University of California, Davis

UC Davis Fleet Services Lighting Retrofit
Final Proposal

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ABT 212: Path to Zero Net Energy: A hands-on approach
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2019-06-12

1. Abstract

The UC Davis Fleet Services needs upgrades to their outdated lighting system as the current lighting system has been negatively impacting the work quality at the facility such as creating potential workplace hazards. A conducted audit showed that many of the lighting system components, including fixtures, lights bulbs, and wires, have aged and need to be replaced. The goal of this project is to facilitate a healthy workplace environment with optimal lighting level by retrofitting their lighting system. Our team did this be meeting with vendors and contractors through a span of several weeks, getting lighting design proposals from vendors, Associated Lighting Representatives (ALR) and Cal Lighting, conducting several types of analysis, Energy Cost Savings, Overall Lighting Performance, Costs, and Durability, and finally ranking the two vendors based on an evaluative matrix. Our research found that ALR ranks higher than CAL Lighting based on the evaluative matrix, indicating that the recommended lighting system from ALR has a better overall performance. However, CAL Lighting's design proposal provides higher energy efficiency fixtures in general as well as longer averaged lifespans

2. Background

The UC Davis Fleet Services are interested in a retrofit of their lighting system since the lighting system at the facility has not seen an upgrade since the 1960s. This has resulted in inadequate lighting which has affected the work quality at the facility. Furthermore, since the facility works with heavy equipment, the insufficient lighting quality creates potential for workplace hazards. An audit was conducted within the last few years that showed that many components of the facility's lighting system are near or at the end of their lifespan as well. Our client for this project is the director of Fleet Services, Dan McCann. Our client is primarily interested in looking for a new lighting system that focuses heavily on durability and the provision of enough lighting for their workers.

Furthermore, studies that focused on areas that are similar to the different areas at the UC Davis Fleet Services were researched. By doing so, our team was hoping to find similar scenarios that could be applied to Fleet Services. For example, a study that focused on studying the energy savings that occurred after parking garages switched to bi-level LED lumens was done by the California Energy Commission (California Energy Commission). The study took place at the California State University, Sacramento in one of their parking garages. The lighting

system for the garage was retrofitted and the high intensity discharge (HID) lamps there originally were replaced with LEDs in order to reduce power consumption. The study then compared the data on the energy consumption of the HID lamps and the LEDs. This study in particular is extremely useful for the facility area that houses the vehicles for storage.

Another study looked at evaluating lighting performances in office buildings that had daylight controls. The study took place in Hong Kong and took into account the building design, the artificial lighting system, and the available daylight (Li et al.). This paper essentially confirmed using natural daylight illuminance would help save energy that could be an upwards of 50% in office areas. This study is particularly useful when analysing the office spaces at the Fleet Services office areas, especially since the workers at the facility in these areas specifically stated they often used natural sunlight.

3. Methodology

3.1 Data Collection

3.1.1 Meet with Client

A meeting with our project's client was scheduled near the end of April to formally introduce our team as well as to get a general understanding of their concerns, what our team should focus on, as well as some suggestions on the design proposal they would like to include for the facility.

3.1.2 Data Measurement of Existing Lighting System

Critical areas that need lighting improvements as soon as possible were identified during site visits. An audit that was conducted by the Energy Conservation Office was also verified. The audit included research on the model of the fixtures and lights as well as the current conditions of the lighting system. The verification was done through the usage of specific energy auditing tools: Minolta Illuminance Meter T-10, Bosch Laser rangefinder, and Acuity Discriminator BD1. Through the usage of these tools, the team was able to measure the existing illuminances, the dimension of each area at the facility, and distinguish the type of fixtures. Data analysis on current total energy usage as well as case studies on past lighting retrofit projects were also conducted.

3.1.3 Design Proposal from Vendors

Two design proposals for a new lighting system for the Fleet Service Facility were provided from two lighting vendors, CAL Lighting and Associated Lighting Representative (ALR). Each of the proposal includes recommended replacements for fixtures and lamps based on the improvements our clients need. Budgetary prices were also included in the suggested proposal**.**

3.2 Data Analysis

Cost analysis and energy saving analysis were performed for each vendor's design proposal and once this was completed, the results were then compared. The total cost of each proposal consists the material costs that was quoted by the vendors as well as the labour costs for replacing the fixtures. Also, analyses on the lighting performance of the main concerning areas – Parts, Shops, Heavy Duty Shop, and Shed – were performed by using an online software – Virtual Interior Tool by Acuity Brands – to get the estimated illuminance output of each area at the facility using the recommended light fixtures.

