

Exterior Lighting Assessment

conducted for

Saguaro National Park



NPS NATURAL SOUNDS AND NIGHT SKIES DIVISION

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OVERVIEW

This report provides details of the exterior lighting assessment carried out at Saguaro National Park on August 8th, 2020.

The first section of this report provides an inventory of all existing exterior artificial lighting throughout the Park. The assessed inventory provides an overview of the Park's existing lighting compliance with the International Dark Sky Association's (IDA) Dark Sky Lighting Guidelines. The inventory and assessment are required components within the IDA's Dark Sky Park application. The information presented in this section of the report can be used directly to satisfy this requirement. The first section starts with an overall summary of the lighting inventory and compliance, then presents location by location specifics for the conducted lighting inventory and assessment.

The second section of this report includes design recommendations that Saguaro may choose to explore to support their Dark Sky Park efforts. This section discusses applicable codes and standards, roles and responsibilities, and provides details about the replacement fixtures and lamps called out in the report. This section ends by exploring individual fixture recommendations to meet the existing IDA lighting guidelines.

Saguaro National Park is a unique natural landscape located directly adjacent to an urban area. Seeking a Dark Sky Park certification for Saguaro represents a tremendous opportunity to further night sky conservation, while highlighting the quality of the night sky that can be observed within a park when an entire region decides to reduce light pollution through collaborative planning, conservation efforts, and ordinances.

EVALUATION OF EXISTING LIGHTING CONDITIONS

Summary

This section includes characterization data for all of the fixtures identified within Saguaro National Park. Each fixture was evaluated against the following characteristics:

- Location (longitude and latitude)
- Fixture Type
- Lamp Type
- Height of Fixture (in feet)
- Lamps per Fixture
- Application
- Shielding
- Correlated Color Temperature
- Compliance with IDA's Dark Sky Park Lighting Guidelines

For the evaluation, all fixtures were visually inspected and characterized by the sampling team. Fixture shielding was conservatively assessed. Only fixtures that were fully-shielded were listed as fully-shielded. Fully-shielded fixtures are fixtures that are either:

- constructed so that all of the light emitted by the fixture is projected below the horizontal plane of the lowest point of the fixture in all directions, or
- installed in locations where the architectural details of the building ensure that emitted light is projected below the horizontal plane of the lowest point of the eave in all directions.

Correlated color temperature (CCT) was evaluated for each lamp by:

1. accessing the lamp and reading the relevant lamp information printed on the lamp body/panel or identification based upon the lamp itself,
2. taking a direct measurement of CCT using an Ascentek Lighting Passport device, or
3. talking to park officials responsible for lighting when the fixtures were either not accessible or not on during visits or were known based upon building specifications.

Fully-shielded fixtures containing lamps with CCT less than or equal to 3000 degrees Kelvin were assessed to be compliant with IDA's Dark Sky Lighting guidelines. Additionally, IDA guidelines allow for allowable exceptions for unshielded fixtures when the fixtures are used within special conditions. Allowable exceptions include fixtures required by code for emergency purposes, fixtures containing lamps with less than 500 lumens used for special purposes, fixtures containing motion sensors with the sensor set to the shortest time duration and fixtures controlled by a timer, timer switch, or computer system so that they cannot be left on all night.

The lighting inventory data is provided as map overlays, within summary tables, and through an online story map. The map overlays (presented as figures within this report) include fixture

identification numbers and a quick to read coded designation of whether or not the fixture meets IDA dark sky lighting guidelines. Fixtures indicated with a red dot do not meet IDA lighting guidelines, while fixtures indicated with a green dot meet the guidelines.

The online story map contains all of the characterization data (including photographs for each fixture) and is accessible through:

<https://arcg.is/0meXSu>

When prompted, enter: Username: SaguaroInventory Password: SaguaroInventory2020

Overall, 188 individual fixtures were identified and characterized during the on-site visit (Figure 1). Currently, 61.7% (116 fixtures) of exterior artificial lighting within Saguaro National Park is compliant with IDA’s lighting guidelines. The breakdown of fixtures within each main Park area is presented in Table 1.



Figure 1. Fixtures Identified within Saguaro National Park. Dots indicate locations of existing fixtures.

Table 1. Exterior Lighting Fixture IDA Dark Sky Lighting Guidelines Compliance by Facility Area

<u>Location Area</u>	<u>Total # of Fixtures</u>	<u>Total # Dark Sky Compliant Fixtures</u>	<u>% of Dark Sky Compliant Fixtures</u>
EAST UNIT			
<i>Fire Operations</i>	11	9	81.8
<i>Greene Property</i>	17	5	29.4
<i>Heli Pad / Magnetic Observatory</i>	5	0	0
<i>Quarters 14, 15, 16</i>	10	7	70
<i>Horse Corral</i>	4	1	25
<i>Headquarters</i>	9	5	55.6
<i>Rincon Mountain VC Area</i>	26	15	57.7
<i>Maintenance Area</i>	6	0	0
WEST UNIT			
<i>Maintenance Area</i>	10	1	10
<i>Quarters 30, 31, 32</i>	19	15	78.9
<i>Operations Building</i>	14	13	92.8
<i>Red Hills Visitor Center</i>	57	45	78.9
Total for All Areas	188	116	61.7

Rincon Mountain District

There were 88 identified fixtures within the Rincon Mountain District (Figure 2). 47.7% (42 fixtures) of the lighting in the district is compliant with IDA lighting guidelines. The Rincon Mountain District contains the Fire Operations Complex; Greene Property; Heli Pad / Magnetic Observatory; Quarters 14, 15, and 16; the Horse Corral, the Headquarters Building, the Visitor Center area, and the Maintenance Area. Details of each facility within the area follow within this subsection.

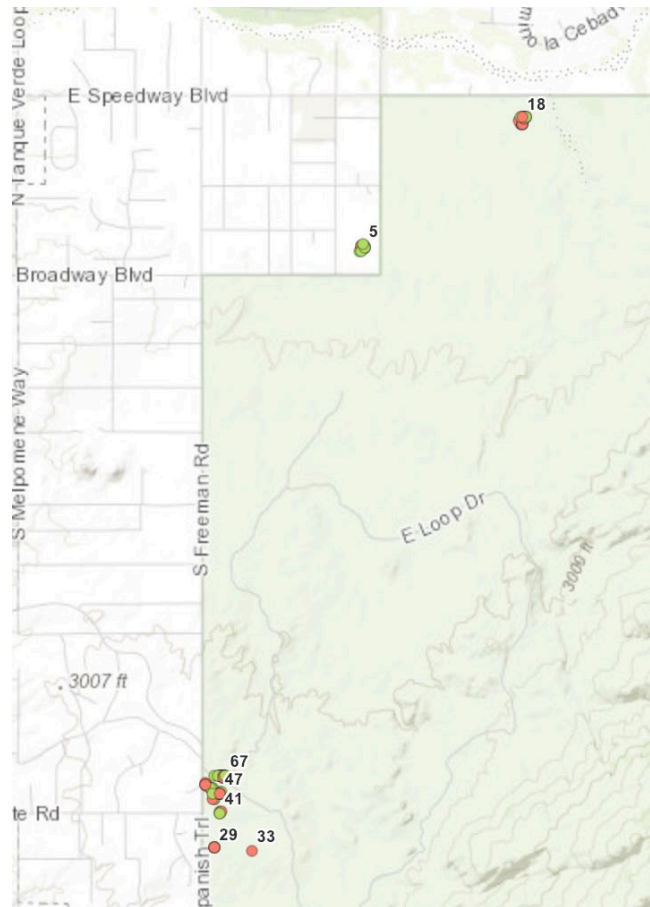


Figure 2. Fixtures Identified within the East Unit of Saguaro National Park. Dark sky compliant lighting has a green marker and non-compliant lighting has a red marker. Details follow within this subsection.

Fire Operations

There were 11 identified fixtures within the Fire Operations Complex (Figure 3). 81.8% (9 fixtures) of the existing lighting in this complex is compliant with IDA lighting guidelines. A summary of all the lighting in this area is presented in Table 3.



Figure 3. Fixture Compliance with Dark Sky Guidelines for the Fire Operations Complex. Dark sky compliant lighting has a green marker and non-compliant lighting has a red marker.

Table 3. Summary of the Fire Operations Complex Lighting Evaluation

Location	Fixture ID	Description Fixture, Lamp, Height (ft), CCT (K)	Fully-Shielded	Application	Special Purpose	Conformity with IDA Lighting Guidelines
Fire Operations Center	1	Lamp Post, HPS, 16, 1800	Yes	Parking	No	Yes
	2	Lamp Post, HPS, 16, 1800	Yes	Parking	No	Yes
	3	Lamp Post, HPS, 16, 1800	Yes	Parking	No	Yes
	4	Recessed, HPS, 4, 1800	Yes	Entrance/Egress	No	Yes
	5	Recessed, HPS, 4, 1800	Yes	Entrance/Egress	No	Yes
	6	Recessed, HPS, 4, 1800	Yes	Entrance/Egress	No	Yes
	7	Recessed, HPS, 4, 1800	Yes	Entrance/Egress	No	Yes
	8	Recessed, HPS, 4, 1800	Yes	Entrance/Egress	No	Yes
	9	Recessed, HPS, 4, 1800	Yes	Entrance/Egress	No	Yes
	10	Wall Sconce, Fluorescent, 7, 2700	No	Entrance/Egress	No	No
	11	Wall Sconce, Fluorescent, 7, 2700	No	Entrance/Egress	No	No

Greene Property

There were 17 identified fixtures throughout the Greene Property (Figure 4). 29.4% (5 fixtures) of the existing fixtures at the property are compliant with IDA lighting guidelines. A summary of all the lighting in this area is presented in Table 4.



