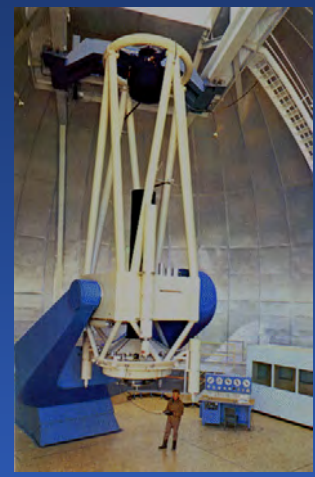
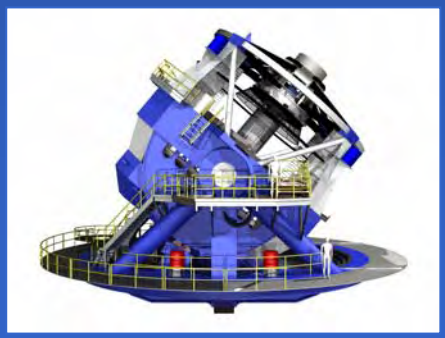
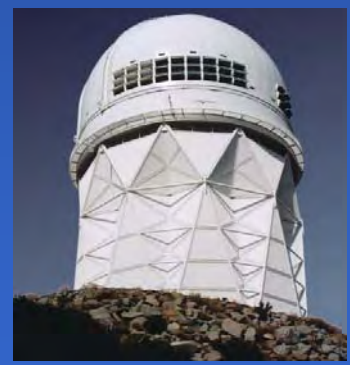
MAG Dark Skies Stakeholders Group
Tuesday, July 6, 2010.