Lifetime energy saving was estimated using a daily-operated based analysis method. Assuming all the areas operate 8 hours a day, 5 days a week, the total energy cost saving is calculated with a 3 % increase in energy rates each year and extrapolated to total energy cost saving assuming the lifespan of all fixtures are same as the shortest lifespan of the fixtures among all the recommended fixtures of each design plan.

An evaluative matrix was set up to rank the alternatives based on four main criteria: Cost, Annual Energy Saving, Overall Lighting Performance, and Durability. Each criterion is weighted based of the priority of our client's concerns.

4. Results & Discussion

Data Comparison between two Design Proposals

	ALR	CAL Lighting
Total Costs	$98,502	$101,236
Energy Saving (Annual)	20308 kWh	21541 kWh
Energy Cost Saving	$1,450	$1,400
Improving Existing Light Level	100%	80%
Meet Recommended Light Level	100%	80%
Durability (averaged)	56800 Hours	66667 Hours
Lifetime Energy Cost Saving (3% increase in electricity rate)	$21,250	$22,053

Table 1: Analyses on two Design Proposals

Assumptions/Notes:

1. Total costs include material costs, equipment rental costs, and labour costs with 10% contingency.
2. Labour hours include time spent to dispose old fixtures and lamps.
3. Labour hours is calculated assuming electrical technicians work 8 hours a day, 5 days a week.
4. Energy cost saving is calculated using an electricity rate of $0.065/kWh.
5. Lighting performance is evaluated at the main concerning areas – Parts, Shops, Heavy Duty Shop, and Shed.
6. All the analyses are conducted assuming fixture-to-fixture replacements.
7. Lifespan of all fixtures for ALR and CAL lighting is assumed to be 50,000 hours and 60,000 hours respectively.

Lighting Performance

	Existing Illumination (Averaged) [lux]	Target Brightness [lux]	Upgraded Illumination (Estimated Average) [lux]	
			ALR	**CAL Lighting**
Parts I	397	250	783	1154
Parts II	326	250	615	895
Shed	272	1000	1661	1014
Shop	706	750	770	500
Heavy Duty Shop	633	750	1228	782

Table 2: Analyses on Lighting Performance of Critical Areas

Assumptions/Notes:

1. Target Brightness of each area is obtained from the recommended light level from National Optical astronomy Observatory (NOAO)
2. Dimensions of Shed area is assumed to be the same size as the Shop.
3. For the area that has more than one fixture, the estimated illuminance is calculated by averaging the output illuminance of each fixture and weighted by the number of fixtures that are implemented in that area.

Durability

Associated Lighting Representative (ALR)

ALR	
Type	**Lifespan (hours)**
Elite 4-OW1IP-8000L-DIM10-MVOLT-40K-85-OW1IPFL-SSL	50,000
HE Williams GC-L120/840-W-DIM-UNV	50,000
Elite 24-FPL1-LED-5000L-DIM10-MVOLT-35K-85	84,000
Elite 4-OEC-LED-4000L-DIM10-MVOLT-35K-85	50,000
Elite 4-OEW-LED-4000L-DIM10-MVOLT-40K-85	50,000
Averaged	**56,800**

Table 3: Durability on ALR's recommended fixtures

CAL Lighting (CAL)

CAL Lighting	
Type	**Lifespan (hours)**
Metalux VHB LED	87,000
Metalux Vaportite LED	60,000
Metalux SNLED LENSED LED	60,000
Metalux SNLED LENSED LED	60,000
Indatech HXPEL SERIES	50,000
Metalux 24FP LED	83,000
Averaged	**66,667**

Table 4: Durability on CAL's recommended fixtures

Evaluative Matrix

Figure 1: Ranking Criteria

	ALR	CAL Lighting
Energy Cost Saving	2	1
Overall Lighting Performance	1	2
Costs	2	1
Durability	1	2
Total Score (After weighing)	12	10.5

Table 5: Evaluative Matrix

Assumptions/Notes:

1. Assigned scores in matrix where 1 = Important, 2 = More Important

From the evaluative matrix above, Associated Lighting Representative (ALR) ranks higher than CAL Lighting using our weighted ranking criteria, indicating that the recommended lighting system from ALR has a better performance overall. However, CAL Lighting's design proposal provides higher energy efficiency fixtures in general as well as longer averaged lifespans.

