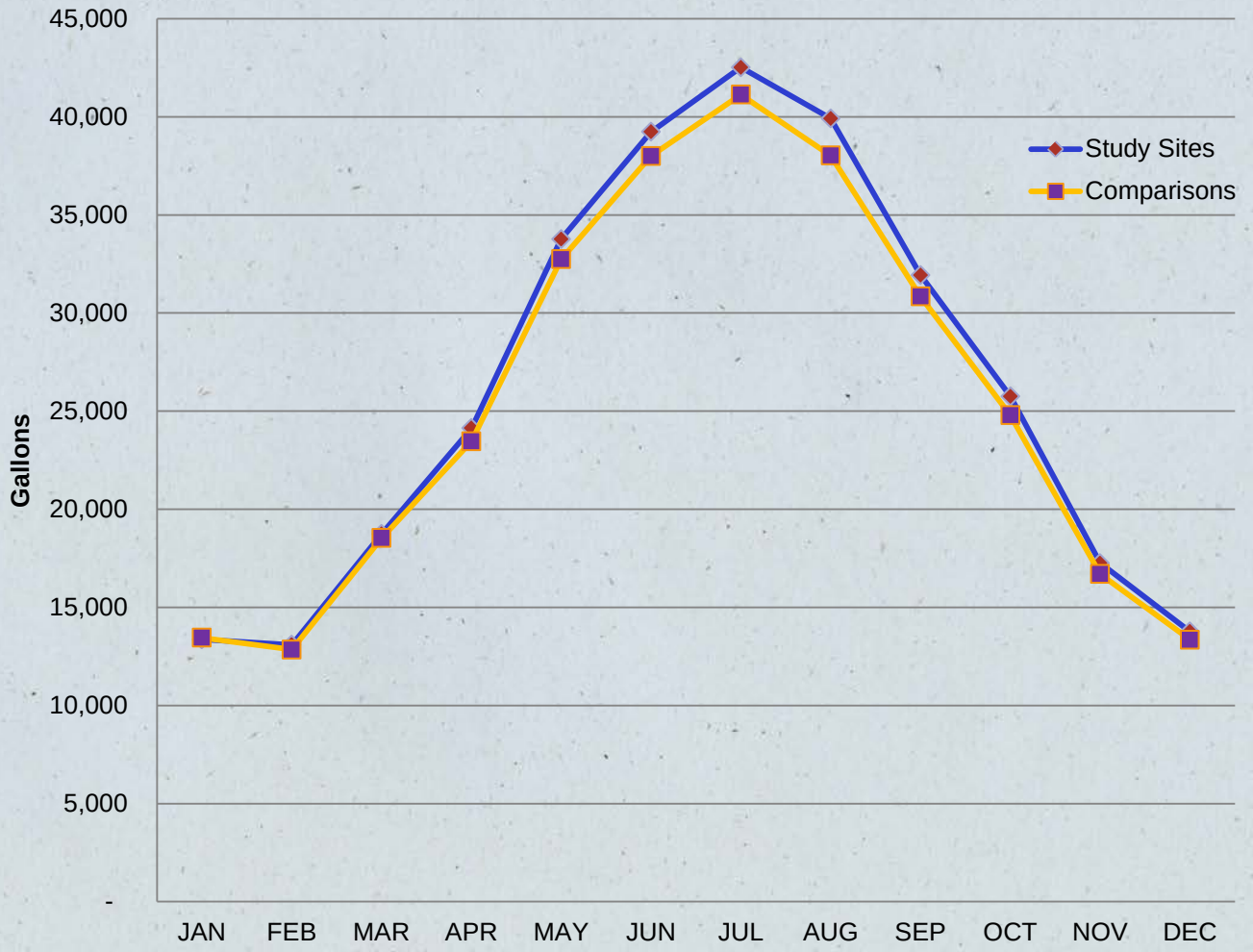
Study Site vs. Comparison Group Pre-retrofit Period by Month

