LED Equipment Evaluation

PHASE V: 400W HPS Equivalent

Prepared by:
Bureau of Street Lighting
City of Los Angeles

Disclaimer

This report was prepared by the City of Los Angeles for the sole purpose of promoting energy efficiency through the use of new technologies.

It does not recommend the use of any specific LED equipment nor does it recommend the use of a specific supplier.

The City of Los Angeles assumes no legal liability or responsibility for the accuracy, completeness, or usefulness of this report.

Date of test: 4/1/2011 to 7/30/2011

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Introduction

Background

For several decades the high pressure sodium lamp has been considered a standard for roadway lighting around the world. However, recently there have been major technological advances in solid state lighting for street lighting purposes. The new solid state fixtures use LEDs to produce a high quality white light, while using substantially less energy than the HPS fixtures currently being used by BSL. The LED fixtures have the potential to reduce maintenance and operation costs for the City's lighting district.

As a result, the City of Los Angeles has committed itself to the long-term testing and evaluation of new LED street lighting technology. The Energy Efficiency Division of the Bureau of Street Lighting will evaluate new LED fixtures as they become commercially available. The fixtures that show the most potential will be chosen to participate in the City's LED Pilot Project and subjected to field testing for a period of 90 days. Manufacturers that have participated in the LED Pilot Project and meet the Bureau's most recent LED specifications will be eligible to bid on City contracts.

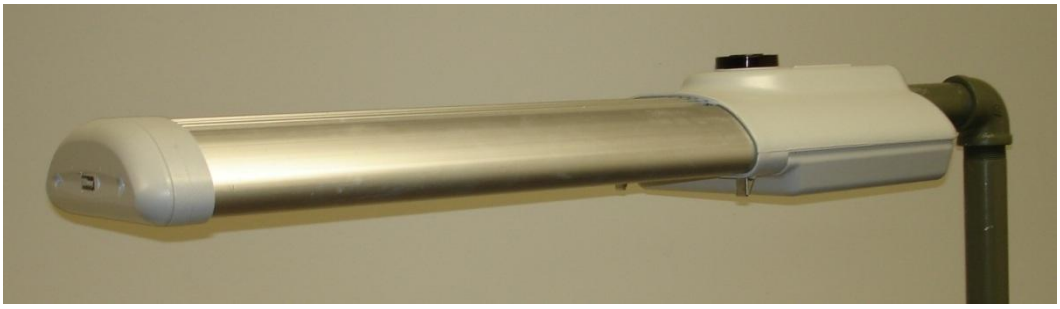
Purpose of the Report

During this phase of testing there were three manufacturers who submitted products which passed our preliminary review. Those products were then given a complete evaluation to determine if it can be used to replace a 400W HPS cobra-head luminaire on a major, medium pedestrian street. The fixture was evaluated based on BSL mechanical, electrical and lighting standards, as well as, newly introduced and accepted LED standards from the SSL industry. In

addition, power consumption, voltage, and on/off cycles were monitored on a daily basis using a Remote Monitoring System. The results of these evaluations are presented in this report and will be a major factor in determining whether BSL will use this fixture in future street lighting projects.

Manufacturer A

Manufacturer B



Manufacturer C

Section 1: Luminaire Testing and Evaluation

1.1 Mechanical Build Quality

Evaluation Method

The fixture was visually inspected by BSL engineers. Criteria included material durability, quality manufacturing, weather proofing, etc.

The mechanical evaluation of this unit was based on luminaire mechanical requirements specified on page 40 of Special Specifications for the Construction of Street Lighting Systems ("The Blue Book"), as well as, criteria developed by BSL specifically for LED luminaires.

Evaluation Conditions

The evaluation was carried out in a controlled lab environment.

Evaluation Summary

These requirements are specified to ensure fixture durability, safety and ease of maintenance. The requirements are additional to any/all of those specified in "The Blue Book".

Luminaire must be clearly labeled with the full catalog number in accordance with ANSI C136.22.

Passed: ALL **Failed: NONE**

There shall be no sharp edges or corners near serviceable parts.

Passed: ALL **Failed: NONE**

All access doors shall have the ability to remain in a fully open position during maintenance without manual assistance.

Passed: ALL **Failed: NONE**

All components shall be securely fastened so it will not become a dropping hazard.

Passed: ALL **Failed: NONE**

Drivers shall be easily assessable and removable for ease of maintenance. "Quick Disconnects" are required.

Passed: A, B

Failed: C - *Quick Disconnects there, but needs screwdriver to remove driver*

All solid-state electronic components shall be sealed to IP 66. This may be accomplished either through component or luminaire housing design.

Passed: ALL **Failed: NONE**

All capacitors must have a <u>minimum</u> temperature rating of 90 degrees Celsius.

N/A: No capacitors outside sealed driver

All internal wiring shall be rated for 105 C and routed away from heat generating components of the driver assembly and LED panels. Wire shall not interfere with light distribution.

Passed: ALL **Failed: NONE**

Neither housing nor lens shall be constructed with poly carbonate/plastic that will discolor over time.

Passed: ALL **Failed: NONE**

All access doors shall have rubber (non-foam) gaskets. Gaskets shall be securely fastened.

N/A: No gasket necessary since door is for access to driver which is fully sealed

Adhesive compounds shall not degrade when subjected to normal operating temperatures.

Passed: ALL **Failed: NONE**

Optical assemblies that can be installed in different positions shall be labeled so that field crews do not need supplemental instructions.

N/A: All units can not be changed

The reflector shall be sturdy and not easily bent.

N/A: No units have a reflector

Screws on the luminaire housing shall be captive and all the same type.

Passed: ALL **Failed: NONE**

Mechanical Build Quality Score									
1	2	3	4	5	6	7	8	9	10
Bad									Very Good
							C	A, B	

1.2 Electrical Build Quality

Evaluation Method

The electrical evaluation of this unit was based on a test procedure developed by BSL/EED.

Evaluation Conditions

The evaluation was carried out in a controlled lab environment.