Figure 4. Fixture Compliance with Dark Sky Guidelines for Visitor Center Area Bollards. Dark sky compliant lighting has a green marker and non-compliant lighting has a red marker.

Table 4. Summary of the Greene Property Lighting Evaluation

Location	Fixture ID	Description Fixture, Lamp, Height (ft), CCT (K)	Fully-Shielded	Application	Special Purpose	Conformity with IDA Lighting Guidelines
Greene Property	12	Wall Sconce, Incandescent, 6, 2700	No	Entrance/Egress	No	No
	13	Wall Sconce, Empty Socket, 6,	No	Entrance/Egress	No	No
	14	Flood, Empty Socket, 8,	No	Entrance/Egress	No	No
	15	Wall Sconce, Empty Socket, 6,	No	Entrance/Egress	No	No
	16	Wall Sconce, Incandescent, 6,	No	Entrance/Egress	No	No
	17	Flood, Empty Socket, 8,	No	Entrance/Egress	No	No
	18	Flood, Fluorescent, 10, 2700	No	Entrance/Egress	No	No
	19	Wall Sconce, Empty Socket, 6, 2700	No	Entrance/Egress	No	Yes
	20	Wall Sconce, Empty Socket, 6, 2700	No	Entrance/Egress	No	Yes
	21	Lamp Post, LED, 28, 3000	Yes	Area	No	Yes
	22	Flood, Halogen, 8.5, 2700	No	Entrance/Egress	No	No
	23	Hanging Light, Incandescent, 7.5, 2700	Yes	Area	No	Yes
	24	Hanging Light, Incandescent, 7.5, 2700	Yes	Area	No	Yes
	25	Flood, Incandescent, 10, 2700	No	Entrance/Egress	No	No
	26	Flood, Halogen, 8, 2700	No	Entrance/Egress	No	No
	27	Wall Sconce, Incandescent, 6, 2700	No	Entrance/Egress	No	No
28	Flood, Incandescent, 8.5, 2700	No	Entrance/Egress	No	No	

Heli Pad / Magnetic Observatory

There are 5 identified fixtures in this area (Figure 5). None of the existing lighting is compliant with IDA lighting guidelines. A summary of all the lighting in this area is presented in Table 5.



Figure 5. Fixture Compliance with Dark Sky Guidelines for the Heli Pad / Magnetic Observatory Area. Dark sky compliant lighting has a green marker and non-compliant lighting has a red marker.

Table 5. Summary of the Heli Pad / Magnetic Observatory Lighting Evaluation

Location	Fixture ID	Description Fixture, Lamp, Height (ft), CCT (K)	Fully-Shielded	Application	Special Purpose	Conformity with IDA Lighting Guidelines
Heli Pad / Magnetic Observatory	29	Ceiling Mount, HPS, 11.5, 1800	No	Area	No	No
	30	Ceiling Mount, HPS, 11.5, 1800	No	Area	No	No
	31	Wall Pack, HPS, 8.5, 1800	No	Area	No	No
	32	Wall Pack, HPS, 8.5, 1800	No	Area	No	No
	33	Flood, Halogen, 7, 2700	No	Entrance/Egress	No	No

Quarters 14, 15, 16

There were 10 identified fixtures on the residential quarters in the Rincon Mountain District (Figure 6). 70% (7 fixtures) of the existing lighting is compliant with IDA lighting guidelines. A summary of all the lighting in this area is presented in Table 6.



Figure 6. Fixture Compliance with Dark Sky Guidelines for Quarters 14, 15, and 16. Dark sky compliant lighting has a green marker and non-compliant lighting has a red marker.

Table 6. Summary of Quarters 14, 15, and 16 Exterior Lighting Evaluation

Location	Fixture ID	Description Fixture, Lamp Height (ft), CCT (K)	Fully-Shielded	Application	Special Purpose	Conformity with IDA Lighting Guidelines
Quarters 14, 15, and 16	34	Flood, LED, 7, 5000	Yes	Entrance/Egress	Motion Sensor	Yes
	35	Flood, Halogen, 7, 2700	No	Entrance/Egress	Motion Sensor	Yes
	36	Wall Sconce, LED, 7, 2700	No	Entrance/Egress	No	No
	37	Flood, LED, 7, 5000	Yes	Entrance/Egress	Motion Sensor	Yes
	38	Wall Sconce, Fluorescent, 7, 6500	No	Entrance/Egress	No	No
	39	Wall Sconce, LED, 7, 2700	No	Entrance/Egress	No	No
	85	Flood, LED, 7, 5000	Yes	Entrance/Egress	Motion Sensor	Yes
	86	Flood, LED, 7, 5000	Yes	Entrance/Egress	Motion Sensor	Yes
	87	Flood, LED, 7, 5000	Yes	Entrance/Egress	Motion Sensor	Yes
	88	Flood, LED, 7, 5000	Yes	Entrance/Egress	Motion Sensor	Yes

Horse Corral

There were 4 identified fixtures on the horse corral (Figure 7). 25% (1 fixture) of the existing lighting is compliant with IDA lighting guidelines. A summary of all the lighting in this area is present in Table 7.



Figure 7. Fixture Compliance with Dark Sky Guidelines for the Horse Corral. Dark sky compliant lighting has a green marker and non-compliant lighting has a red marker.

Table 7. Summary of the Horse Corral Exterior Lighting Evaluation

Location	Fixture ID	Description Fixture, Lamp, Height (ft), CCT (K)	Fully-Shielded	Application	Special Purpose	Conformity with IDA Lighting Guidelines
Horse Corral	40	Ceiling Mount, LED, 8, 5000	Yes	Area	No	No
	41	Ceiling Mount, LED, 10, 5000	Yes	Area	No	Yes
	42	Flood, LED, 9, 5000	Yes	Entrance/Egress	No	No
	43	Flood, LED, 11, 5000	Yes	Entrance/Egress	No	No

Headquarters Building

There were 9 identified fixtures within the Headquarters Building and Annex (Figure 8). 55.5% (5 fixtures) of lighting on the Headquarters Building is compliant with IDA lighting guidelines. A summary of all the lighting in this area is present in Table 8.



Figure 8. Fixture Compliance with Dark Sky Guidelines for the Headquarters Building and Annex. Dark sky compliant lighting has a green marker and non-compliant lighting has a red marker.

Table 8. Summary of the Headquarters Building and Annex Lighting Evaluation

Location	Fixture ID	Description Fixture, Lamp, Height (ft), CCT (K)	Fully-Shielded	Application	Special Purpose	Conformity with IDA Lighting Guidelines
Headquarters Building and Annex	44	Flood, LED, 8, 5000	Yes	Entrance/Egress	Motion Sensor	Yes
	45	Wall Sconce, Fluorescent, 7, 2700	Yes	Entrance/Egress	No	Yes
	46	Wall Sconce, Fluorescent, 7, 1600	Yes	Entrance/Egress	Motion Sensor	Yes
	47	Ceiling Mount, Fluorescent, 8.5, 2700	No	Pathway	No	No
	48	Ceiling Mount, Fluorescent, 8.5, 2700	No	Pathway	No	No
	49	Ceiling Mount, Fluorescent, 8.5, 2700	No	Pathway	No	No
	50	Ceiling Mount, Fluorescent, 8.5, 2700	No	Pathway	No	No
	51	Flood, LED, 8, 5000	Yes	Entrance/Egress	Motion Sensor	Yes
	52	Wall Sconce, Fluorescent, 7, 2700	Yes	Entrance/Egress	No	Yes

Rincon Mountain Visitor Center Area

There were 26 identified fixtures in and around the Visitor Center (Figure 9). 56.7% (15 fixtures) of the existing lighting is compliant with IDA lighting guidelines. A summary of all the lighting in this area is present in Table 9.