p-values ranged between .61 and .93



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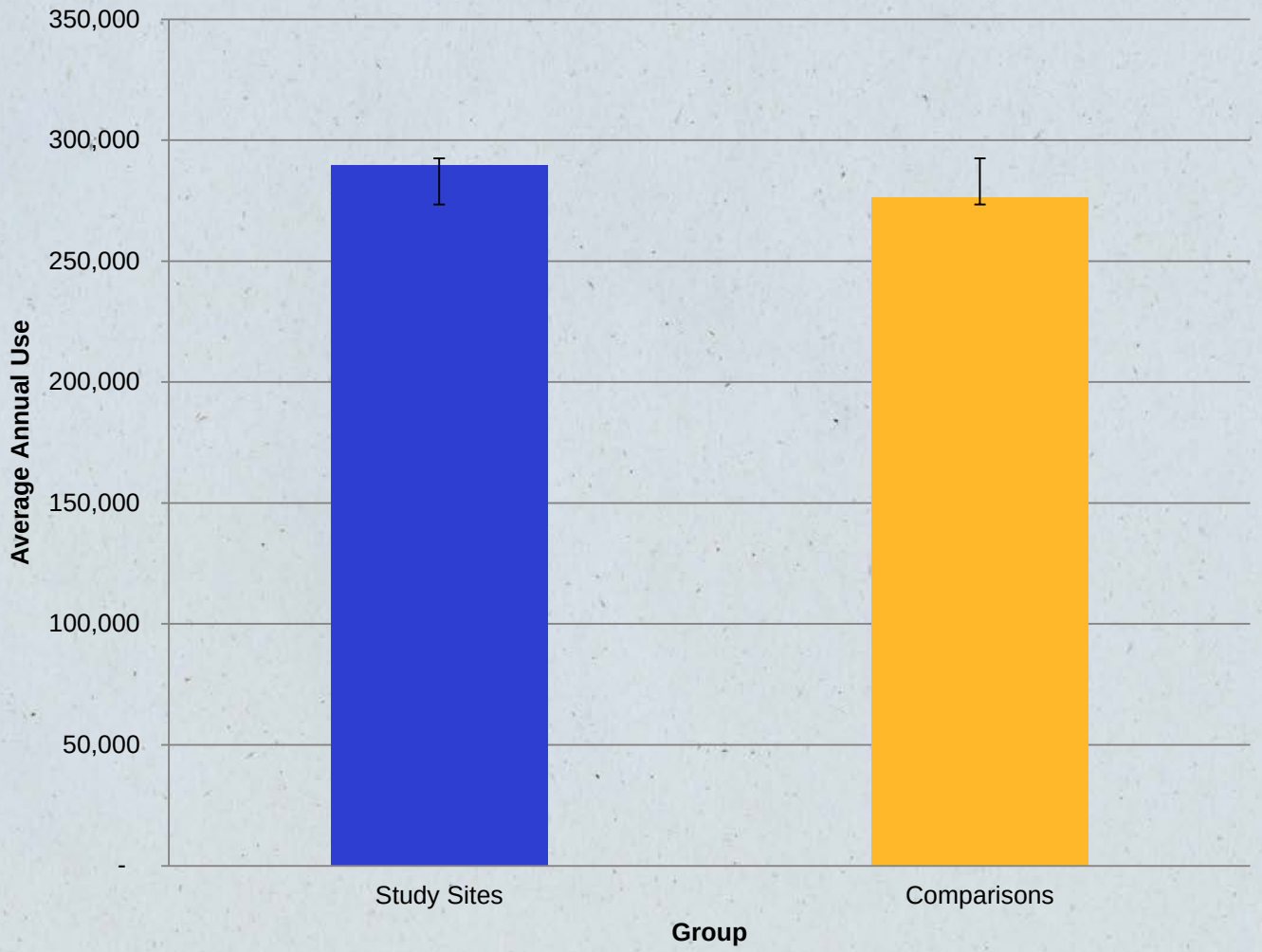
Post-retrofit Average Total Use Comparison