Outdoor Lighting Lighting Codes





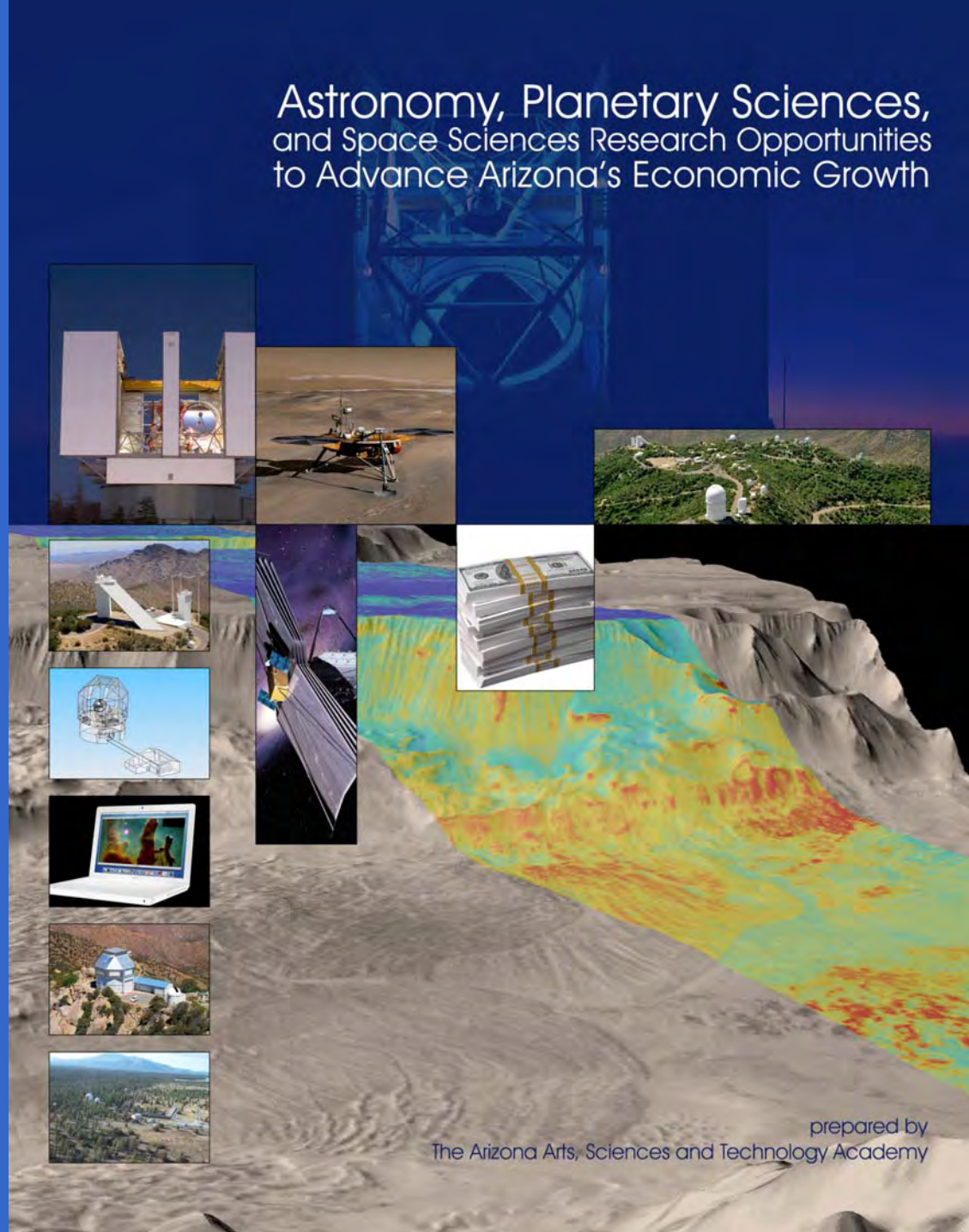


Dan Brocious, Smithsonian Institution, Whipple Observatory and
Chris Luginbuhl, U.S. Naval Observatory


Coconino
Mohave
Navajo
Apache
U.S. Naval Obs.
Lowell Obs.
Braeside Obs.
(ASU)
Discovery Channel
Tel.
Embry-Riddle Obs.
Yavapai
La Paz
Gila
Greenlee
Maricopa
Pinal
Desert Eagle Obs.
Graham
Mt. Graham
Intl. Obs.
Gov Aker
Obs.
Yuma
Mt. Lemmon
Kitt Peak Natl. Obs.
Natl. Solar Obs.
Mt. Bigelow
Pima
Desert Beaver Obs.
Vega-Bray Obs.
Smithsonian Astro. Obs.
Cochise
Arizona Sky Village
MMT Obs.
Winer Obs.
Tenagra Obs.
Fairborn Obs.
Santa Cruz
0 4.35mi
0 7km

Stargazing nets $250 mil a year for Ariz. economy

The Arizona Republic
January 17, 2008.



Astronomy is worth billions to Arizona

This study found substantial capital investment

(in excess of $1 billion) in,

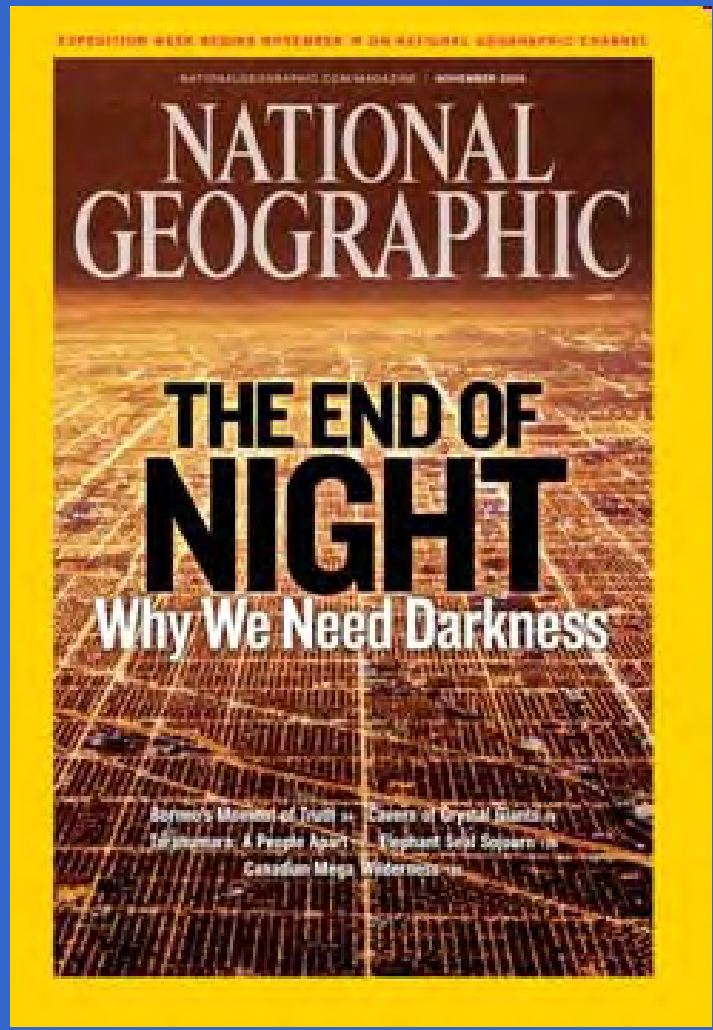
and economic return

(more than quarter of a billion dollars annually)

from APSS research in Arizona. The data also suggest the untapped potential of these research fields to expand the State's economic base. The study revealed levels of active research funding that well exceed other fields in the State, such as bioscience funding from the National Institutes of Health.