5. Sources of Error

5.1 Measuring Devices

The measuring devices that our team used may not have been very accurate.

5.2 Cal Lighting Design Issues

The vendor, Cal Lighting, only sent us the lights and fixtures that they would recommend to our facility and not where they would place said lights and fixtures. As a result, our team placed the recommended lights in the areas that we thought were most appropriate. However, this may differ from the design Cal Lighting may have.

6. Recommendations

6.1 Considerations to Meet Another Vendor

Towards the end of the project, our team met with a UC Davis Electrical Estimator who gave us figures for the labour costs. At the meeting, the Electrical Estimator, Marvin LeBlanc, suggested our team to consider another vendor, LITE, for the project. The recommended vendor apparently has other projects with UC Davis at the moment and may be better suited for Fleet Services in terms of installation and fixtures with higher energy efficiency.

6.2 New Suggestions from ALR

The ALR vendor also sent a new fixture plan for Fleet Services that may be worth looking into and potentially adding to the plan the vendor already gave. The new plan came at the very end of the project so our team was unable to perform the calculations and analysis to see how the additional fixtures would affect the Energy Cost Savings, Overall Lighting Performance, Costs, and Durability of the new lighting plan. Devon, the member of Facilities who did the audit of the Fleet Service Facility, has been included in the communication with this vendor and also has access to the new data.

6.3 Million LED Challenge

Our last recommendation is to check to see if the chosen lighting design is in line with the standards set by the Million LED Challenge partners, a challenge that UC Davis is participating in (Logi et al.). The Million LED Challenge specifies the performance criteria needed to evaluate and select the light bulbs that will go into UC facilities and be available to the UC community for purchase.

7. Conclusion

Using our weighting ranking criteria, Associated Lighting Representative (ALR) ranks higher than CAL Lighting. This indicates that the recommended lighting system from ALR has a better overall performance. However, CAL Lighting's design proposal provides higher energy efficiency fixtures in general as well as longer averaged lifespans. In addition, our sources of error in this project, the accuracy of our measuring devices and the design used to conduct the analysis for Cal Lighting. Furthermore, some recommendations from our team would be to look into the vendor that Marvin, the UC Davis Electrical Engineer, proposed, look into the new fixture plan that the vendor, ALR, gave, and to check to see if the selected design meets the criteria of the Million LED Challenge. Lastly, federal and state financial incentives such as rebate for purchasing LED lights for commercial buildings could not be found. The best route to go for potential money savings if through the Million LED Challenge.