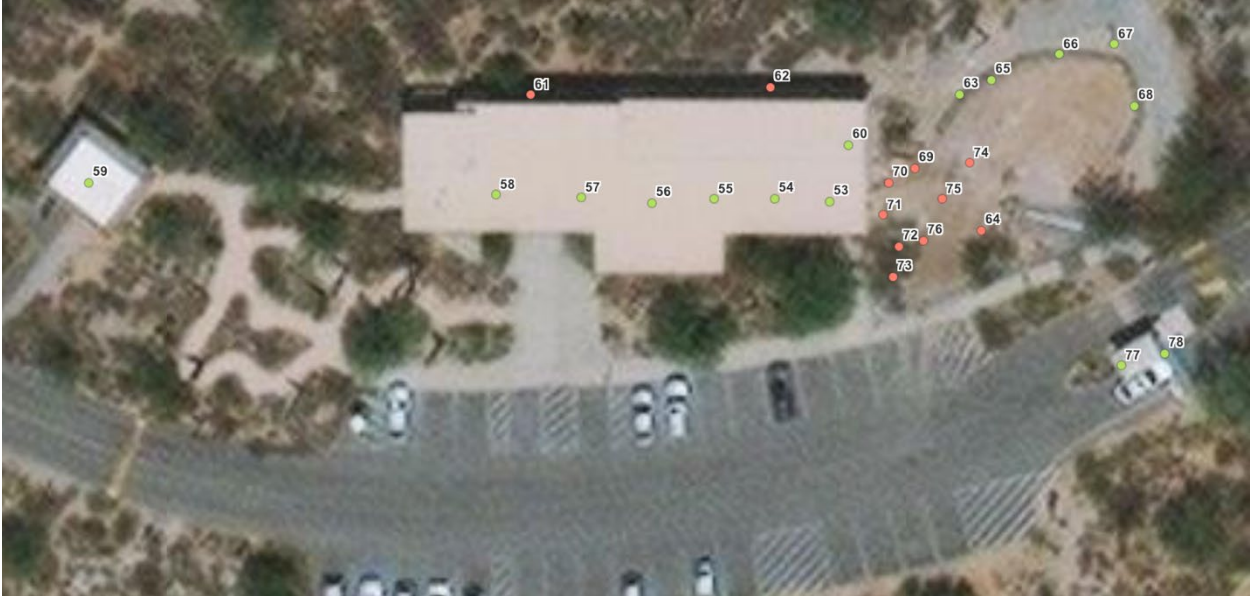


Figure 9. Fixture Compliance with Dark Sky Guidelines for the Rincon Mountain Visitor Center Area. Dark sky compliant lighting has a green marker and non-compliant lighting has a red marker.

Table 9. Summary of the Rincon Mountain Visitor Center Area Lighting Evaluation

Location	Fixture ID	Description Fixture, Lamp, Height (ft), CCT (K)	Fully-Shielded	Application	Special Purpose	Conformity with IDA Lighting Guidelines
Rincon Mountain Visitor Center Area	53	Ceiling Mount, Fluorescent, 10, 2700	Yes	Area	No	Yes
	54	Ceiling Mount, Fluorescent, 10, 2700	Yes	Area	No	Yes
	55	Ceiling Mount, Fluorescent, 10, 2700	Yes	Area	No	Yes
	56	Ceiling Mount, Fluorescent, 10, 2700	Yes	Area	No	Yes
	57	Ceiling Mount, Fluorescent, 10, 2700	Yes	Area	No	Yes
	58	Ceiling Mount, Fluorescent, 10, 2700	Yes	Area	No	Yes
	59	Ceiling Mount, Fluorescent, 8, 2700	Yes	Area	No	Yes
	60	Ceiling Mount, Fluorescent, 10, 2700	Yes	Area	No	Yes
	61	Wall Sconce, Fluorescent, 9, 2700	No	Area	No	No
	62	Wall Sconce, Fluorescent, 9, 2700	No	Area	No	No
	63	Recessed, LED, 1, 3000	Yes	Pathway	No	Yes
	64	Other, LED, 0, 3000	No	Pathway	No	No
	65	Recessed, LED, 1, 3000	Yes	Pathway	No	Yes
	66	Recessed, LED, 1, 3000	Yes	Pathway	No	Yes
	67	Recessed, LED, 1, 3000	Yes	Pathway	No	Yes
	68	Recessed, LED, 1, 3000	Yes	Pathway	No	Yes
	69	Other, LED, 0, 3000	No	Pathway	No	No
	70	Other, LED, 0, 3000	No	Pathway	No	No
	71	Other, LED, 0, 3000	No	Pathway	No	No
	72	Other, LED, 0, 3000	No	Pathway	No	No
	73	Other, LED, 0, 3000	No	Pathway	No	No
	74	Other, LED, 0, 3000	No	Pathway	No	No
	75	Other, LED, 0, 3000	No	Pathway	No	No
	76	Other, LED, 0, 3000	No	Pathway	No	No
	77	Wall Pack, LED, 8, 2700	Yes	Area	No	Yes
	78	Wall Pack, LED, 8, 1600	Yes	Area	No	Yes

Rincon Mountain District Maintenance Area

There were 6 identified fixtures in the Rincon Mountain District Maintenance Area (Figure 10). None of the existing lighting is compliant with IDA lighting guidelines. A summary of all the lighting in this area is present in Table 10.



Figure 10. Fixture Compliance with Dark Sky Guidelines for the Rincon Mountain District Maintenance Area. Dark sky compliant lighting has a green marker and non-compliant lighting has a red marker.

Table 10. Summary of the Maintenance Area Exterior Lighting Evaluation

Location	Fixture ID	Description Fixture, Lamp, Height (ft), CCT (K)	Fully-Shielded	Application	Special Purpose	Conformity with IDA Lighting Guidelines
Rincon Mountain District Maintenance Area	79	Flood, LED, 10.5, 5000	Yes	Entrance/Egress	No	No
	80	Flood, LED, 10.5, 5000	Yes	Entrance/Egress	No	No
	81	Flood, LED, 12, 5000	Yes	Entrance/Egress	No	No
	82	Flood, LED, 12, 5000	Yes	Entrance/Egress	No	No
	83	Flood, LED, 12, 5000	No	Entrance/Egress	No	No
	84	Flood, LED, 8, 5000	No	Entrance/Egress	No	No

Tucson Mountain District

There were 100 identified fixtures within the Tucson Mountain District of the Park (Figure 11). 74% (74 fixtures) of the lighting in the District is compliant with IDA lighting guidelines. The District contains a Maintenance Area; Quarters 30, 31, and 32; the Operations Building; and the Red Hills Visitor Center. Details of each facility within the area follow within this subsection.

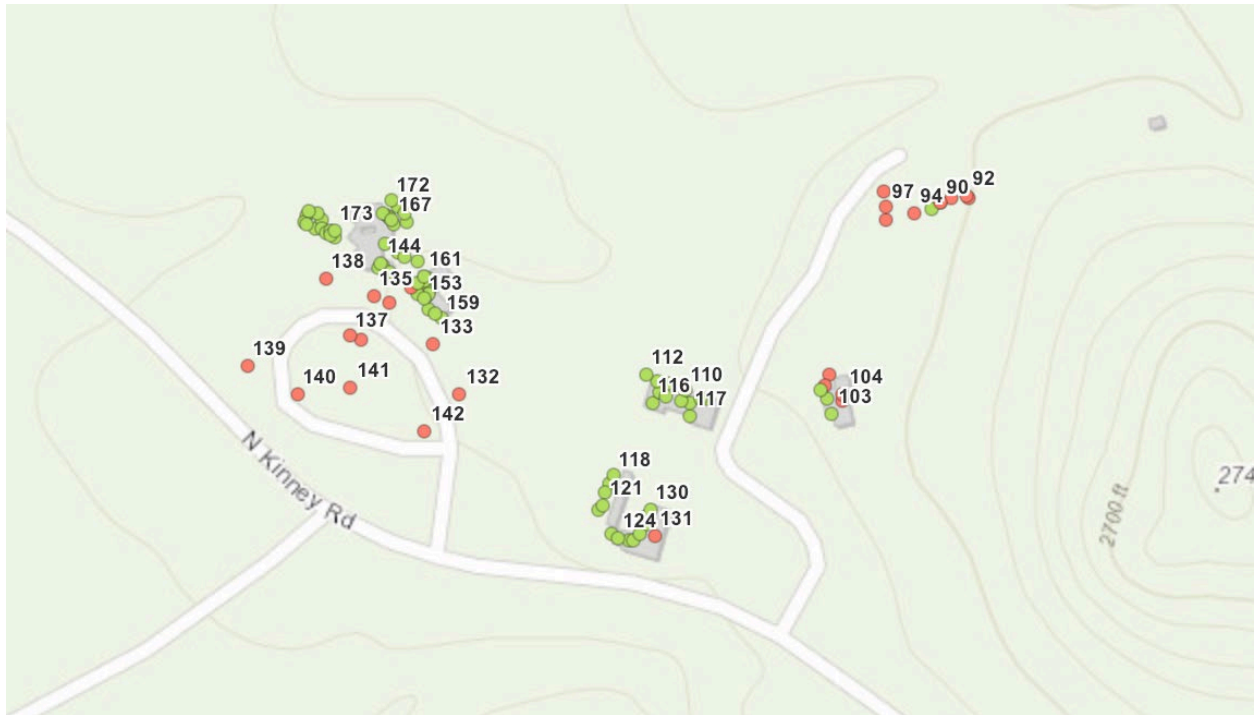


Figure 11. Fixtures Identified within the Tucson Mountain District of Saguaro National Park. Dark sky compliant lighting has a green marker and non-compliant lighting has a red marker. Details follow within this subsection.