T-test of Independent Samples, N = 74, *p* > .58



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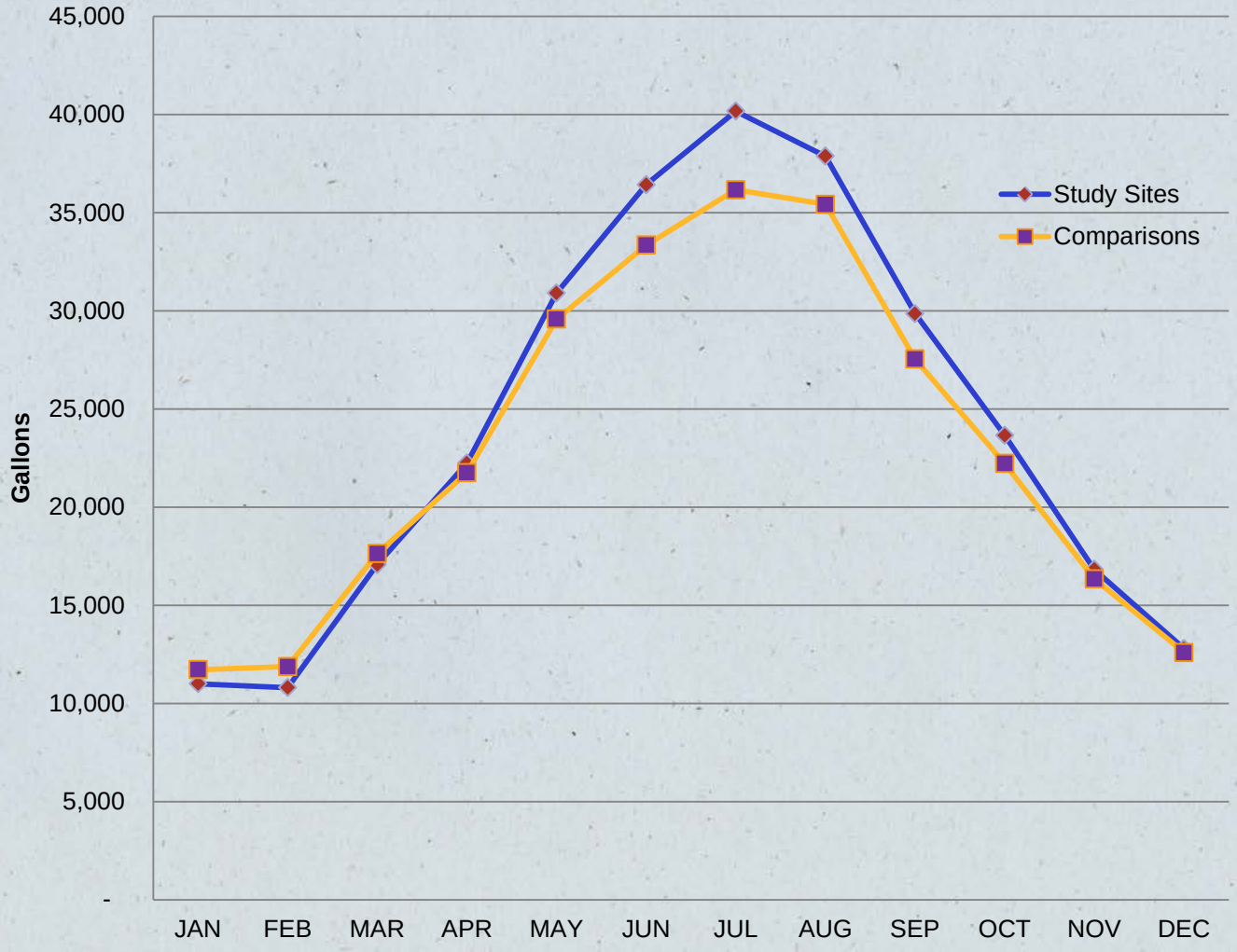
Study Site vs. Comparison Group Post-retrofit Period by Month

N = 74, *p*-values between .27 and .83)