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Appendix

Light				
Lamp/Fixture	Type	Index	Hours	# People
Fixture	Elite 4-OW1IP-8000L-DIM10-MVOLT-40K-85-OW1IPFL-SSL	D	2	2
Fixture	HE Williams GC-L120/840-W-DIM-UNV	E	3	2
Fixture	Elite 24-FPL1-LED-5000L-DIM10-MVOLT-35K-85	F	2	1
Fixture	Elite 4-OEC-LED-4000L-DIM10-MVOLT-35K-85	G	3	2
Fixture	Elite 4-OEW-LED-4000L-DIM10-MVOLT-40K-85	J	2	2
Extra				
Lift	Hi-Bay & High Ceiling	Shop, Heavy Duty, Shed		
Number of light needed in total				
Index	Type	#	Total Hours/person	
D	Elite 4-OW1IP-8000L-DIM10-MVOLT-40K-85-OW1IPFL-SSL	8	16	
E	HE Williams GC-L120/840-W-DIM-UNV	13	39	
F	Elite 24-FPL1-LED-5000L-DIM10-MVOLT-35K-85	26	52	** 2 ppl job
G	Elite 4-OEC-LED-4000L-DIM10-MVOLT-35K-85	54	162	
J	Elite 4-OEW-LED-4000L-DIM10-MVOLT-40K-85	81	162	
		Total	**431**	
Total construction time	53.875 Days	10.775Weeks	**10 Weeks + 4 Days**	
Construction Time (w/o High Bay (A))	32.375 Days	6.475Weeks	**6 Weeks + 3 Days**	
Labor Cost	**Rate**	**Hours**		
Electrical Technician	$77.00	431	$33,187.00	
Electrical Technician	$77.00	379	$29,183.00	
Inspector/Supervisor	$107.00	8	$856.00	
Equipment	**Rate/Day**	**Rate/Week**		
Scissor Lift	$140.00	$440.00	$4,960.00	
Lift W/ Articulated Arm	$315.00	$970.00	$3,880.00	(only for Shop & Car Wash)
		Sub-Total	**$72,066.00**	
Material Cost				
Index	Type	**Part**	**Cost**	Quantity
D	Elite 4-OW1IP-8000L-DIM10-MVOLT-40K-85-OW1IPFL-SSL		**$275.00**	8
E	HE Williams GC-L120/840-W-DIM-UNV		**$210.00**	13
F	Elite 24-FPL1-LED-5000L-DIM10-MVOLT-35K-85		**$85.00**	26
G	Elite 4-OEC-LED-4000L-DIM10-MVOLT-35K-85		**$85.00**	54
J	Elite 4-OEW-LED-4000L-DIM10-MVOLT-40K-85		**$71.00**	81
		Sub-Total	**$17,481.00**	
		Total	**$98,501.70**	(10% contingency)

Table 6: Total Cost Breakdown for ALR's Design Proposal

Light					
Area	**Type**	**Index**	**Hours**	**# People**	**Notes**
General Mid Bay	Metalux VHB LED	**A**	3	2	Need Lift
Wet Location	Metalux Vaportite LED	**B**	2	2	Need Lift
Suspended General Lighting	Metalux 4WSL/8WSL LED	**C**	1	1	
Under Canopy parking and refueling	Metalux TB TOP BAY LED Solid State LED	**D**	1	1	
Explosion Proof	Indatech HXPEL SERIES	**E**	3	2	
Office	Metalux 24FP LED	**F**	2	2	

Extra	
Lift	Hi-Bay & High Ceiling

Number of light needed in total				
Index	**Type**	**#**	**Total Hours/person**	
A	Metalux VHB LED	28	84	
B	Metalux Vaportite LED	24	48	* 2 ppl job
C	Metalux SNLED LENSED LED	66	66	
D	Metalux SNLED LENSED LED	38	38	
E	Indatech HXPEL SERIES	3	9	
F	Metalux 24FP LED	44	88	
		Total	**333**	

Total construction time	41.625 Days	8.325 Weeks	**8 Weeks + 1 Day**
Construction Time (w/o using Lift)	25.125 Days	5.025Weeks	**5 Weeks + 4 Days**

Labor Cost	**Rate**	**Hours**	**Total Cost**
Electrical Technician	$77.00	333	$25,641.00
Electrical Technician	$77.00	229	$17,633.00
Inspector/Supervisor	$107.00	6	$642.00
Equipment	**Rate/Day**	**Rate/Week**	**Total Cost**
Scissor Lift	$140.00	$440.00	$2,760.00
Lift W/ Articulated Arm	$315.00	$970.00	$970.00
		Sub-Total	**$47,646.00**

Material Cost					
Index	**Type**	**Part**		**Cost**	**Quantity**
A	Metalux VHB LED	VHBLED-LD1-15-W-UNV-L835-CD1-SVPD3-U	$	243.00	28
B	Metalux Vaportite LED	4VT3-LD5-8-W-UNV-L835-CD-1-U	$	231.00	24
C	Metalux SNLED LENSED LED	4SNLED-LD5-46SL-LN-UNV-L835-CD1-U 48" LED STRIPLIGHT, 4600 LM, 35K, 0-10V	$	124.00	66
D	Metalux SNLED LENSED LED	8TSNLED-LD5-98SL-LN-UNV-L835-CD1-U	$	246.00	38
E	Indatech HXPEL SERIES	LE551-L5-V1-4-V-PB-D1	$	1,785.00	3
F	Metalux 24FP LED	24FPX-47-L835-SWPD1	$	208.00	44
		Sub-Total		**$44,387.00**	
		Total		**$101,236.30**	(10% contingency)