Tucson Mountain District Maintenance Area

There were 10 identified fixtures within the Tucson Mountain District Maintenance Area (Figure 12). 10% (1 fixture) of the exterior lighting in this area is compliant with IDA lighting guidelines. A summary of all the lighting in this area is present in Table 12.



Figure 12. Fixtures Identified within the Tucson Mountain District Maintenance Area. Dark sky compliant lighting has a green marker and non-compliant lighting has a red marker.

Table 12. Summary of the Tucson Mountain District Maintenance Area Exterior Lighting Evaluation

Location	Fixture ID	Description Fixture, Lamp, Height (ft), CCT (K)	Fully-Shielded	Application	Special Purpose	Conformity with IDA Lighting Guidelines
Tucson Mountain District Maintenance Area	89	Wall Pack, HPS, 9.5, 1800	No	Area	No	No
	90	Wall Pack, HPS, 9.5, 1800	No	Area	No	No
	91	Ceiling Mount, Fluorescent, 10.5, 5000	Yes	Area	No	No
	92	Ceiling Mount, Fluorescent, 10.5, 5000	Yes	Area	No	No
	93	Wall Pack, HPS, 9.5, 1800	No	Area	No	No
	94	Wall Pack, HPS, 9.5, 1800	No	Area	No	No
	95	Ceiling Mount, Fluorescent, 10.5, 3000	Yes	Entrance/Egress	Motion Sensor	Yes
	96	Wall Sconce, Fluorescent, 8, 3000	No	Area	No	No
	97	Wall Sconce, Fluorescent, 8, 3000	No	Area	No	No
	98	Wall Sconce, Fluorescent, 8, 3000	No	Area	No	No

Quarters 30, 31, 32

There were 19 identified fixtures present on Quarters 30, 31, and 32. 78.9% (15 fixtures) of the exterior lighting in these buildings is compliant with IDA lighting guidelines. A summary of all the lighting in this area is present in Table 13.



Figure 13. Fixture Compliance with Dark Sky Guidelines for Quarters 30, 31, and 32. Dark sky compliant lighting has a green marker and non-compliant lighting has a red marker.

Table 13. Summary of Quarters 30, 31, and 32 Exterior Lighting Evaluation

Location	Fixture ID	Description Fixture, Lamp, Height (ft), CCT (K)	Fully-Shielded	Application	Special Purpose	Conformity with IDA Lighting Guidelines
Quarters 30, 31, and 32	99	Wall Sconce, Fluorescent, 7, 2700	No	Area	No	No
	100	Wall Sconce, Fluorescent, 7, 2700	No	Area	No	No
	101	Wall Sconce, Fluorescent, 7, 2700	Yes	Area	No	Yes
	102	Wall Sconce, Fluorescent, 7, 2700	Yes	Area	No	Yes
	103	Wall Sconce, Fluorescent, 7, 2700	Yes	Area	No	Yes
	104	Wall Sconce, Fluorescent, 7, 2700	No	Area	No	No
	105	Wall Sconce, Fluorescent, 7, 2700	No	Area	No	No
	106	Ceiling Mount, Fluorescent, 9.5, 3000	Yes	Area	No	Yes
	107	Ceiling Mount, Fluorescent, 9.5, 3000	Yes	Area	No	Yes
	108	Ceiling Mount, Fluorescent, 9.5, 2700	Yes	Area	No	Yes
	109	Ceiling Mount, Fluorescent, 9.5, 2700	Yes	Area	No	Yes
	110	Flood, Halogen, 9, 2700	Yes	Area	No	Yes
	111	Flood, Halogen, 9, 2700	Yes	Area	No	Yes
	112	Flood, Halogen, 9, 2700	Yes	Area	No	Yes
	113	Flood, Halogen, 9, 2700	Yes	Area	No	Yes
	114	Ceiling Mount, Fluorescent, 9.5, 2700	Yes	Area	No	Yes
	115	Ceiling Mount, Fluorescent, 9.5, 2700	Yes	Area	No	Yes
116	Ceiling Mount, Fluorescent, 9.5, 2700	Yes	Area	No	Yes	
117	Ceiling Mount, Fluorescent, 9.5, 2700	Yes	Area	No	Yes	

Operations Building

There were 14 identified fixtures present on the Operations Building. 92.9% (13 fixtures) of the exterior lighting on the Operations Building is compliant with IDA lighting guidelines. A summary of all the lighting on the building is present in Table 14.



Figure 14. Fixture Compliance with Dark Sky Guidelines for the Operations Building. Dark sky compliant lighting has a green marker and non-compliant lighting has a red marker.

Table 14. Summary of Operations Building Exterior Lighting Evaluation

Location	Fixture ID	Description Fixture, Lamp, Height (ft), CCT (K)	Fully-Shielded	Application	Special Purpose	Conformity with IDA Lighting Guidelines
Operations Building	118	Wall Sconce, LED, 8, 5000	Yes	Area	Motion Sensor	Yes
	119	Wall Sconce, LED, 8, 5000	Yes	Area	Motion Sensor	Yes
	120	Wall Sconce, LED, 8, 5000	Yes	Area	Motion Sensor	Yes
	121	Wall Sconce, LED, 8, 5000	Yes	Area	Motion Sensor	Yes
	122	Wall Sconce, LED, 8, 5000	Yes	Area	Motion Sensor	Yes
	123	Recessed, LED, 9.5,	Yes	Area	Motion Sensor	Yes
	124	Recessed, LED, 9.5,	Yes	Area	Motion Sensor	Yes
	125	Recessed, LED, 9.5,	Yes	Area	Motion Sensor	Yes
	126	Recessed, LED, 9.5,	Yes	Area	Motion Sensor	Yes
	127	Recessed, LED, 9.5,	Yes	Area	Motion Sensor	Yes
	128	Recessed, LED, 9.5,	Yes	Area	Motion Sensor	Yes
	129	Recessed, LED, 9.5,	Yes	Area	Motion Sensor	Yes
	130	Recessed, LED, 9.5,	Yes	Area	Motion Sensor	Yes
	131	Wall Sconce, Fluorescent, 7, 2700	No	Entrance/Egress	No	No

Red Hills Visitor Center Area

There were 57 identified fixtures within the Red Hills Visitor Center Area. 78.8% (45 fixtures) of the existing lighting in the vicinity of the Visitor Center is compliant with IDA lighting guidelines. Figure 15a provides compliance and locations of the lighting associated with the visitor center building. Figure 15b provides compliance and locations for the parking lot bollard fixtures. A summary of all the lighting in this area is present in Tables 15a and 15b.



Figure 15a. Fixture Compliance with Dark Sky Guidelines for the Red Hills Visitor Center Building. Dark sky compliant lighting has a green marker and non-compliant lighting has a red marker.



Figure 15b. Fixture Compliance with Dark Sky Guidelines for the Red Hills Visitor Center Parking Lot Bollards. Dark sky compliant lighting has a green marker and non-compliant lighting has a red marker.

Table 15. Summary of the Red Hills Visitor Center Exterior Lighting Evaluation

Location	Fixture ID	Description Fixture, Lamp, Height (ft), CCT (K)	Fully-Shielded	Application	Special Purpose	Conformity with IDA Lighting Guidelines
Visitor Center Bollards	132	Bollard, LED, 3, 4100	No	Pathway	No	No
	133	Bollard, LED, 3, 4100	No	Pathway	No	No
	134	Bollard, LED, 3, 4100	No	Pathway	No	No
	135	Bollard, LED, 3, 4100	No	Pathway	No	No
	136	Bollard, LED, 3, 4100	No	Pathway	No	No
	137	Bollard, LED, 3, 4100	No	Pathway	No	No
	138	Bollard, LED, 3, 4100	No	Pathway	No	No
	139	Bollard, LED, 3, 4100	No	Pathway	No	No
	140	Bollard, LED, 3, 4100	No	Pathway	No	No
	141	Bollard, LED, 3, 4100	No	Pathway	No	No
	142	Bollard, LED, 3, 4100	No	Pathway	No	No
Visitor Center Building	143	Recessed, LED, 9.5, 1600	Yes	Entrance/Egress	No	Yes
	144	Recessed, LED, 9.5, 1600	Yes	Entrance/Egress	No	Yes
	145	Recessed, LED, 9.5, 1600	Yes	Entrance/Egress	No	Yes
	146	WallSconce, LED, 9.5, 2700	Yes	Pathway	No	Yes
	147	WallSconce, LED, 9.5, 2700	Yes	Pathway	No	Yes
	148	WallSconce, LED, 9.5, 2700	Yes	Pathway	No	Yes
	149	Recessed, LED, 9.5, 4000	Yes	Entrance/Egress	No	No
	150	Recessed, LED, 9.5, 2700	Yes	Area	No	Yes
	151	Recessed, LED, 9.5, 2700	Yes	Area	No	Yes
	152	Recessed, LED, 9.5, 1600	Yes	Area	No	Yes
	153	Recessed, Fluorescent, 9.5, 2700	Yes	Entrance/Egress	No	Yes
	154	Recessed, LED, 9.5, 2700	Yes	Entrance/Egress	No	Yes
	155	Recessed, LED, 9.5, 2700	Yes	Entrance/Egress	No	Yes
	156	Recessed, LED, 9.5, 2700	Yes	Entrance/Egress	No	Yes
	157	Recessed, LED, 1, 2700	Yes	Pathway	No	Yes
	158	Recessed, LED, , 2700	Yes	Pathway	No	Yes
	159	Recessed, LED, 1, 2700	Yes	Pathway	No	Yes
	160	Recessed, LED, 9.5, 2700	Yes	Area	No	Yes
	161	Recessed, Fluorescent, 9.5, 2700	Yes	Entrance/Egress	No	Yes
	162	Recessed, Fluorescent, 9.5, 2700	Yes	Area	No	Yes
	163	Recessed, LED, 12.5, 2700	Yes	Entrance/Egress	No	Yes
164	Recessed, LED, 1, 2700	Yes	Pathway	No	Yes	
165	Recessed, LED, 1, 2700	Yes	Pathway	No	Yes	
166	Recessed, LED, 1, 2700	Yes	Pathway	No	Yes	
167	Recessed, LED, 1, 2700	Yes	Pathway	No	Yes	
168	Recessed, LED, 1, 2700	Yes	Pathway	No	Yes	
169	Recessed, LED, 1, 2700	Yes	Pathway	No	Yes	
170	Recessed, LED, 1, 2700	Yes	Pathway	No	Yes	
171	Recessed, LED, 1, 2700	Yes	Pathway	No	Yes	