Light Pollution

Any adverse effect of artificial light including sky glow, glare, light trespass, light clutter, decreased visibility at night, and energy waste.



Feature article

Lighting and Astronomy

Christian B. Luginbuhl,
Constance E. Walker, and
Richard J. Wainscott

The rapid growth of light pollution threatens the future of astronomical observations.

The Earth at Night

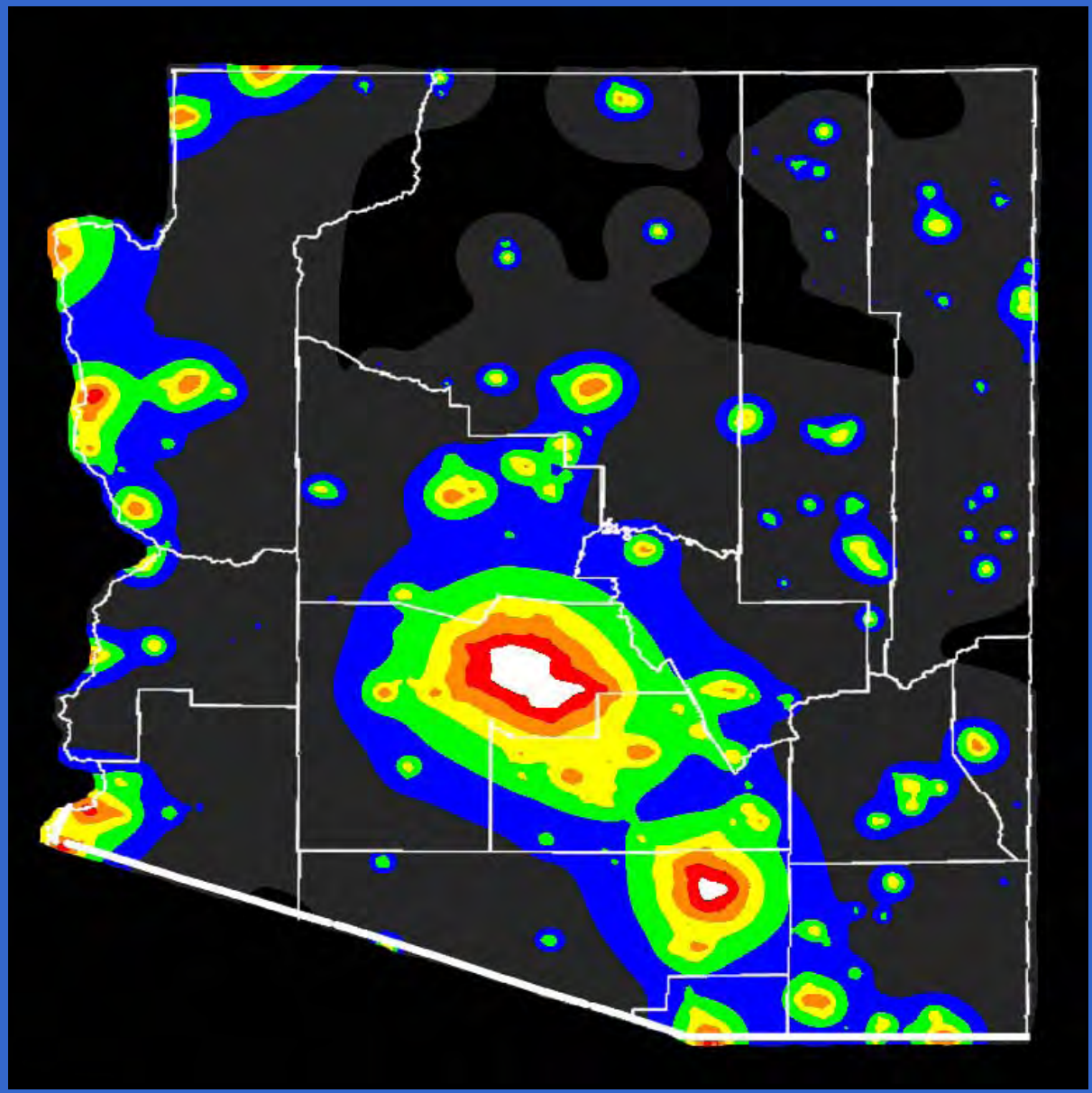
North America at Night

Southwestern United States, home of many of the large telescopes in the continental United States.