Table 7: Total Cost Breakdown for CAL Lighting's Design Proposal

Room Location	Fixtures	Fixture Type	LED Replace	Schedule	Energy Demand/ Fixture (W)	Hour/Week (Avg)	Existing Energy Use (Ave)	Upgraded Annual Energy Use (kWh)	Energy Cost Existing	Upgraded Annual Energy Cost	
Open Area	9	Open HID High Bay	LED	24/7	50	168	3931.2	3931.20	$ 255.53	$ 255.53	**No Replacement
Shop	7	Open HID High Bay		6a-5p			3003		$ 195.20		
Shop	4	Open HID High Bay		6a-5p			3432		$ 223.08		
Shop	1	Open HID High Bay	G x 24	6a-5p	40	55	143	2745.60	$ 9.30	$ 178.46	
Shop	16	Open Fluorescent		6a-5p			5491.2		$ 356.93		
Shop	4	Open Fluorescent		6a-5p			800.8		$ 52.05		
Break Room	2	Closed Flush to Ceiling	LED						$ -	$ -	
RR1			LED						$ -	$ -	
RR2	1	Open Fluorescent	J	6a-5p	42	55	314.6	120.12	$ 20.45	$ 7.81	
Car Wash	4	Closed Hanging	D	6a-5p	60	55	800.8	686.40	$ 52.05	$ 44.62	
Car Wash	2	Open HID High Bay	D	6a-5p	60	55	572	343.20	$ 37.18	$ 22.31	
Car Wash	2	Open HID High Bay	D	6a-5p	60	55	1716	343.20	$ 111.54	$ 22.31	
Heavy Duty Shop	13	Induction	E	6a-5p	100	55	1189.76	3718.00	$ 77.33	$ 241.67	
Heavy Duty Shop Under Truck	3	?	LED	6a-5p	120	55	1029.6	1029.60	$ 66.92	$ 66.92	**No Replacement
Office Main	14	Closed Flush to Ceiling	F	M-F:7a-5p, Sa: 7a-12:30p, Su: 10-1p	41	63.5	5547.36	1895.35	$ 360.58	$ 123.20	
Office Safe Room	1	Closed Hanging	G	As needed	40	37.5	234	78.00	$ 15.21	$ 5.07	
Office Bathroom	1	Closed Hanging	G	NA	40						
Parts I	12	Closed Flush	G	6a-5p	40	55	2745.6	1372.80	$ 178.46	$ 89.23	
Parts II	12	Open Hanging	G	As needed	40	37.5	1638	936.00	$ 106.47	$ 60.84	
Tire Front	24	Open Hanging	J	6a-5p	42	55	4804.8	2882.88	$ 312.31	$ 187.39	
Tire Back	4	Open Hanging	J	As needed	42	37.5	546	327.60	$ 35.49	$ 21.29	
Tire Storage	8	Open Hanging	J	As needed	42	37.5	1092	655.20	$ 70.98	$ 42.59	
Office	16	Closed Hanging	G	6a-5p	40	55	3203.2	1830.40	$ 208.21	$ 118.98	
Shed	26	Open Hanging	J	6a-5p	42	55	5205.2	3123.12	$ 338.34	$ 203.00	
Shed	6	Open Hanging	J	6a-5p	42	55	514.8	720.72	$ 33.46	$ 46.85	
Shed	6	Open Hanging	J	Dawn til dusk 7 days/wk	42	70	1528.8	917.28	$ 99.37	$ 59.62	
Storage	6	Open Hanging	J	6a-5p	42	55	1201.20	720.72	$ 78.08	$ 46.85	
						TOTAL	50684.92	28377.39	$3,294.52	$1,844.53	