Location	Fixture ID	Description Fixture, Lamp, Height (ft), CCT (K)	Fully-Shielded	Application	Special Purpose	Conformity with IDA Lighting Guidelines
Visitor Center Building	172	Recessed, LED, 1, 2700	Yes	Pathway	No	Yes
	173	Recessed, LED, 7.5, 2700	Yes	Entrance/Egress	No	Yes
	174	Recessed, LED, 7.5, 2700	Yes	Entrance/Egress	No	Yes
	175	Recessed, LED, 7.5, 2700	Yes	Entrance/Egress	No	Yes
	176	Recessed, LED, 1, 2700	Yes	Pathway	No	Yes
	177	Recessed, LED, 1, 2700	Yes	Pathway	No	Yes
	178	Recessed, LED, 1, 2700	Yes	Pathway	No	Yes
	179	Recessed, LED, 1, 2700	Yes	Pathway	No	Yes
	180	Recessed, LED, 1, 2700	Yes	Pathway	No	Yes
	181	Recessed, LED, 1, 2700	Yes	Pathway	No	Yes

DESIGN RECOMMEDATIONS

Summary

This section includes applicable codes, along with the actions recommended to address existing lighting that is not in compliance with IDA lighting guidelines. The section includes an overall summary of the fixture replacements, lamp replacements and fixture removals recommended to address IDA compliance concerns. The recommendations were made based upon onsite observations, discussions with staff, and previous experience. The presented lighting recommendations include a combination of upgrading existing lighting when appropriate, removing fixtures from power when appropriate, and relamping fixtures to meet historic and/or aesthetic purposes.

Discussion of Exterior Lighting Codes and Standards

The General Services Administration PBS-P100 Facilities Standards for the Public Building Service (March 2015) provides prescriptive lighting requirements in Chapter 6.3 of the standard. The requirements specify that facilities must provide exterior lighting that meets local zoning laws, provides lighting levels that do not exceed the Illuminating Engineering Society (IES) 10th Edition Lighting Handbook, and complies with the IDA/IES Model Lighting Ordinance (MLO).

IDA and IES worked together to develop the MLO which was released in June of 2011. The extent to which lighting is required within the MLO is based upon lighting zone designations. LZ0 (Lighting Zone 0) is the lighting zone recommended for National Park locations by the IDA. The description of LZ0 directly from the ordinance is:

Areas where the natural environment will be seriously and adversely affected by lighting. Impacts include disturbing the biological cycles of flora and fauna and/or detracting from human enjoyment and appreciation of the natural environment. Human activity is subordinate in importance to nature. The vision of human residents and users is adapted to the darkness, and they expect to see little or no lighting. When not needed, lighting should be extinguished.

For LZ0, the performance method of compliance calls for the base lumens per site to be 0 for all sites. This means that according to IDA/IES's MLO, lighting is not required in LZ0 areas. However, the performance method provides an additional allowance to provide illumination for building entrances or exits. The additional allowance is 400 lumens per door, with a maximum of three allowances per site. To be considered an applicable allowance, the luminaire must be within 20 ft of the door.

The GSA standard also specifies that means of egress must be illuminated according to the National Fire Protection Act (NFPA) 101. NFPA101, also known as the *Life Safety Code*, provides the minimum criteria for the design of egress facilities. NFPA 101 1.3 specifies that application of the *Life Safety Code* is applicable to new construction and existing buildings and structures. Chapter 7 of the code covers Means of Egress. Chapter 7 Section 8.1.3 states:

“The floors and other walking surfaces within an exit and within portions of the exit access and exit discharge designated in 7.8.1.1 shall be illuminated to values of at least 1 footcandle measured at the floor.”

During emergency events, Chapter 7 Section 9.2.1 states:

“Emergency illumination shall be provided for a period of 1½ hours in the event of failure of normal lighting. Emergency lighting facilities shall be arranged to provide initial illumination that is at least an average of 1 footcandle and a minimum at any point of 0.1 footcandle measured along the path of egress at floor level. Illumination levels may decline to 0.6 footcandles average and a minimum at any point of 0.06 footcandles at the end of the emergency illumination lighting time duration.”

The GSA standard also specifies that lighting in designated historic locations *“may be upgraded with energy efficient light sources and optical enhancements that preserve the historic appearance of the luminaire and space.”*

Design Considerations

The IDA/IES MLO, *Life Safety Code*, local adopted building code ordinances, and historic preservation goals all need to be considered when providing design recommendations. Applying these codes to lighting in protected areas remains an on-going point of discussion. Generally, adopting a fully-shielded period relevant fixture that provides a minimum 1 foot-candle ground surface illuminance level in egress areas is a good approach to satisfying applicable codes.

Additional design considerations include:

Historic Preservation – Historic structures throughout the park were found to have period and non-period relevant exterior lighting. Within both the IDA/IES MLO LZ0 and within IDA Dark Sky Lighting Guidelines, allowances are given for egress lighting. IDA/IES MLO specifies that egress may be lighted through the use of a 400 lumen or lower lamp with a maximum of three lamps used per site. IDA Dark Sky lighting guidelines allow for use of unshielded fixtures in special applications as long as their lamp initial lumen output is 500 lumens or lower. Therefore, due to the limitations in what can be done to lighting fixtures on historic structures and within historic districts, the simplest approach is often to provide a low lumen lamp with a CCT of less than 3000K.

Uniformity in Aesthetics and Illumination – Lighting that is uniform in visual appearance and illumination performance is a preferred design aesthetic.

Safety – Lighting itself should not present a hazard. Several existing fixtures are in a state of disrepair. Recommended fixtures and lamps do not present a trip or fall hazard nor shock hazard if appropriately installed.

Fixture height – Fixtures should be as low to the ground as feasible.

Environmental Conditions – Temperature extremes should be considered when selecting fixtures and lamps. Using commercially supplied fully-shielded fixtures is preferable to creating custom shielding, as commercially designed fixtures (theoretically) consider the potential heat build-up within the fixture and design a solution to prevent the lamp from exploding. Similarly, cold temperatures can prove challenging to operating lamps, as well.

Installation and Maintenance – Installing and maintaining fixtures is usually straight forward. Going with the same fixture for multiple applications is useful, because it cuts down on installation time and routine maintenance. While fixtures that have a built in LED are as easy to install as fixtures requiring a lamp, fixtures requiring a lamp may have a longer overall life. Changing out an individual lamp is easier than changing out a fixture.

Controls – Controls add a level of complexity for operation, installation, and maintenance. Most NPS installations go with very simplistic controls, including dusk to dawn photosensors and motion sensors. Zone controls and remotely operated control systems offer some advantages as already observed on the new entrance station and around the visitor center. However, these will only be specified if there is interest.

Lighting for a Purpose – Lighting should only be used where and when it is necessary. When lighting is not necessary, lighting should be off. Lighting will be used for egress, aiding in wayfinding, and maintaining historical aesthetics.

Specified Replacement Fixtures and Lamps

There are three specified replacement fixtures and one specified lamp replacement used to address non-compliant lighting within the park. Removing fixtures and adding a timer switch to existing lighting circuits are also options used to reduce non-compliant lighting. Fixtures and lamps were priced from commercially available sources online. The following lamp and fixtures are specified, but any fixture that has similar specifications that meet the Park's established LMP can be substituted based upon cost and availability.