Ambient temperature: 25ºC

Evaluation Summary

Input voltage 120 VAC, 50-60 HZ

Passed (ALL)

Power factor: >0.9

Passed (ALL)

Total harmonic distortion: <15%

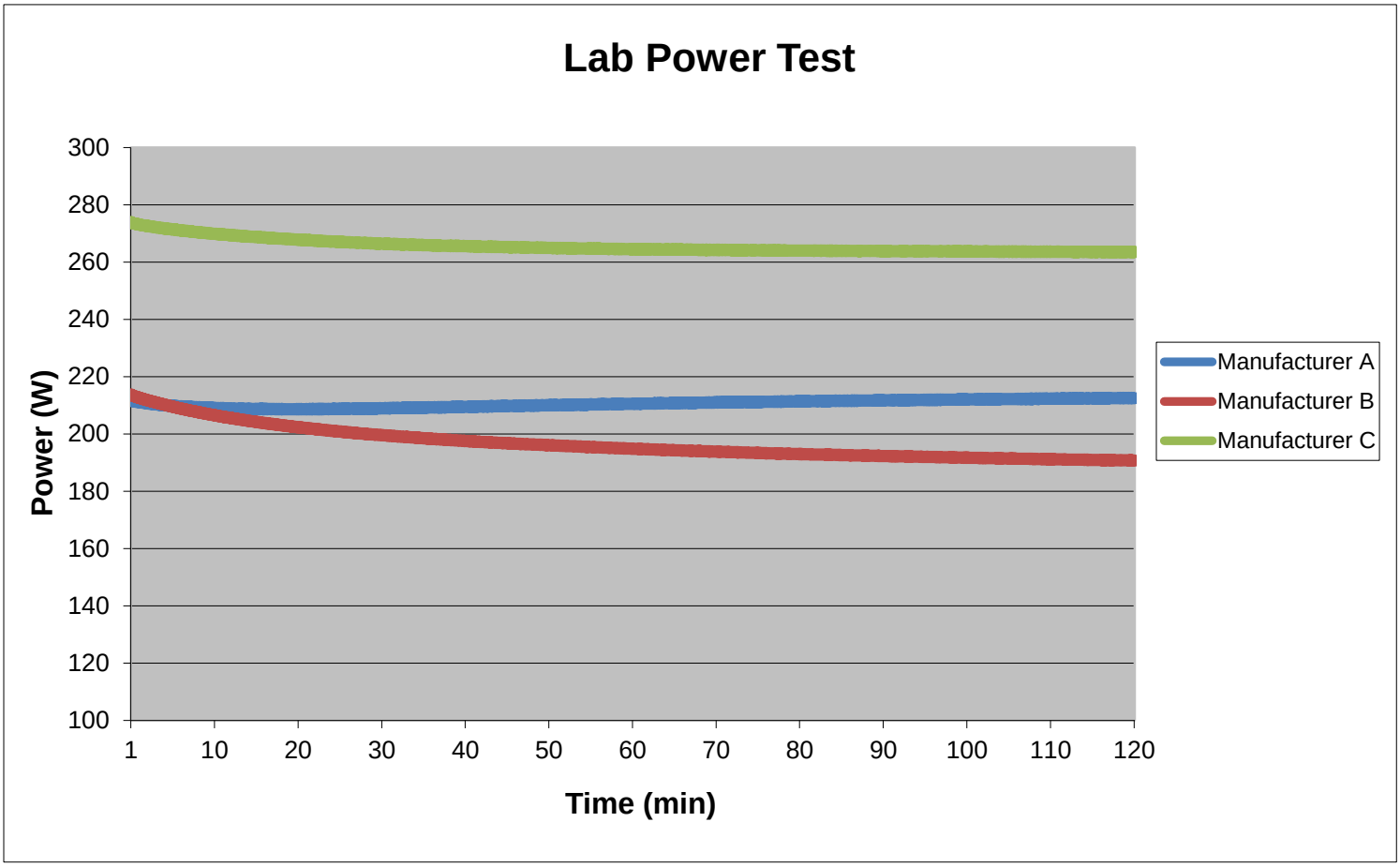
Passed (ALL)

Rated (lamp/LED) life in hours: 50,000

Passed based on manufacturer's claims/warranty (ALL)

Power consumption:

The power was measured for approximately 2 hours in our lab until it was determined that the test unit's power consumption had steadied (shown below). The fixtures were then moved to standard street lighting pole on a major street. Power readings were taken daily with the use of a Remote Monitoring System (RMS). The RMS readings showed the luminaire continued to function normally for its duration at the test site.



Electrical Build Quality Score									
1	2	3	4	5	6	7	8	9	10
Bad									Very Good
							B	A, C	

1.3 Maintenance and Life Expectancy

Evaluation Method

The fixture was scored based on manufacture's projected useful life. The end of useful life is generally considered to be when the fixture reaches 30% lumen depreciation.

Evaluation Conditions

N/A

Evaluation Summary

Maintenance/Life (Hours)									
1	2	3	4	5	6	7	8	9	10
10k	20k	30k	40k	50k	60k	70k	80k	90k	100k
						A	C		B

1.4 Ease of Installation

Evaluation Method

The fixture was scored on a scale 1 to 10 based on time and effort needed for installation. Electrician field notes were considered.

Evaluation Conditions

The evaluation was carried out in the lab as well as the uncontrolled field site.

Evaluation Summary

Ease of Installation									
1	2	3	4	5	6	7	8	9	10
Difficult									Easy
							A,B,C		

1.5 Driver Controls

Evaluation Method

The fixture was scored on a scale of 1 to 10 as to driver control functionality. The ability to easily adjust operating current would be considered most desirable.

Evaluation Conditions

The evaluation was carried out in a controlled lab environment.

Evaluation Summary

Driver Controls									
1	2	3	4	5	6	7	8	9	10
Difficult									Easy
C							A, B		

1.6 Driver Access

Evaluation Method

The fixture was scored on a scale of 1 to 10 as to ease of driver access.

Evaluation Conditions

The evaluation was carried out in a controlled lab environment.

Evaluation Summary

Driver Access									
1	2	3	4	5	6	7	8	9	10
Difficult									Easy
							C	A, B	

1.7 Illuminance Light Level (Street)

Evaluation Method

The fixture was scored on a scale from 1 to 10, based on the amount of light produced compared to an existing typical 400WHPS streetlight installed in the City of Los Angeles.

For this evaluation, light readings were taken from a grid representing one half the existing pole spacing.