Lights as seen from above, as from the International Space Station, for example, looking down. Here the landscape outside of the cities looks dark. But this is misleading... it is not dark here.

The next slide shows what these lights do to the sky, in other words, what it looks like looking upwards, the other direction, showing that light pollution spreads much farther than the cities in which the lights are used... you can be 50 or 100 miles from the Phoenix metropolitan area and still see the effects of the city lights

Light Pollution in Arizona

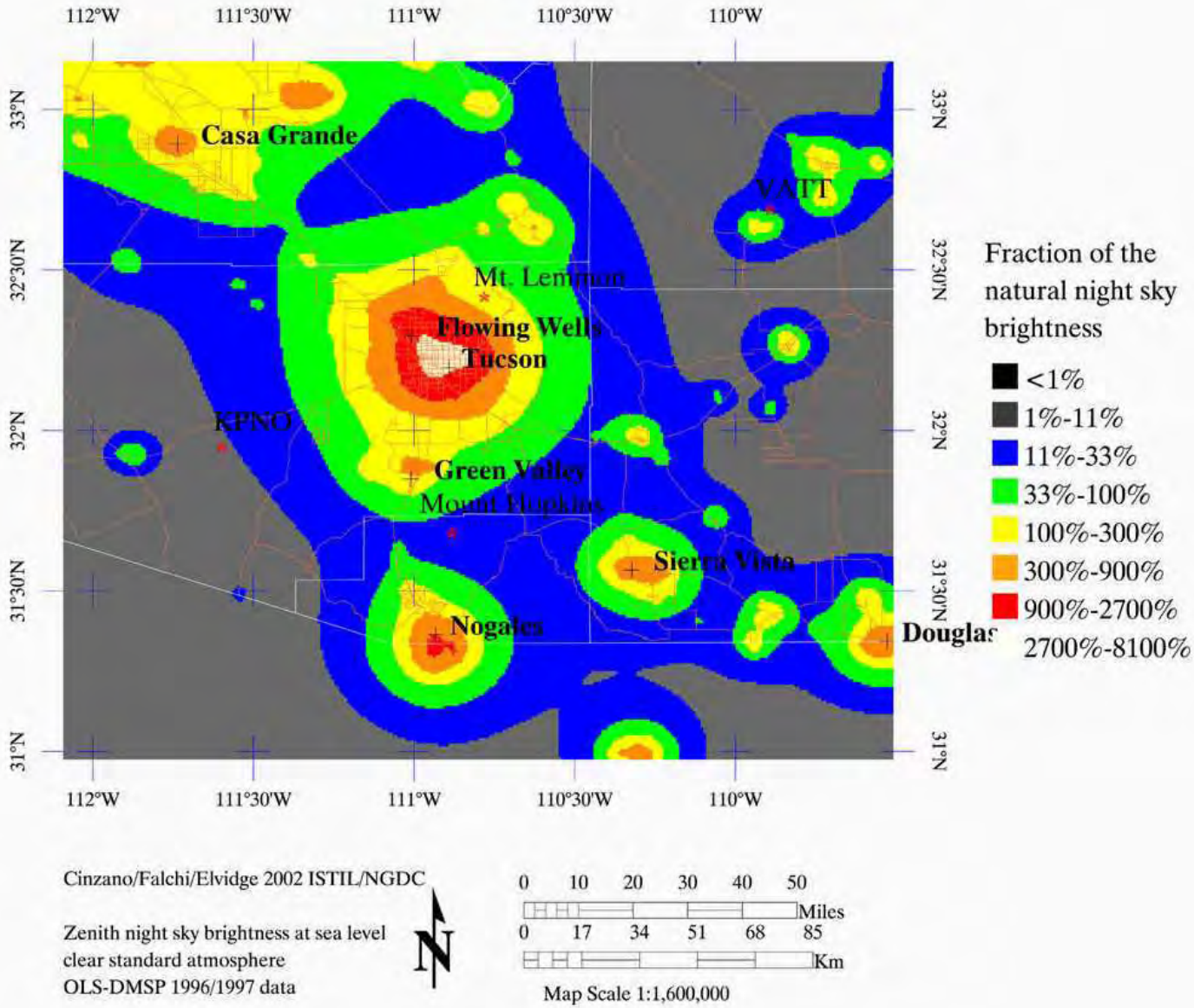


Fraction of the natural night sky brightness

- <1%
- 1%-11%
- 11%-33%
- 33%-100%
- 100%-300%
- 300%-900%
- 900%-2700%
- 2700%-8100%