Lamp Replacement



A19-27L

When recommended for a relamp, this lamp is designated on retrofit maps as:

- A19-27L

Model details:

Lamp	Dia (in)	Length (in)	Base	Watts	CCT	Lumens	Vendor	Cost	Website
A19-27	2.36	4.33	E26	6	2700	450	Halco 80971	\$1.29	website

Fixture Replacements

Wall Mount Cylinder



Vendor: Progress Lighting
Colors: Bronze, white, black, metallic gray
Application: Entrance/Egress, Security, Define Building Edge

Designated on retrofit maps as:

- WC5 + A19-27L

Model details:

LIST ID	Diameter (in)	Height (in)	Watts	Lumens	Model# (Lamp)	Integrated LED CCT	Cost	website
WC5	5	8	17	788	P5674-20/30K	3000	\$119	website

This wall mount cylinder fixture is fully-shielded and comes either with an LED incorporated into the fixture or without an incorporated LED. The price provided is for a non-incorporated fixture with a separate A19-27L bulb ordered for the fixture. This fixture replaces existing wall sconces throughout the park.

Ceiling Mount Cylinder



Vendor: Progress Lighting
Colors: Bronze, white, black, metallic gray
Application: Entrance/Egress

Designated on retrofit maps as:

■ CC5 + A19-27L

Model details:

LIST ID	Diameter (in)	Height (in)	Watts	Lumens	Model# (Lamp)	Integrated LED CCT	Cost	website
CC5	5	6.5	17	757	P5774-31/30K	3000	\$97	website

This ceiling mount cylinder fixture is fully-shielded and comes either with an LED incorporated into the fixture or without an incorporated LED. The price provided is for a non-incorporated fixture with a separate A19-27L bulb ordered for the fixture. This fixture replaces existing ceiling mounts throughout the park.

Bollard



Vendor: RAB
Colors: Black, white
Application: Bollard, walkway, pathway, parking delineation
ID Name: Bollard (BOL)

Designated on retrofit maps as:

■ BOL

LIST ID	Width (in)	Height (in)	Watts	Lumens	Model# (Lamp)	Integrated LED CCT	Cost	Website
BOL	5	42	10	1198	BLED10Y	3000	270	website

This bollard replaces the existing Red Hills Visitor Center bollards.

Timer Switch



Vendor: amazon

Application: mechanical timer switch

Designated on retrofit maps as:

◆ TIMERSWITCH

Model details:

LIST ID	Fits	Watts	Lumens	Model# (Lamp)	Integrated LED CCT	Cost	Website
TIMERSWITCH	SWITCH	N/A	N/A	FD2HR	N/A	\$29	website

This timer switch is at various locations across the park to bring lighting into compliance through this control mechanism.

Replacement, Relamping, and/or Removal Summary

The provided recommendation involves upgrading all existing lighting fixtures to meet IDA guidelines while considering historic, aesthetic, and performance concerns. This approach reduces the overall lighting footprint in the park, while keeping lighting everywhere fixtures are currently located. Fixtures were marked for removal only when they clearly were not functional.

The provided cost estimate includes materials procurement and labor. Labor costs were estimated based upon the time it takes to install/remove the fixture/lamp and assumes a baseline \$50/hour for a GS level electrician. The labor hours and labor cost estimate are both conservative.

Recommendation Summary

Upgrading existing exterior lighting to meet IDA guidelines while considering aesthetic and performance concerns requires procurement of the following number of fixtures and/or lamps listed below. Complete details for location by location recommendations are presented within the main body of the remaining report.

#	Lamp/Fixture	Description	Total Cost	Order from
33	A19-27L	450 lumen 2700K lamp	\$43	website
6	CC5	fully-shielded ceiling mount	\$576	website
19	WC5	fully-shielded wall cylinder	\$2242	website
11	Bollard	fully-shielded bollard	\$2970	website
5	Timer switch	2-hour mechanical timer switch	\$145	website
7	Remove	remove existing fixtures	\$0	

The total cost of procurement is estimated to be \$6,000 (rounded to the nearest \$100).

Addressing each existing lighting fixture will require a total estimated 46 hours of labor at an estimated labor cost of \$2,300 (rounded to the nearest \$100). This labor rate does not include procurement or mobilization costs, only estimated time for the fixture/lamp change retrofits.

Total cost of the provided recommendation is estimated to be: \$8,300 (rounded to the nearest \$100).

Site Specific Recommendations

Full details for complete replacement, removal, and replamping of all existing lighting identified in the retrofitting recommendation are provided within the remainder of this section on a location by location basis. Overall, there are 72 fixtures located within Saguaro National Park that require retrofits for compliance purposes (Figure 16). These retrofits are accomplished through 58 changes to existing lighting infrastructure (several individual non-compliant fixtures are retrofitted with a single timer switch in some cases). Table 16 provides the summary breakdown of retrofits for each park area presented in Section 1 along with a labor estimate and overall anticipated cost to complete the work in each area.



Figure 16. Generalized Location of Specified Replacements within Saguaro National Park.

Table 16. Summary of fixture retrofits needed for non-compliant fixtures to meet IDA guidelines within each park area.

<u>Location Area</u>	<u># of Retrofits</u>	<u>Retrofit Procurement Cost (\$)</u>	<u>Estimated Labor Hours</u>	<u>Estimated Labor Cost (\$)</u>	<u>Total Cost (\$)</u>
<u>Rincon Mountain District</u>					
Fire Operations	2	238	1	50	288
Greene Property	12	7	8.25	413	419
Heli Pad / Observatory	5	462	2.5	125	587
Quarters 14, 15, 16	3	357	1.5	75	432
Horse Corral	1	30	0.5	25	55
Headquarters	4	388	2	100	488
Visitor Center Area	3	33	1	50	83
Maintenance Area	2	60	1	50	70
<i>Rincon Mountain District Total</i>	32	1575	17.75	888	2432
<u>Tucson Mountain District</u>					
Maintenance Area	9	863	4	200	1063
Quarters 30, 31, 32	4	476	2	100	576
Operations Building	1	119	0.5	25	144
Visitor Center Bollards	11	2970	22	1100	4070
Visitor Center Building	1	1	0.25	13	14
<i>Tucson Mountain District Total</i>	26	4429	28.75	1438	5867
Total for All Areas	58	5604	46.25	2326	8299

Rincon Mountain District Recommendations

There are a total of 46 fixtures recommended for retrofitting using 32 different change outs across the Rincon Mountain District. A summary of the recommended retrofits is presented in Tables 17a and 17b, with additional details (concerning each fixtures location and replacement recommendation) provided in the text and figures following the table.

Table 17a. Summary of fixture retrofits to meet IDA guidelines within the Saguaro’s East Unit.

Location	Fixture ID	Existing Fixture Description Fixture, Lamp, Height (ft) CCT (K), Fully-Shielded, Application, Exempt	Proposed Action	Fixture or Lamp Cost (\$)	Labor (Hours)	Labor Cost (\$)	Total Cost (\$)
Fire Operations	10	Wall Sconce, Fluorescent, 7, 2700, No, Entrance/Egress, No	WC5 + A19-27L	119	0.5	25	144
	11	Wall Sconce, Fluorescent, 7, 2700, No, Entrance/Egress, No	WC5 + A19-27L	119	0.5	25	144
Greene Property	12	Wall Sconce, Incandescent, 6, 2700, No, Entrance/Egress, No	A19-27L	1.29	0.25	12.5	13.79
	13	Wall Sconce, Empty Socket, 6, , No, Entrance/Egress, No	A19-27L	1.29	0.25	12.5	13.79
	14	Flood, Empty Socket, 8, , No, Entrance/Egress, No	REMOVE	0	1	50	50
	15	Wall Sconce, Empty Socket, 6, , No, Entrance/Egress, No	A19-27L	1.29	0.25	12.5	13.79
	16	Wall Sconce, Incandescent, 6, 2700, No, Entrance/Egress, No	A19-27L	1.29	0.25	12.5	13.79
	17	Flood, Empty Socket, 8, , No, Entrance/Egress, No	REMOVE	0	1	50	50
	18	Flood, Fluorescent, 10, 2700, No, Entrance/Egress, No	REMOVE	0	1	50	50
	22	Flood, Halogen, 8.5, 2700, No, Entrance/Egress, No	REMOVE	0	1	50	50
	25	Flood, Incandescent, 10, 2700, No, Entrance/Egress, No	REMOVE	0	1	50	50
	26	Flood, Halogen, 8, 2700, No, Entrance/Egress, No	REMOVE	0	1	50	50
	27	Wall Sconce, Incandescent, 6, 2700, No, Entrance/Egress, No	A19-27L	1.29	0.25	12.5	13.79
	28	Flood, Incandescent, 8.5, 2700, No, Entrance/Egress, No	REMOVE	0	1	50	50
Heli Pad / Magnetic Observatory	29	Ceiling Mount, HPS, 11.5, 1800, No, Area, No	CC5 + A19-27L	97	0.5	25	122
	30	Ceiling Mount, HPS, 11.5, 1800, No, Area, No	CC5 + A19-27L	97	0.5	25	122
	31	Wall Pack, HPS, 8.5, 1800, No, Area, No	WC5 + A19-27L	119	0.5	25	144
	32	Wall Pack, HPS, 8.5, 1800, No, Area, No	WC5 + A19-27L	119	0.5	25	144
	33	Flood, Halogen, 7, 2700, No, Entrance/Egress, No	Timer Switch	30	0.5	25	55

Table 17b. Summary of fixture retrofits to meet IDA guidelines within the Saguaro’s East Unit.