Grid Characteristics:

- Roadway - 10 foot increments parallel to curb for 80 feet
- Roadway – 10 foot increments perpendicular to curb for 80 feet

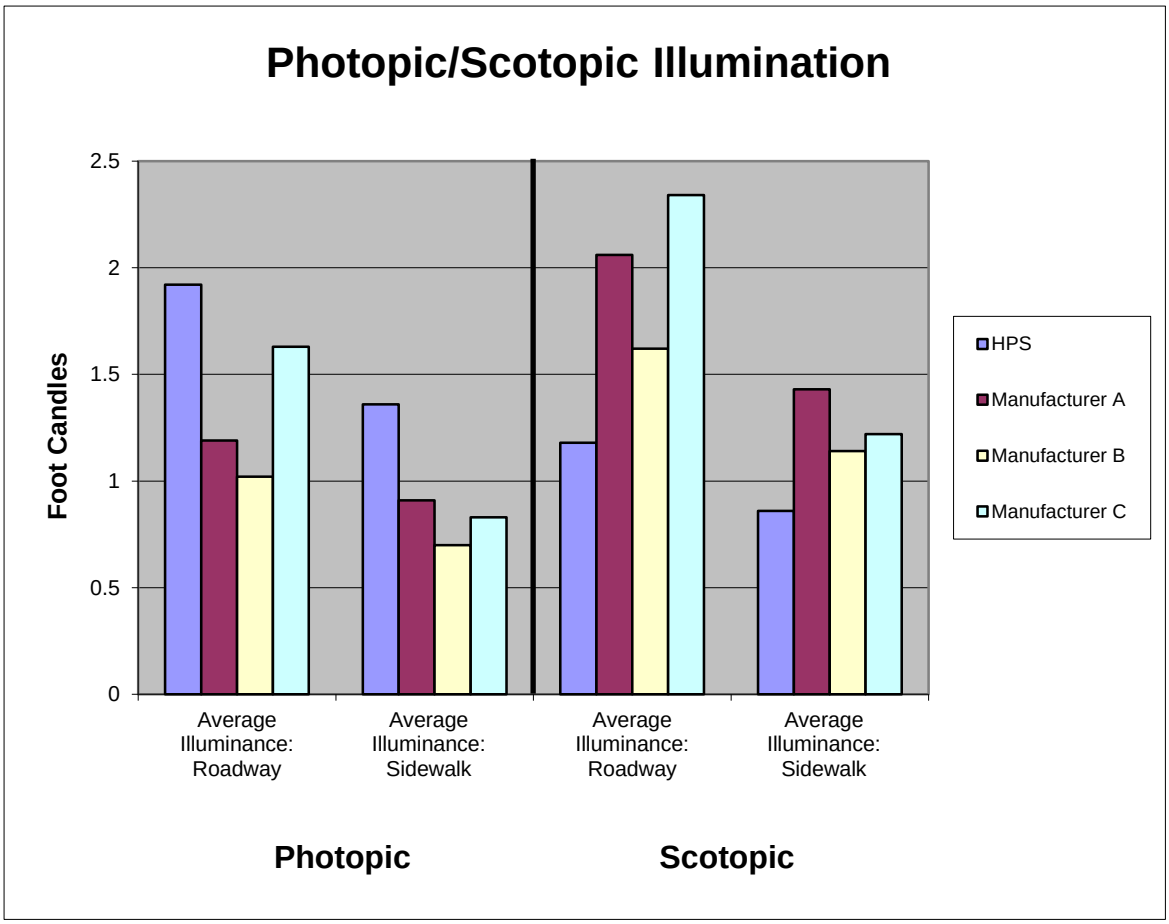
Illumination readings were recorded using a Solar Light PMA2100 scotopic/photopic meter. Scotopic readings were taken for possible use in the future to calculate S/P ratios.

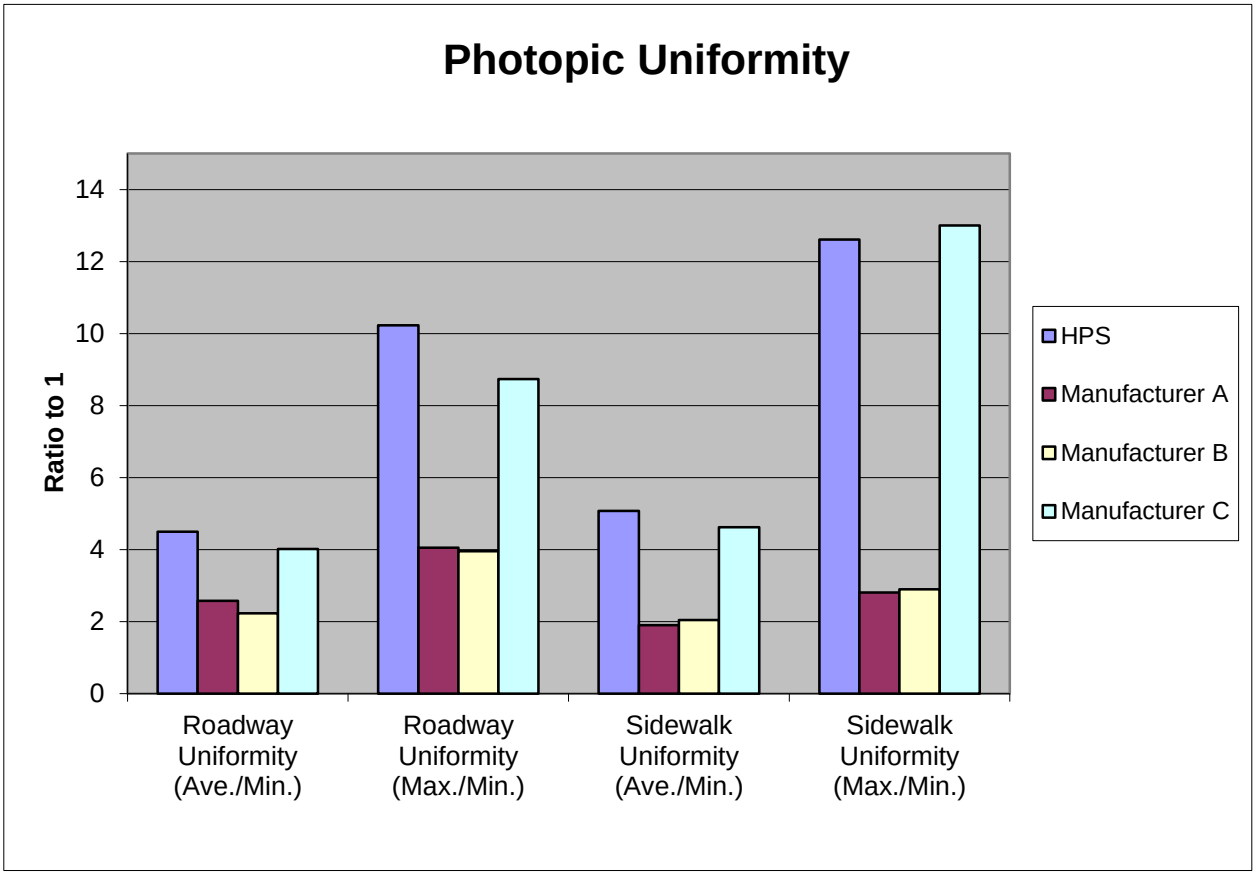
Evaluation Conditions

The illumination readings were taken between May 23rd 2011 and July 21st 2011. The readings were taken at our test site location (see map and pictures in appendix). Field conditions fairly similar each night. The street was open to traffic, and there was some ambient light pollution from local businesses.