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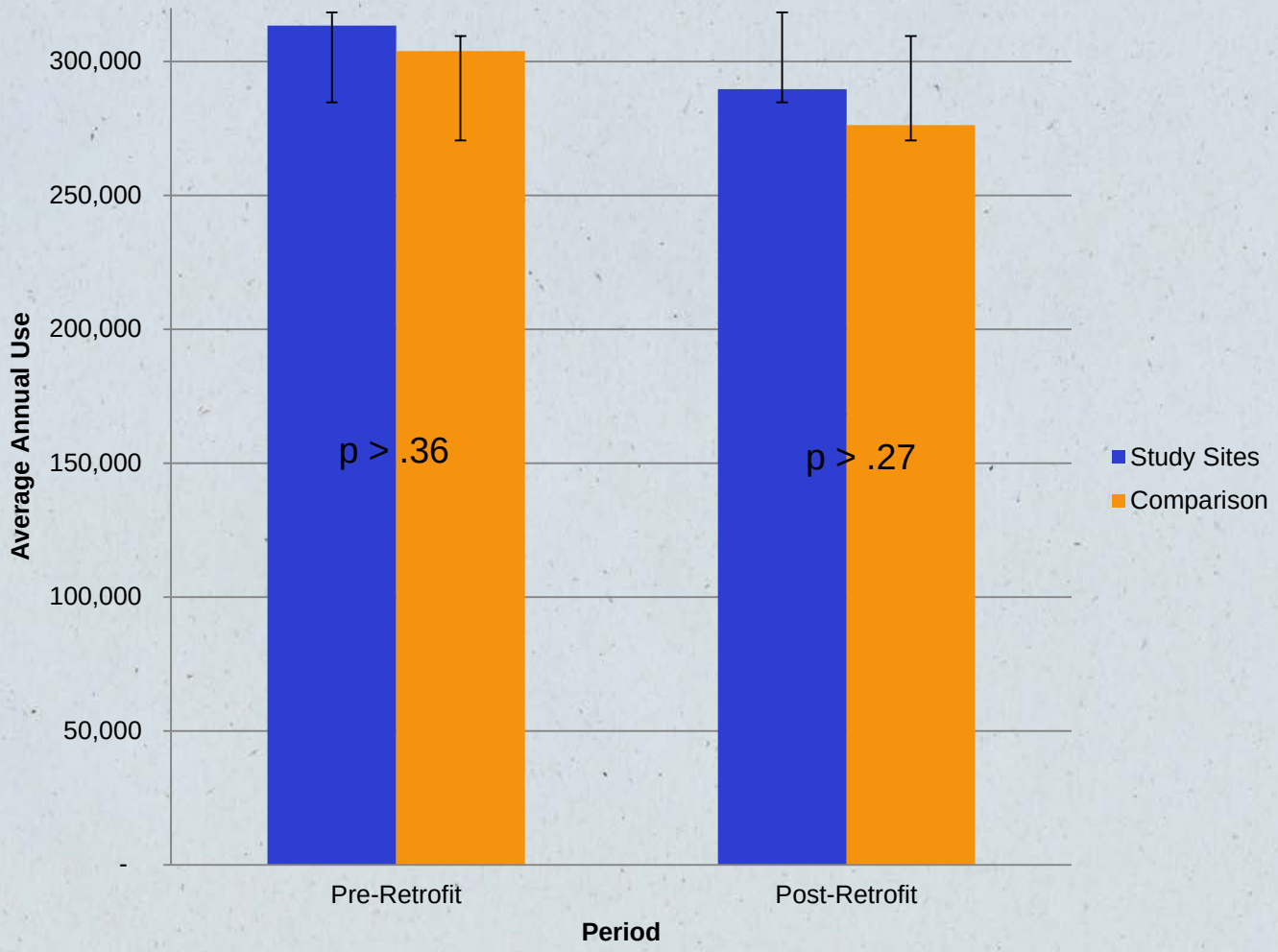
Overall Study Sites Are Not Significantly Different from General Population