Fixture D	Elite 4-OW1IP-8000L-DIM10-MVOLT-40K-85-OW1IPFL-SSL	$275.00	60W
Fixture E	HE Williams GC-L120/840-W-DIM-UNV	$210.00	100W
Fixture F	Elite 24-FPL1-LED-5000L-DIM10-MVOLT-35K-85	$85.00	41W
Fixture G	Elite 4-OEC-LED-4000L-DIM10-MVOLT-35K-85	$85.00	40W
Fixture J	Elite 4-OEW-LED-4000L-DIM10-MVOLT-40K-85	$71.00	42W

Table 8: Energy Saving Analysis for ALR's Design Proposal

Room	Existing Energy Use (kWh)	LED Replace	Upgraded Energy Demand/fixture (W)	Hour/week (avg.)	Upgraded Energy Use (kWh)	Energy Cost Existing	Energy Cost Upgrade	Savings
Parts I	2745.6	C	35.1	55	1204.632	$ 178.46	$ 78.30	$ 100.16
Parts II	1638	C	35.1	37.5	821.34	$ 106.47	$ 53.39	$ 53.08
Tire Front	4804.8	C	35.1	55	2409.264	$ 312.31	$ 156.60	$ 155.71
Tire Back	546	C	35.1	37.5	273.78	$ 35.49	$ 17.80	$ 17.69
Tire Storage	1092	C	35.1	37.5	547.56	$ 70.98	$ 35.59	$ 35.39
Office	3203.2	F	28.9	55	1322.464	$ 208.21	$ 85.96	$ 122.25
Shed	5205.2	D	51	55	3792.36	$ 338.34	$ 246.50	$ 91.83
Shed	514.8	D	51	55	875.16	$ 33.46	$ 56.89	$ (23.42)
Shed	1528.8	D	51	70	1113.84	$ 99.37	$ 72.40	$ 26.97
Storage	1201.2	C	35.1	55	602.316	$ 78.08	$ 39.15	$ 38.93
Open Area	3931.2	D	51	168	4009.824	$ 255.53	$ 260.64	$ (5.11)
Shop	3003	A	70	55	1401.4	$ 195.20	$ 91.09	$ 104.10
Shop	3432	A	70	55	800.8	$ 223.08	$ 52.05	$ 171.03
Shop	143	LED	50	55	143	$ 9.30	$ 9.30	$ -
Shop	5491.2	H	75	55	3432	$ 356.93	$ 223.08	$ 133.85
Shop	800.8	G	35	55	400.4	$ 52.05	$ 26.03	$ 26.03
Break Room	NA	F	28.9		NA	$ -	$ -	$ -
RR1	NA	F	28.9		NA	$ -	$ -	$ -
RR2	314.6	F	43	55	122.98	$ 20.45	$ 7.99	$ 12.46
Car Wash	800.8	B	49	55	560.56	$ 52.05	$ 36.44	$ 15.62
Car Wash	572	B	49	55	280.28	$ 37.18	$ 18.22	$ 18.96
Car Wash	1716	B	49	55	280.28	$ 111.54	$ 18.22	$ 93.32
Heavy Duty Shop	1189.76	A	70	55	2602.6	$ 77.33	$ 169.17	$ (91.83)
Heavy Duty Shop Under Truck	1029.6	E	88	55	755.04	$ 66.92	$ 49.08	$ 17.85
Office Main	5547.36	F	28.9	63.5	1335.9892	$ 360.58	$ 86.84	$ 273.74
Office Safe Room	234	F	28.9	37.5	56.355	$ 15.21	$ 3.66	$ 11.55
Office Bathroom		F	28.9	NA		$ -	$ -	$ -
	50684.92				29144.2242	$ 3,294.520	$ 1,894.375	$ 1,400.145