Evaluation Summary

Illuminance Light Level (Street)									
0	0	0	4	5	6	7	8	9	10
	<60%	50%	60%	70%	80%	90%	HPS	110%	120%
		B	A		C				


Photopic/Scotopic Illumination
Foot Candles
2.5
2
1.5
1
0.5
0
Average Illuminance: Roadway
Average Illuminance: Sidewalk
Average Illuminance: Roadway
Average Illuminance: Sidewalk
Photopic
Scotopic
HPS
Manufacturer A
Manufacturer B
Manufacturer C


Photopic Uniformity
Ratio to 1
14
12
10
8
6
4
2
0
Roadway Uniformity (Ave./Min.)
Roadway Uniformity (Max./Min.)
Sidewalk Uniformity (Ave./Min.)
Sidewalk Uniformity (Max./Min.)
HPS
Manufacturer A
Manufacturer B
Manufacturer C

1.8 Illuminance Uniformity Ratio (Street)

Evaluation Method

This fixture was scored on a scale from 1 to 10 based on how uniform the illumination was. An average to minimum uniformity ratio of ≤ 2:1 would receive a 10.

For this evaluation, light readings were taken from a grid representing one half the existing pole spacing.

Grid Characteristics:

(Same as illumination grid 1.7)

Evaluation Conditions

(Same as evaluation conditions for 1.7)

Evaluation Summary

Illuminance Uniformity Ratio (Street)									
1	2	3	4	5	6	7	8	9	10
≥11:1	10:1	9:1	8:1	7:1	6:1	5:1	4:1	3:1	≤ 2:1
							C	A, B	

1.9 Illuminance Light Level (Sidewalk East)

Evaluation Method

The fixture was scored on a scale from 1 to 10, based on the amount of light produced compared to an existing 400WHPS streetlight.

For this evaluation, light readings were taken from a grid representing one half the existing pole spacing.

Grid Characteristics:

- Sidewalk – 10 foot increments parallel to curb for 80 feet

- Sidewalk – 5 foot increments perpendicular to curb for 10 feet

Illumination readings were recorded using a Solar Light PMA2100 scotopic/photopic meter. Scotopic readings were taken for possible use in the future to calculate S/P ratios.

Evaluation Conditions

(Same as evaluation conditions for 1.7)

Evaluation Summary

Illuminance Light Level (Sidewalk East)									
0	0	3	4	5	6	7	8	9	10
	<50%	50%	60%	70%	80%	90%	HPS	110%	120%
		B	A, C						

1.10 Illuminance Uniformity (Sidewalk East)

Evaluation Method

The fixture was scored on a scale from 1 to 10, based on the amount of light produced compared to an existing 400WHPS streetlight.

For this evaluation, light readings were taken from a grid representing one half the existing pole spacing.

Grid Characteristics:

- Sidewalk – 10 foot increments parallel to curb for 80 feet
- Sidewalk – 5 foot increments perpendicular to curb for 15 feet

Illumination readings were recorded using a Solar Light PMA2100 scotopic/photopic meter. Scotopic readings were taken for possible use in the future to calculate S/P ratios.

Evaluation Conditions

(Same as evaluation conditions for 1.7)

Evaluation Summary

Illuminance Uniformity Ratio (Sidewalk East)									
1	2	3	4	5	6	7	8	9	10
≥11:1	10:1	9:1	8:1	7:1	6:1	5:1	4:1	3:1	≤2:1
						C			A, B

1.11 Illuminance Light Level (Sidewalk West)

Evaluation Method

The fixture was scored on a scale from 1 to 10, based on the amount of light produced compared to an existing 400WHPS streetlight.

For this evaluation, light readings were taken from a grid representing one half the existing pole spacing.

Grid Characteristics:

- Sidewalk – 10 foot increments parallel to curb for 80 feet
- Sidewalk – 5 foot increments perpendicular to curb for 15 feet

Illumination readings were recorded using a Solar Light PMA2100 scotopic/photopic meter. Scotopic readings were taken for possible use in the future to calculate S/P ratios.

Evaluation Conditions

(Same as evaluation conditions for 1.7)

Evaluation Summary

Illuminance Light Level (Sidewalk West)									
0	0	3	4	5	6	7	8	9	10
	<50%	50%	60%	70%	80%	90%	HPS	110%	120%
	B	C	A						

1.12 Illuminance Uniformity Ratio (Sidewalk West)

Evaluation Method

The fixture was scored on a scale from 1 to 10, based on the amount of light produced compared to an existing 400WHPS streetlight.

For this evaluation, light readings were taken from a grid representing one half the existing pole spacing.

Grid Characteristics:

- Sidewalk – 10 foot increments parallel to curb for 80 feet
- Sidewalk – 5 foot increments perpendicular to curb for 15 feet

Illumination readings were recorded using a Solar Light PMA2100 scotopic/photopic meter. Scotopic readings were taken for possible use in the future to calculate S/P ratios.

Evaluation Conditions

(Same as evaluation conditions for 1.7)

Evaluation Summary

Illuminance Uniformity Ratio (Sidewalk Far)									
1	2	3	4	5	6	7	8	9	10
≥11:1	10:1	9:1	8:1	7:1	6:1	5:1	4:1	3:1	≤2:1
								C	A, B

1.13 Photometric Data Reliability

Evaluation Method

The LED fixture field measurements were compared to the LM-79 compliant IES photometric file. A score was based on how accurate a computer model can be designed to match our field readings.

Evaluation Conditions

The evaluation was carried out in a controlled lab environment and an uncontrolled field environment.