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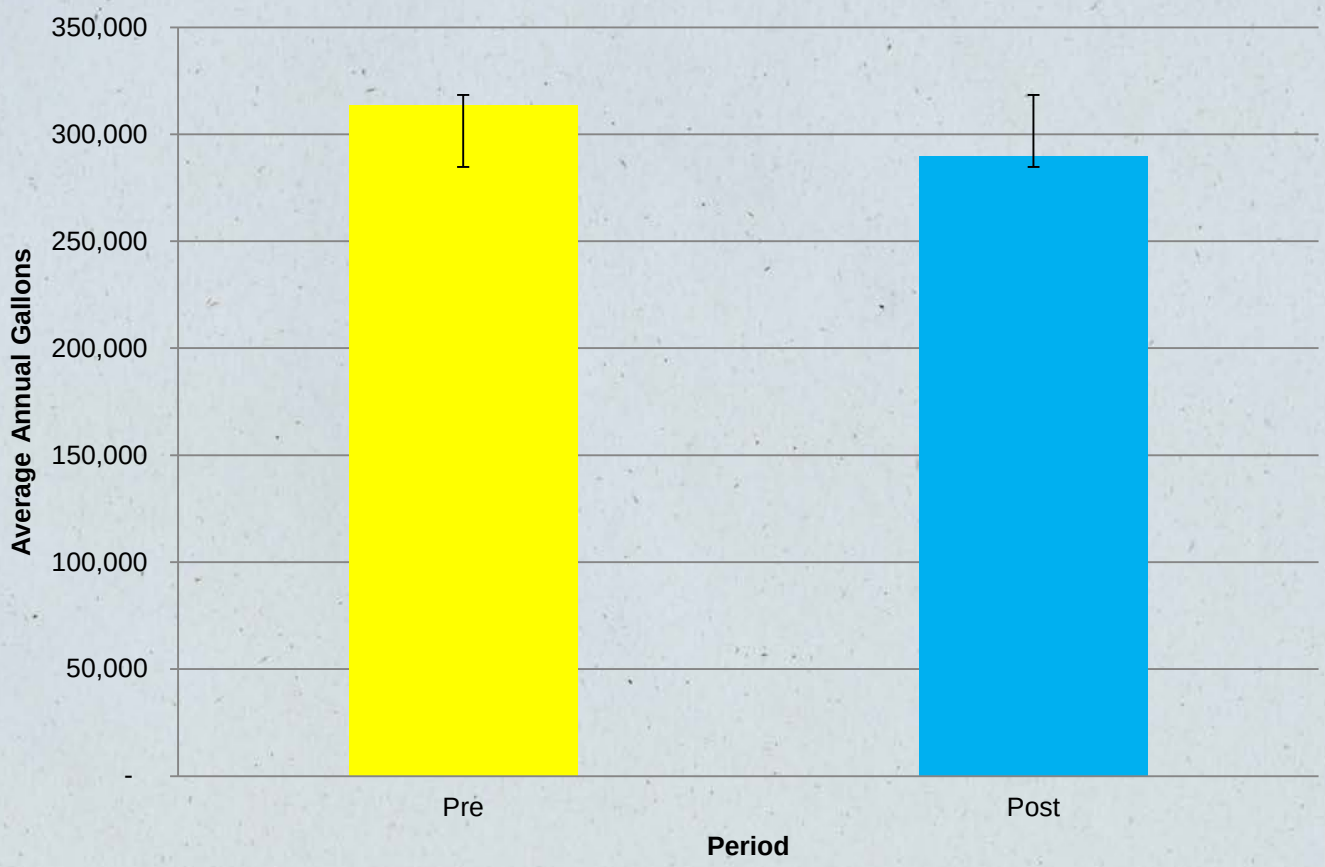
Comparison Study Sites Selection Pre vs. Post-retrofit

T-test for dependent samples *N* = 74, *p* < .02)