Location	Fixture ID	Existing Fixture Description Fixture, Lamp, Height (ft) CCT (K), Fully-Shielded, Application, Exempt	Proposed Action	Fixture or Lamp Cost (\$)	Labor (Hours)	Labor Cost (\$)	Total Cost (\$)
Quarters 14, 15, 16	36	Wall Sconce, LED, 7, 2700, No, Entrance/Egress, No	WC5 + A19-27L	119	0.5	25	144
	38	Wall Sconce, Fluorescent, 7, 6500, No, Entrance/Egress, No	WC5 + A19-27L	119	0.5	25	144
	39	Wall Sconce, LED, 7, 2700, No, Entrance/Egress, No	WC5 + A19-27L	119	0.5	25	144
Horse Corral	40	Ceiling Mount, LED, 8, 5000, Yes, Area, No	Timer Switch	30	0.5	25	55
	42	Flood, LED, 9, 5000, Yes, Entrance/Egress, No					
	43	Flood, LED, 11, 5000, Yes, Entrance/Egress, No					
Headquarters	47	Ceiling Mount, Fluorescent, 8.5, 2700, No, Pathway, No	CC5 + A19-27L	97	0.5	25	122
	48	Ceiling Mount, Fluorescent, 8.5, 2700, No, Pathway, No	CC5 + A19-27L	97	0.5	25	122
	49	Ceiling Mount, Fluorescent, 8.5, 2700, No, Pathway, No	CC5 + A19-27L	97	0.5	25	122
	50	Ceiling Mount, Fluorescent, 8.5, 2700, No, Pathway, No	CC5 + A19-27L	97	0.5	25	122
Rincon Visitor Center Area	61	Wall Sconce, Fluorescent, 9, 2700, No, Area, No	A19-27L	1.29	0.25	12.5	13.79
	62	Wall Sconce, Fluorescent, 9, 2700, No, Area, No	A19-27L	1.29	0.25	12.5	13.79
	64	Other, LED, 0, 3000, No, Pathway, No	Timer Switch	30	0.5	25	55
	69						
	70						
	71						
	72						
73							
74							
75							
76							
Rincon Maintenance Area	79	Flood, LED, 10.5, 5000, Yes, Entrance/Egress, No	Timer Switch	30	0.5	25	55
	80						
	81	Flood, LED, 10.5, 5000, Yes, Entrance/Egress, No	Timer Switch	30	0.5	25	55
	82						
	83						
84							

Fire Operations Complex

There are two fixtures that are recommended for replacement. Fixtures 11 and 12 are non-compliant wall sconces on the outside of the trailer. They are recommended for replacement with the fully-shielded wall cylinder fixture equipped with a new A19-27L lamp (WC5 + A19-27L). Their location, along with the replacement details for each fixture ID presented, is shown in Figure 17.

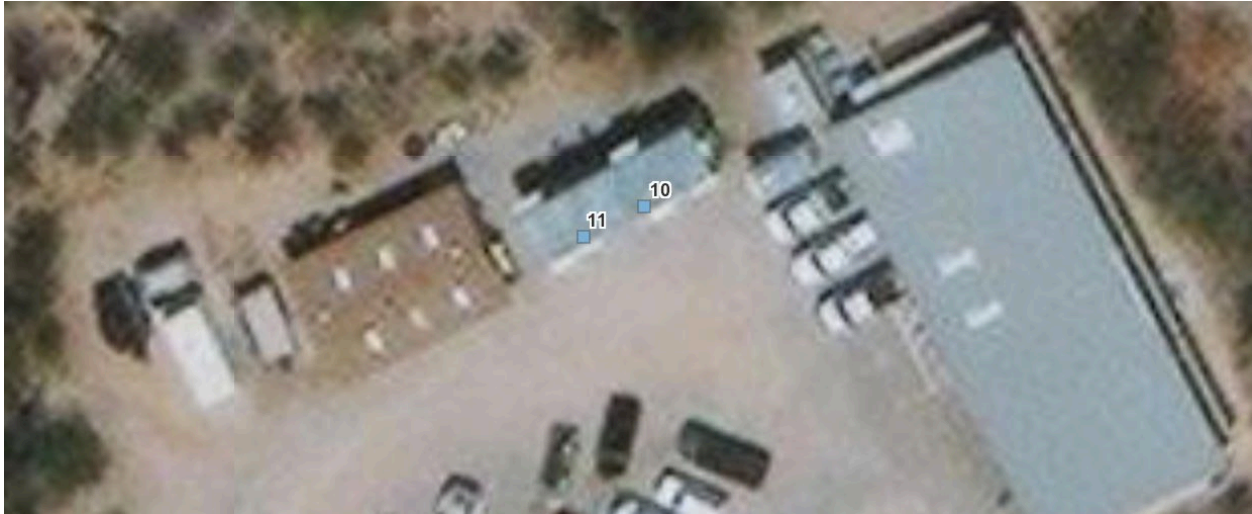


Figure 17. Specified Retrofits for Fire Operations Complex

Greene Property

There are 12 fixtures that are recommended for replacement. I realize that this location will undergo significant changes within the next few years. For the purposes of planning though, I'm recommending that fixtures not used for entrance/egress be removed. These fixtures include fixtures # 14, 17, 18, 22, 25, 26, and 28. For fixtures required for entrance/egress (fixtures # 12, 13, 15, 16, and 27), these fixtures can be relamped with a new compliant A19-27L lamp. This lamp provides low lumen illumination and can be used in locations where historical concerns exist due to the presence of period, but unshielded lighting fixtures. The location for the recommended retrofits, along with the replacement details for each fixture ID presented, is shown in Figure 18.



Figure 18. Specified Retrofits for the Greene Property

Heli Pad / Magnetic Observatory

There are 5 fixtures that are recommended for replacement. The replacement recommendations for the Heli-Pad building include replacing wall pack fixtures # 31 and 32 with the specified wall cylinder fixture equipped with the A19-27L lamp (WC5 + A19-27L). The other two replacements on this building include replacing the two existing ceiling mount fixtures (#29 and 30) under the overhang with the specified ceiling mount cylinders also equipped with the A19-27L lamp (CC5 + A19-27L). For the magnetic observatory, the non-compliant fixture (#33) over the access door can be replaced with the wall cylinder fixture (WC5 + A19-27L). Fixture #33 provides egress to a non-occupied building and could likely be removed instead of replaced, particularly due to the nature of the monitoring facility. However, anyone making the decision to remove this fixture will have to make sure its removal is in accordance with existing codes. The location of the recommended retrofits, along with the replacement details for each fixture ID presented, is shown in Figure 19a (Heli Pad) and 19b (Magnetic Observatory).

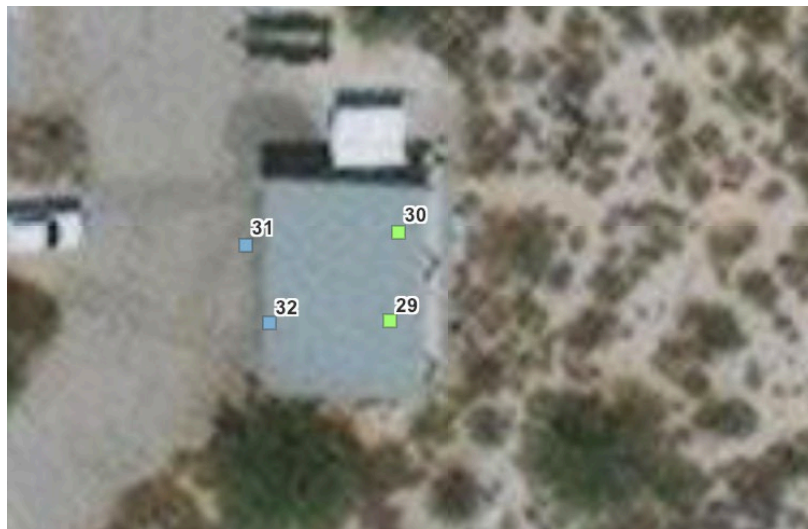


Figure 19a. Specified Retrofits for the Heli Pad Building



Figure 19b. Specified Retrofits for the Magnetic Observatory

Quarters 14, 15, and 16

There are 3 fixtures that are recommended for replacement. Fixtures #36, 38, and 39, all present on Quarters 16, are recommended for replacement with the specified wall cylinder fixture and A19-27L lamps (WC5 + A19-27L). Fixtures on the other two quarters are all compliant. The location of the retrofits proposed for Quarters 16, along with the replacement details for each fixture ID presented, is shown in Figure 20.