Evaluation Summary

LM-79 and Photometric Data (% Difference Files Vs. Field)									
0	1.5	2	3	4.5	5	6	7.5	9	10
No Files	>25%		20-25%	15-20%		10-15%	5-10%		0%-5%
	A			B		C			

1.14 Photometric Spacing Performance

Evaluation Method

The fixture was scored on a scale of 1 to 10 based on predicted illumination performance at various pole spacings. LM-79 IES photometric files provided by the manufacturer were used to model performance.

Evaluation Conditions

The evaluation was carried out in a controlled lab environment.

Evaluation Summary

Photometric Spacing Performance									
0	0	0	4	5	6	7	8	9	10
115'	120'	125'	130'	135'	140'	145'	150'	155'	≥ 160'
				B		C			A

1.15 Light Trespass

Evaluation Method

The fixture was scored on a scale of 1 to 10 based on the amount light trespass compared to the 400W HPS fixture. The readings were taken with a light meter along the property line

on both sides of the street. The meter was held vertically to take illuminance readings at approximately 5’ from the ground. Readings were taken at 10’ increments to correspond with the illumination grid readings.

Evaluation Conditions

(Same as evaluation conditions for 1.7)

Evaluation Summary

Light Trespass									
1	2	3	4	5	6	7	8	9	10
≥110%	HPS	90%	80%	70%	60%	50%	40%	30%	≤20%
				A		B		C	

1.16 Power Saving

Evaluation Method

The fixture was scored on a scale of 5 to 10 based on power savings when compared to a 400W HPS fixture. A score of 10 would indicate a savings of over 65%. A power savings of less than 40% would result in a score of 0.

Evaluation Conditions

The evaluation was based on official manufacturer specifications and verified in a controlled lab environment.

Evaluation Summary

Power Savings									
0	0	0	0	5	6	7	8	9	10
			<40%	40-45%	45-50%	50-55%	55-60%	60-65%	>65%
				C		A	B		

1.17 Discomfort Glare

Evaluation Method

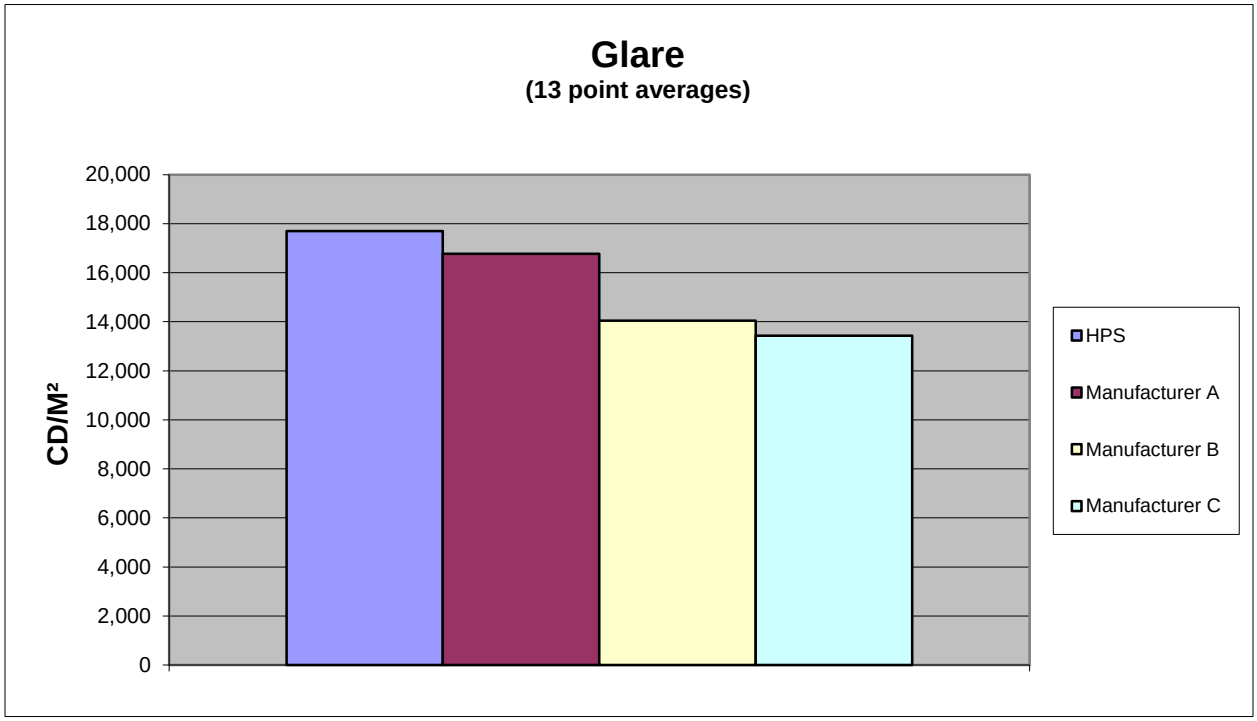
Light readings were taken from twenty one various locations where it was determined that glare sensitivity may exist and create a significant negative impact to drivers and pedestrians. Luminance readings were recorded using a Minolta Luminance Meter LS-100 at an average eye level, aimed at our target luminaire.

Evaluation Conditions

(Same as evaluation conditions for 1.7

Evaluation Summary

Discomfort Glare									
1	2	3	4	5	6	7	8	9	10
200%	180%	160%	140%	120%	HPS	80%	60%	40%	20%
					A	B, C			



1.18 Light Patterns on Street

Evaluation Method

The fixture was scored from a scale of 1 to 10 based on the existence and severity of any light pattern anomalies. A score of 10 would indicate no noticeable light patterns.

Evaluation Condition

The evaluation was carried out in an uncontrolled field environment.

Evaluation Summary

Light Patterns									
1	2	3	4	5	6	7	8	9	10
Distinct									None
									ALL

1.19 Packaging

Evaluation Method

This fixture was scored on a scale of 1 to 10 based on the quality of the packaging. In addition to protecting the fixture, the packaging must be easy to handle and have a minimal impact on the environment in order to achieve a high score.

Evaluation Conditions

The evaluation was carried out in a controlled lab environment.

Evaluation Summary

Packaging									
1	2	3	4	5	6	7	8	9	10
Excessive									Minimal
						C		A	B

Section 2: Conclusion

Conclusion

The solid state industry of streetlights has advanced tremendously in the past couple years. Our last published testing phase was just over two years ago, and the positive advancements that we have seen in this short time with LED streetlights has been exceptional. As with every phase of testing that we have completed here, the products continue to surpass each other in performance; Phase V was no different.