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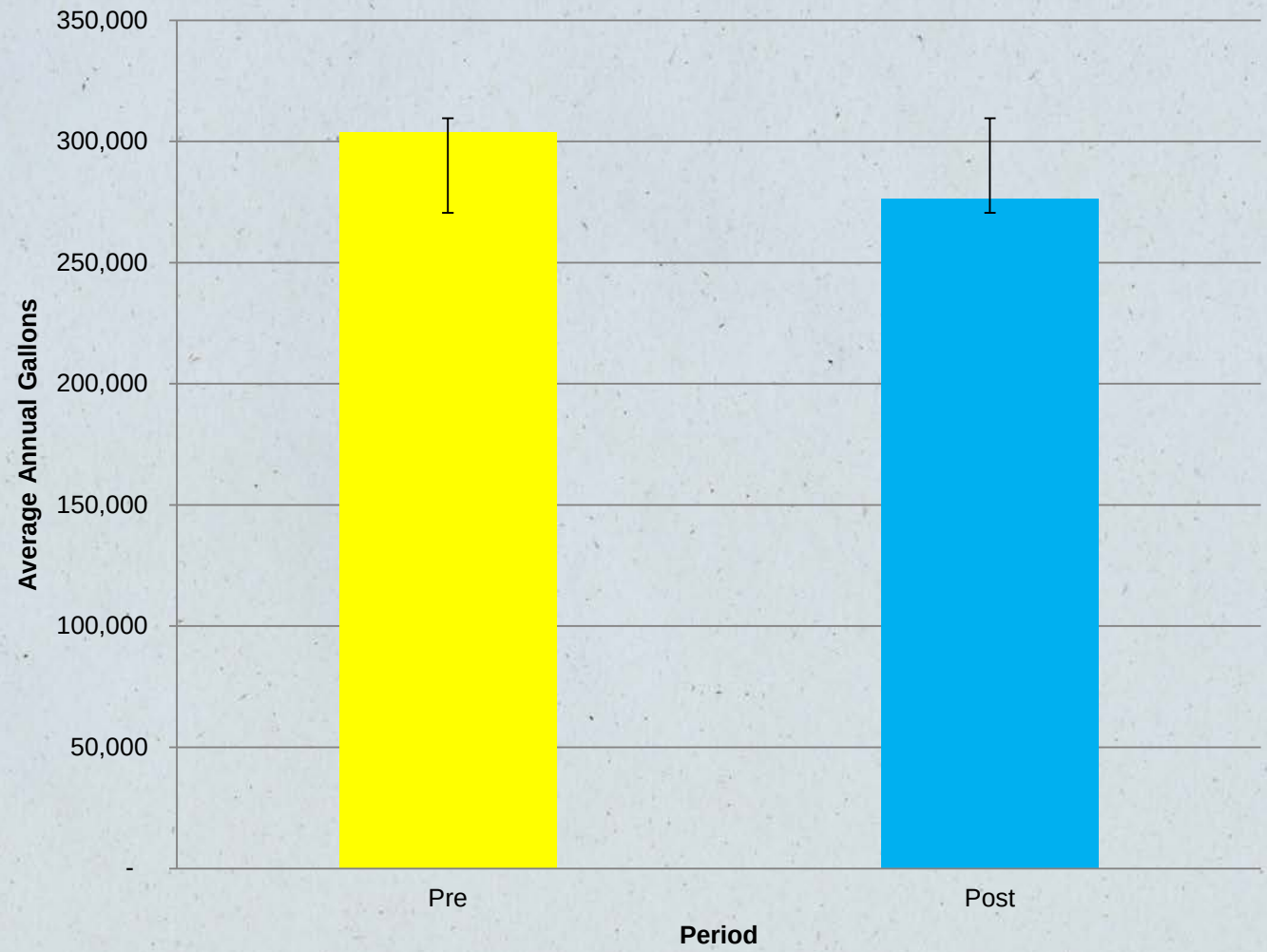
Comparison Sites
Pre vs. Post-retrofit Periods

T-test for dependent samples N = 74, $p < .00$



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Regression Analysis

We get different results depending on which test we perform and sample set. Next we tried some various regression models to see if we could determine some of the other influences.