Figure 20. Specified Retrofits for Quarters 16

Horse Corral

There are 3 fixtures recommended for retrofit using one timer switch at the horse corral. The timer switch can be used in place of the existing flip switch. Their location, along with the replacement details for each fixture ID presented, is shown in Figure 20.



Figure 20. Specified Retrofits for the Horse Corral

Headquarters

There are 4 fixtures (# 47-50) that are recommended for replacement. The retrofit for these four unshielded ceiling mount fixtures is the specified ceiling mount fixture with new A19-27L lamps (CC5 + A19-27L). Their location, along with the replacement details for each fixture ID presented, is shown in Figure 21.



Figure 21. Specified Retrofits for the Headquarters Building and Annex

Rincon Visitor Center Area

There are 3 fixtures that are recommended for replacement. Fixtures #61 and 62 are recommended for relamping with the A19-27L lamp. Fixtures # 64-76, while listed at 3000K and recently added, are not fully shielded in my opinion. Fortunately, they can be brought into compliance by inserting a timer switch into the circuit. One timer switch will retrofit this issue (and likely also then control the recessed lighting along the wall in the open area, as well). The location of the retrofit recommendations, along with the replacement details for each fixture ID presented, is shown in Figure 22.



Figure 22. Specified Retrofits for the Visitor Center

Rincon Mountain District Maintenance Area

There are 5 fixtures that are recommended for retrofitting using timer switches. I inferred that there will be a total of two timer switches needed (one per each building), however, this will need to be confirmed prior to making the retrofits. Additionally, it may be desirable to instead retrofit each building with a motion sensor that will trigger the lights when someone approaches. This is another acceptable location that would take a little more planning. However, both solutions are acceptable from a dark sky certification point of view. The location of the fixtures requiring a retrofit, along with the replacement details for each fixture ID presented, is shown in Figure 23.



Figure 23. Specified Retrofits for the Maintenance Area

Tucson Mountain District Recommendations

There are a total of 26 fixtures recommended for retrofitting across the Tucson Mountain District of the Park. A summary of the recommended retrofits for this District are presented in Tables 18a and 18b, with additional details (concerning each fixtures location and replacement recommendation) provided in the text and figures following the table.

Table 18a. Summary of fixture retrofits to meet IDA guidelines within the Saguaro’s West Unit.

Location	Fixture ID	Existing Fixture Description Fixture, Lamp, Height (ft) CCT (K), Fully-Shielded, Application, Exempt	Proposed Action	Fixture or Lamp Cost (\$)	Labor (Hours)	Labor Cost (\$)	Total Cost (\$)
Maintenance Area	89	Wall Pack, HPS, 9.5, 1800, No, Area, No	WC5 + A19-27L	119	0.5	25	144
	90	Wall Pack, HPS, 9.5, 1800, No, Area, No	WC5 + A19-27L	119	0.5	25	144
	91	Ceiling Mount, Fluorescent, 10.5, 5000, Yes, Area, No	Timer Switch	30	0.5	25	55
	92	Ceiling Mount, Fluorescent, 10.5, 5000, Yes, Area, No					
	93	Wall Pack, HPS, 9.5, 1800, No, Area, No	WC5 + A19-27L	119	0.5	25	144
	94	Wall Pack, HPS, 9.5, 1800, No, Area, No	WC5 + A19-27L	119	0.5	25	144
	96	Wall Sconce, Fluorescent, 8, 3000, No, Area, No	WC5 + A19-27L	119	0.5	25	144
	97	Wall Sconce, Fluorescent, 8, 3000, No, Area, No	WC5 + A19-27L	119	0.5	25	144
	98	Wall Sconce, Fluorescent, 8, 3000, No, Area, No	WC5 + A19-27L	119	0.5	25	144
Quarters 30, 31, 32	99	Wall Sconce, Fluorescent, 7, 2700, No, Area, No	WC5 + A19-27L	119	0.5	25	144
	100	Wall Sconce, Fluorescent, 7, 2700, No, Area, No	WC5 + A19-27L	119	0.5	25	144
	104	Wall Sconce, Fluorescent, 7, 2700, No, Area, No	WC5 + A19-27L	119	0.5	25	144
	105	Wall Sconce, Fluorescent, 7, 2700, No, Area, No	WC5 + A19-27L	119	0.5	25	144
Operations Building	131	Wall Sconce, Fluorescent, 7, 2700, No, Entrance/Egress, No	WC5 + A19-27L	119	0.5	25	144

Table 18a. Summary of fixture retrofits to meet IDA guidelines within the Saguaro’s West Unit.

Location	Fixture ID	Existing Fixture Description Fixture, Lamp, Height (ft) CCT (K), Fully-Shielded, Application, Exempt	Proposed Action	Fixture or Lamp Cost (\$)	Labor (Hours)	Labor Cost (\$)	Total Cost (\$)
Red Hills Visitor Center Bollards	132	Bollard, LED, 3, 4100, No, Pathway, No	BOL	270	2	100	370
	133	Bollard, HPS, 3, 1800, No, Pathway, No	BOL	270	2	100	370
	134	Bollard, HPS, 3, 1800, No, Pathway, No	BOL	270	2	100	370
	135	Bollard, HPS, 3, 1800, No, Pathway, No	BOL	270	2	100	370
	136	Bollard, HPS, 3, 1800, No, Pathway, No	BOL	270	2	100	370
	137	Bollard, HPS, 3, 1800, No, Pathway, No	BOL	270	2	100	370
	138	Bollard, HPS, 3, 1800, No, Pathway, No	BOL	270	2	100	370
	139	Bollard, HPS, 3, 1800, No, Pathway, No	BOL	270	2	100	370
	140	Bollard, HPS, 3, 1800, No, Pathway, No	BOL	270	2	100	370
	141	Bollard, HPS, 3, 1800, No, Pathway, No	BOL	270	2	100	370
	142	Bollard, HPS, 3, 1800, No, Pathway, No	BOL	270	2	100	370
Red Hills Visitor Center	149	Recessed, LED, 9.5, 4000, Yes, Entrance/Egress, No	A19-27L	1.29	0.25	12.5	13.79

Red Hills Maintenance Area

There are 9 fixtures that are recommended for retrofitting. Fixtures #91 and 92 can be retrofitted using a timer switch. The specified replacement for the existing non-shielded wall pack fixtures 89, 90, and 93-98 is the fully shielded wall cylinder containing A19-27L lamps (WC5 + A19-27L). The retrofit locations, along with the replacement details for each fixture ID presented, is shown in Figure 24.



Figure 24. Specified Retrofits for the Maintenance Area

Quarters 30, 31, and 32

Existing unshielded fixtures located on Quarters 30 at #99, 100, 104, and 105 are recommended for replacement with the specified wall cylinder with new A19-27L lamps (WC5 + A19-27L). Fixtures on Quarters 31 and 32 are compliant. The retrofit locations on Quarters 30, along with the replacement details for each fixture ID presented, is shown in Figure 25.



Figure 25. Specified Retrofits for Quarters 30

Operations Building

Fixture #131, located on the rear porch area of the Operations Building, is recommended for replacement with the specified wall cylinder fixture and A19-27L lamp (WC5 + A19-27L). It's location, along with the replacement detail for fixture 131, is shown in Figure 26. The rest of the fixtures observed at the Operations Building were said to be activated by motion sensors.



Figure 26. Specified Retrofits for the Operations Building

Visitor Center Building

There are 11 bollard fixtures in the parking lot and one lamp on the visitor center recommended for replacement. The parking lot bollards are recommended for replacement with new fully shielded and correct color temperature bollards (BOL). For cost savings, bollards #134 and 135 could be replaced and the rest could be removed. Fixture 149 on the visitor center had a lamp that was not compliant due to color temperature (4000K). This lamp should be replaced with the A19-27L lamp. The retrofit locations, along with the replacement details for each fixture ID presented, is shown in Figure 27.



Figure 27. Specified Retrofits for the Red Hill's Visitor Center and Parking Lot Area

DISCLAIMER

All data and design recommendations provided within this report were provided to the best of my ability. Some of the evaluated lighting assessed during our time on-site were not functioning and characterization was made based upon discussions with staff.

The provided design recommendation given within this report are based upon previous experience and familiarity with lighting standards developed at other Park Service locations throughout the US. The replacement options presented in this report are also meant to inform the reader concerning the type of fixture and lamps that should be used to meet IDA Dark Sky Park guidelines. While the recommendations include fixture replacement, lamp replacement, and/or fixture removal recommendations, implementation of any recommendations should only be done after review and approval by appropriate Park Service and/or concessionaire staff. This report is also the start of a discussion regarding appropriate levels of lighting and lighting fixtures within the park. Feel free to reach out to me at any time for additional discussions or alternatives to the provided recommendations.

While the fixtures and lamps presented are easily available online, costs may vary from what is listed. I recommend working with a local electrical vendor who may be able to procure the same or similar fixtures at reduced costs. Installation (or removal) of lighting should be completed by qualified personnel and the resulting illumination level along ground surfaces should be verified against GSA, IDA, and/or Park Service specifications.