The preliminary screening process used, narrowed our testing field down to three potential products. Based on photometric files and published documents, the three products were thought to meet the standards of the Bureau of Street Lighting. In order to verify we put the luminaires through a full evaluation.

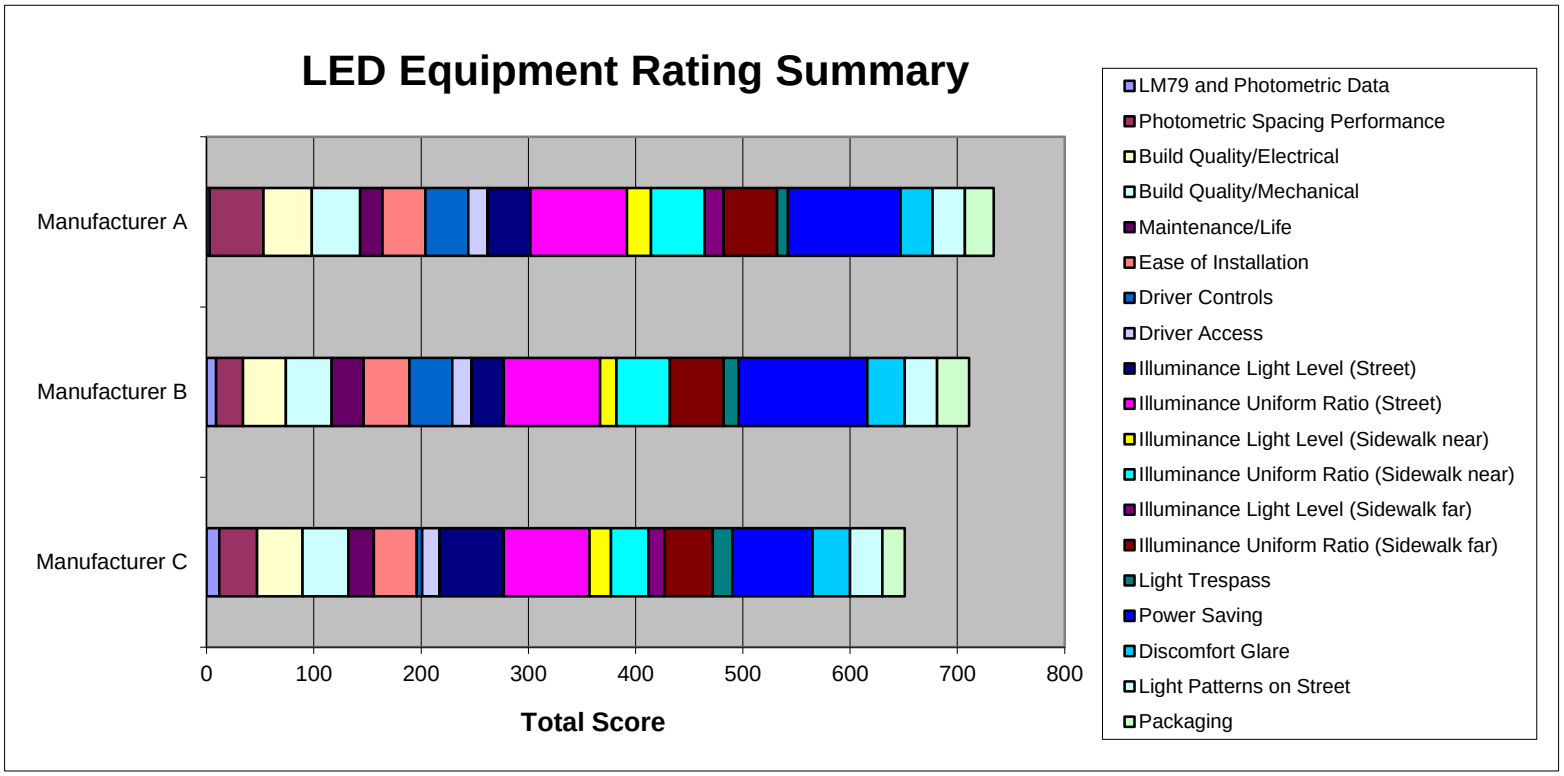
The first evaluation was the mechanical review. Aesthetically, all three units were similar in design, low profile with an optical distribution lens over each LED. One of the units was longer and weighted approximately seven pounds more. Two of the three units passed all the mechanical questions, but it was determined that even though some of the third product did not pass all the criteria, the issues of concern were easily fixable. For those reasons, all three units continued to our electrical and field testing. During our electrical testing it was noticed that the test units ranged in power consumption from as low as 192W, to as high as 266W. When compared to the 400W HPS unit which realistically uses 465W, the test units are saving from approximately 42% to 58%. When all aspects were factored in, the units that saved about 54% power scored highest in our evaluation.

Installation played a key roll in equipment approval. There was little disparity in the different units. Issues of concern ranged from terminal block location to weight and size of the fixture, and even packaging was taken into account. We also considered how much space the unit with the packaging takes up on the installation truck. This is because we want to minimize the time consumed back and forth re-stocking the installation truck. During this phase of testing all three of our subjects were all fairly similar in packaging and installation.

The results from our field testing were acceptable even though our measurements did not meet the existing HPS field conditions. The illumination measured from manufacturer A came very close to the IES recommended value for a major roadway with medium pedestrian characteristics, and manufacturer B was close behind. Manufacturer C on the other hand was much higher than the recommended value. Roadway uniform ratio (average/minimum) is another determining factor of the test fixtures, and manufacturer A and B were better than the HPS and while manufacturer C was equal with HPS, it was still higher than the recommended value set by IES. The max/min ratio had similar results. Manufacturer C was similar to HPS, while manufacturer A and B were much better with a ratio of about half that of HPS. Another measurement we compared to the HPS lights was the sidewalk illumination. The existing HPS lighting was very high and our test units could not mimic the high level, but for good reason. The existing lighting level on the sidewalks was much higher than the recommended practice, but all three of our test units were able to produce enough lights on the sidewalks to meet IES recommendations. The next field measurement had to do with distribution control. Our street lights are only supposed to illuminate the public roadways and sidewalks. Light spilling onto private property can be a nuisance and all of our test subjects performed better than the existing HPS luminaire. Our final field test was to see how much glare passing motorists and pedestrians