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Regression Models for Study and Comparison Set

Few of the variables in the models we tried showed any influence (highlighted values) and no model showed correlation from the installed products.

Regression Summary for Dependent Variable: POST			
Adjusted R^2= 0, F(1,146)=.3041, p<.58			N=148
	B	t(146)	p-level
Intercept	276,245	16.027	0.000
Treatment	13,442	0.551	0.582

Regression Summary for Dependent Variable: POST			
Adjusted R^2= .58196, F(6,141)=35.107, p<0.0000			N=148
	B	t(141)	p-level
Intercept	14,932	0.442	0.659
Treatment	30,003	1.833	0.069
Lot Size	14.68	6.401	0.000
Landcape Area	7.76	0.782	0.436
Assessed Val	0.86	4.185	0.000
Home Age	(884)	(1.099)	0.274
Pool Present	13,989	0.832	0.407

Variable Definitions:	
Treatment	Property received retrofit
Lot Size	Assessor's lot size
Landscape Area	Area available for landscape
Assessed Val	Assessor's office assessed value
Home Age	Current age of residence
Pool Present	Pool is present or not at property

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Regression for Study Sites Only

Again, little or no influence from the variables available

Regression Summary for Dependent Variable: PREPOST_DIFF				
Adjusted R^2= .05778, F(7,52)=1.5169, p<.18225				N=60
	B	t(52)	p-level	
Intercept	(146,380)	(1.459)	0.151	
Lot Size	4	0.545	0.588	
Landcape Area	13	0.541	0.591	
Home Age	2,832	1.231	0.224	
Age of BY	5,847	1.007	0.319	
Age of FY	(6,395)	(1.053)	0.297	
Income Range	355	0.873	0.387	
PostDURPD	(114,589)	(1.736)	0.088	

Regression Summary for Dependent Variable: TOT_POST				
Adjusted R^2= .91493, F(3,131)=481.41, p<0.000				N=135
	B	t(131)	p-level	
Intercept	12,516	0.310	0.757	
Lot Size	(4.89)	(1.932)	0.056	
TOT_PRE	1.12	37.573	-	
Post DURPD	34,382	0.805	0.422	

Variable Definitions:	
Age of BY	Age of Back Yard
Age of FY	Age of Front Yard
Income Range	Average of Income Range
Post DURPD	Post-retrofit DU Relative Percent Difference
TOT_PRE	Average pre-retrofit annual use

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Conclusions

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Post Retrofit vs. Final Audits for Study Sites

- Most of the retrofitted irrigation systems maintained improved distribution uniformity rates over the study period, although there was some measurable degradation.
- Precipitation rates remained the same.
- Some loss in pressure rates.
- Overall, the study sites did not save water over the study period.
- This emphasizes the need for real-world trials of conservation technologies. Previous engineered estimates of 22-40% (Soloman et. al. 2006) savings for MSRSHS were not observed in this study.

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Study Sites vs. General Population

- 74 study sites were paired with a closely matched set of non-retrofitted properties to see how they performed vs. general population.
  - No differences pre-retrofit.
  - Although we saw a reduction in this group the study sites did not perform differently from the general population.

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Need for Further Analysis

Overall these results are surprising as well as disappointing given the sustained successful improvements in distribution uniformity. Even though the dependent test showed an increase in usage we do not believe it is actually due to the irrigation technology, given the results of the comparison analyses and regression modeling. We must now look at behavioral habits of the homeowners.

To this end we will examine the hourly automated meter reading records as well as their irrigation clock settings to determine irrigation habits. Perhaps by getting improved DU and advanced irrigation technology participants felt they had “permission” to not manage their water use as closely. This effect has been observed before with other conservation technologies.

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Thanks to the manufacturers for their support of the research and for the products!

Also thanks to the field staff who did the hard work of the audits and retrofits!

Volunteer, not actual SNWA employee

Questions?