Table 9: Energy Saving Analysis for CAL Lighting's Design Proposal

Area	Fixture Type	LED Replace	Bulb Type	B/F Use	B/F Max	Fixtures	Existing Luminance (Averaged)	Upgraded Luminance (Estimated Average)	Target Brightness	Better Brightness ?	Meet Target Brightness?
Parts I	Closed Flush	G	T8-48"	2	2	12	397.2	783	250	TURE	TURE
Parts II	Open Hanging	G	T8-48"	2	2	12	326.4	615	250	TURE	TURE
Tire Front	Open Hanging	J	T8-48"	2	3	24					
Tire Back	Open Hanging	J	T8-48"	2	2	4					
Tire Storage	Open Hanging	J	T8-48"	2	2	8					
Office	Closed Hanging	G	T8-48"	2	2	16					
Shed	Open Hanging	J	T8-48"	2	2	26					
Shed	Open Hanging	J	T8-48"	1	1	6	272	1661	1000	TURE	TURE
Shed	Open Hanging	J	T8-48"	2	2	6					
Storage	Open Hanging	J	T8-48"	2	2	6					
Open Area	Open HID High Bay	LED	LED	1	1	9					
Shop	Open HID High Bay		CFL	1	1	7					
Shop	Open HID High Bay		Halide	1	1	4					
Shop	Open HID High Bay	G x 24	LED	1	1	1	706	770	750	TURE	TURE
Shop	Open Fluorescent		T8-96"	2	3	16					
Shop	Open Fluorescent		T8-48"	2	3	4					
Break Room	Closed Flush to Ceiling	LED	LED	2	2	2					
RR1	Closed Hanging	LED	LED	2	2	1					
RR2	Open Fluorescent	J	T8-96"	2	2	1					
Car Wash	Closed Hanging	D	T8-48"	2	2	4					
Car Wash	Open HID High Bay	D	LED	1	1	2					
Car Wash	Open HID High Bay	D	CFL?	1	1	2					
Heavy Duty Shop	Open HID High Bay	E	FC12T9	1	1	13	632.556667	1228	750	TURE	TURE
Heavy Duty Shop Under Truck	?	LED	LED?	2	2	3					
Office Main	Closed Flush to Ceiling	F	T8-48"	4	4	14					
Office Safe Room	Closed Hanging	G	T8-48"	4	4	1					
Office Bathroom	Closed Hanging	G	T8-48"	4	4	1					

Fixture D	Elite 4-OW1IP-8000L-DIM10-MVOLT-40K-85-OW1IPFL-SSL	60W
Fixture E	HE Williams GC-L120/840-W-DIM-UNV	100W
Fixture F	Elite 24-FPL1-LED-5000L-DIM10-MVOLT-35K-85	41W
Fixture G	Elite 4-OEC-LED-4000L-DIM10-MVOLT-35K-85	40W
Fixture J	Elite 4-OEW-LED-4000L-DIM10-MVOLT-40K-85	42W

Table 10: Lighting Performance of the Critical Areas for ALR's Design Proposal

Room	Fixture Type	Fixtures	LED Replace	Existing Luminance (Averaged)	Upgraded Luminance (Estimated Average)	Target Brightness	Better Brightness ?	Meet Target Brightness?
Parts I	Closed Flush	12	C	397.2	1154	250	TRUE	TURE
Parts II	Open Hanging	12	C	326.4	895	250	TRUE	TURE
Tire Front	Open Hanging	24	C					
Tire Back	Open Hanging	4	C					
Tire Storage	Open Hanging	8	C					
Office	Closed Hanging	16	F					
Shed	Open Hanging	26	D					
Shed	Open Hanging	6	D	272	1014	1000	TRUE	TURE
Shed	Open Hanging	6	D					
Storage	Open Hanging	6	C					
Open Area	Open HID High Bay	9	D					
Shop	Open HID High Bay	7	A					
Shop	Open HID High Bay	4	A					
Shop	Open HID High Bay	1	LED	706	500	750	FALSE	FALSE
Shop	Open Fluorescent	16	H					
Shop	Open Fluorescent	4	G					
Break Room	Closed Flush to Ceiling	2	F					
RR1	Closed Hanging	1	F					
RR2	Open Fluorescent	1	F					
Car Wash	Closed Hanging	4	B					
Car Wash	Open HID High Bay	2	B					
Car Wash	Open HID High Bay	2	B					
Heavy Duty Shop	Open HID High Bay	13	A	633	782	750	TRUE	TURE
Heavy Duty Shop Under Truck	?	3	F					
Office Main	Closed Flush to Ceiling	14	F					
Office Safe Room	Closed Hanging	1	F					
Office Bathroom	Closed Hanging	1	F					

Table 11: Lighting Performance of the Critical Areas for CAL Lighting's Design Proposal