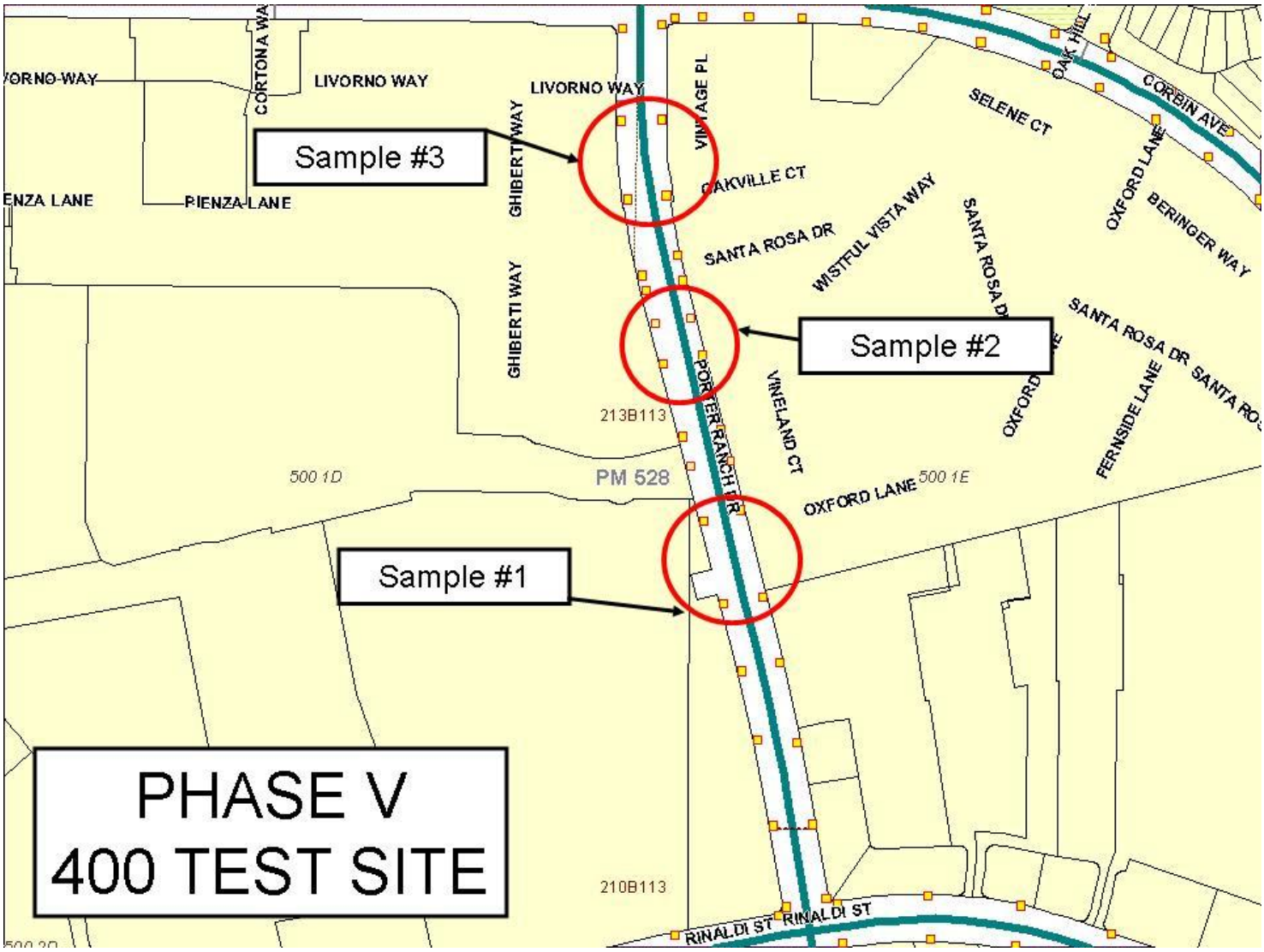
would incur in comparison to the existing HPS fixture. The variations in results were very minimal but all three of the test units produced less glare than the existing HPS lights did.

When we compiled all of our test results and observations, it was obvious how much the technology and products have improved over the last two years. Having power savings now close to 60% while illumination levels near IES recommendations highlights this phase. At the conclusion of our last phase of testing larger luminaires, we felt two units we tested met our standards. After we completed Phase V, we approved two of the three units we put through a full evaluation for city wide HPS replacement. Below are the final scores for each of the three products we evaluated in Phase V. Each of the 19 scoring categories were weighted based on what we felt was more relevant in choosing luminaires for city wide replacement. When added all together this was the final result.

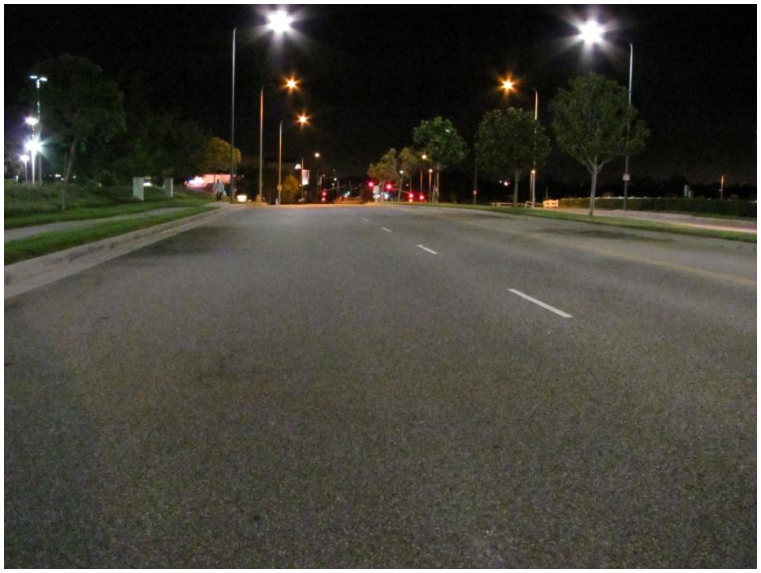


Appendix

LED Test Location Map

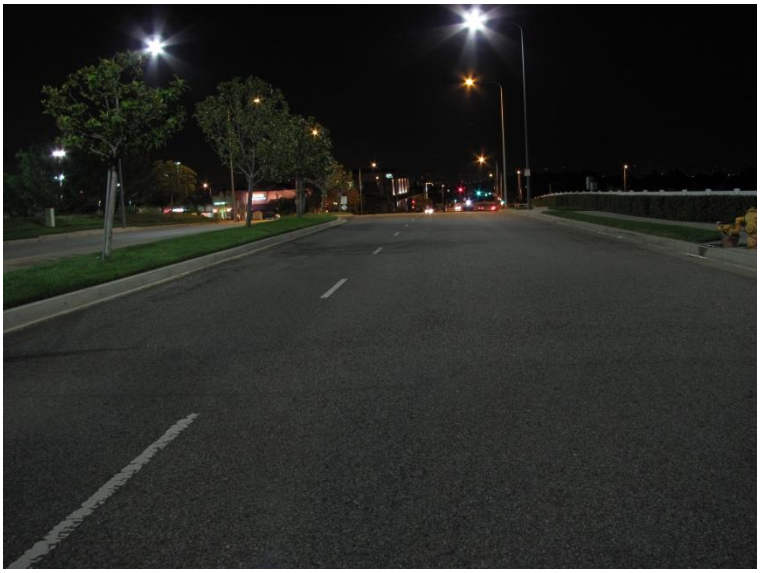


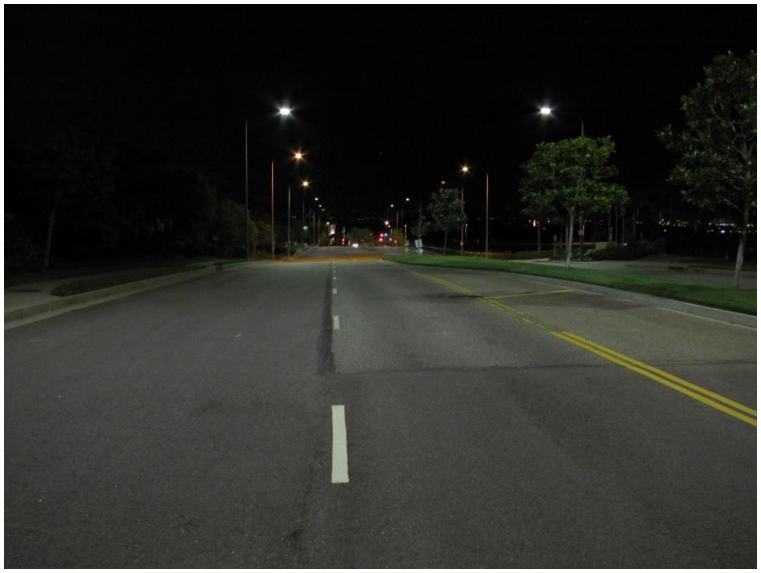
LED Field Installations



Manufacturer A

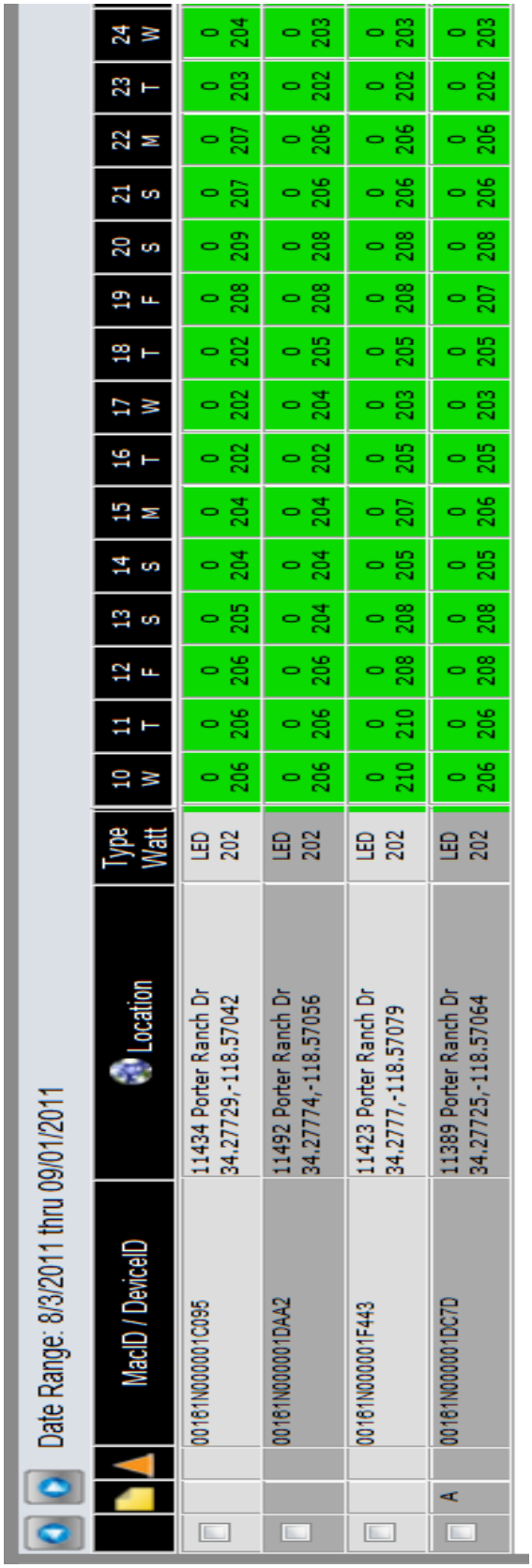
Manufacturer B





Manufacturer C

Remote Monitoring System Sample



Date Range: 8/3/2011 thru 09/01/2011

		MacID / DeviceID	Location	Type Watt	10 W	11 T	12 F	13 S	14 S	15 M	16 T	17 W	18 T	19 F	20 S	21 S	22 M	23 T	24 W
		00181N000001C095	11434 Porter Ranch Dr 34.27729,-118.57042	LED 202	0 206	0 206	0 206	0 205	0 204	0 204	0 202	0 202	0 202	0 208	0 209	0 207	0 207	0 203	0 204
		00181N000001DAA2	11492 Porter Ranch Dr 34.27774,-118.57056	LED 202	0 206	0 206	0 206	0 204	0 204	0 204	0 202	0 204	0 205	0 208	0 208	0 206	0 206	0 202	0 203
		00181N000001F443	11423 Porter Ranch Dr 34.2777,-118.57079	LED 202	0 210	0 210	0 208	0 208	0 205	0 207	0 205	0 203	0 205	0 208	0 208	0 206	0 206	0 202	0 203
A		00181N000001DC7D	11389 Porter Ranch Dr 34.27725,-118.57064	LED 202	0 206	0 206	0 208	0 208	0 205	0 206	0 205	0 203	0 205	0 207	0 208	0 206	0 206	0 202	0 203