(Cinzano, Falchi, Elvidge)

Artificial night sky brightness near Tucson



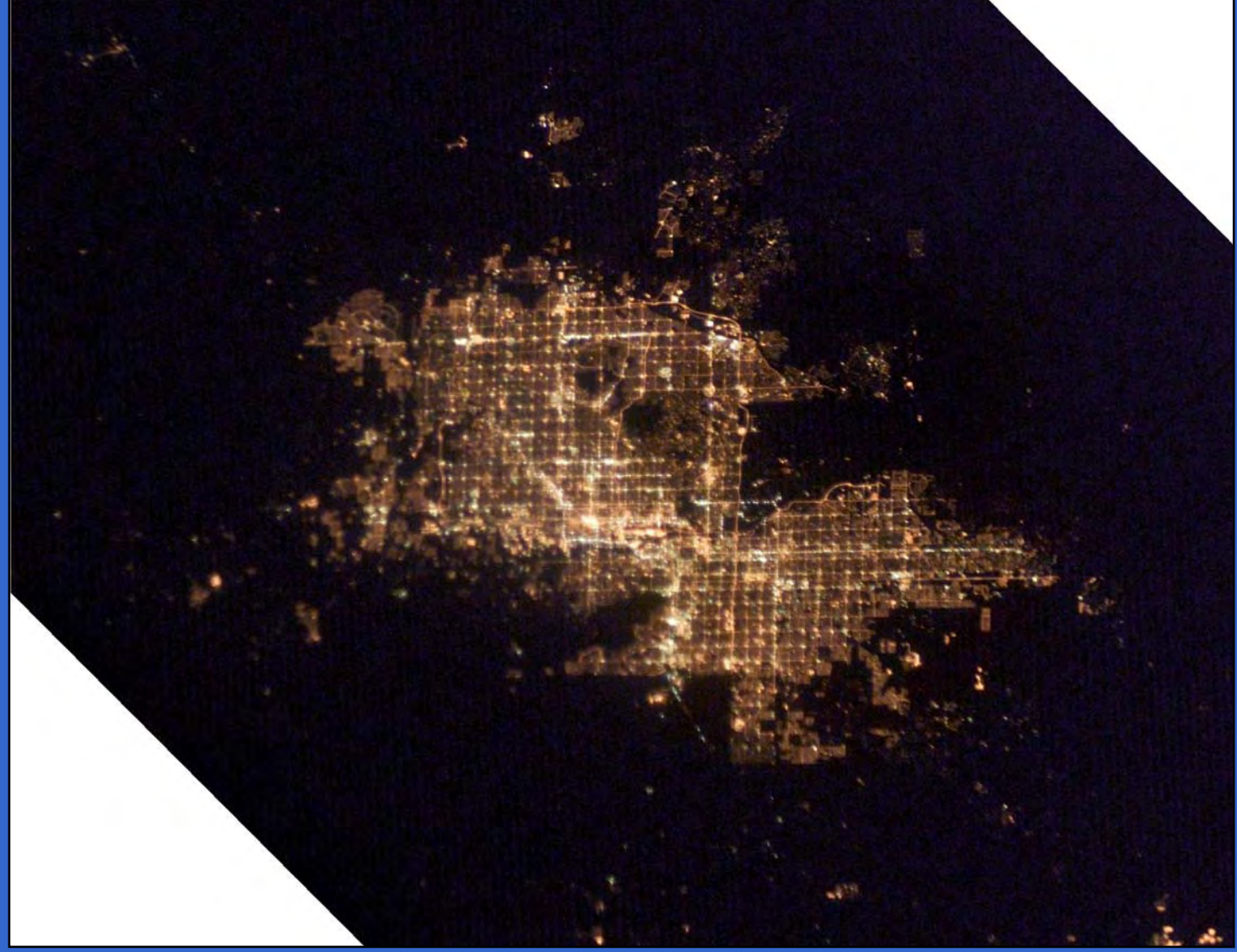


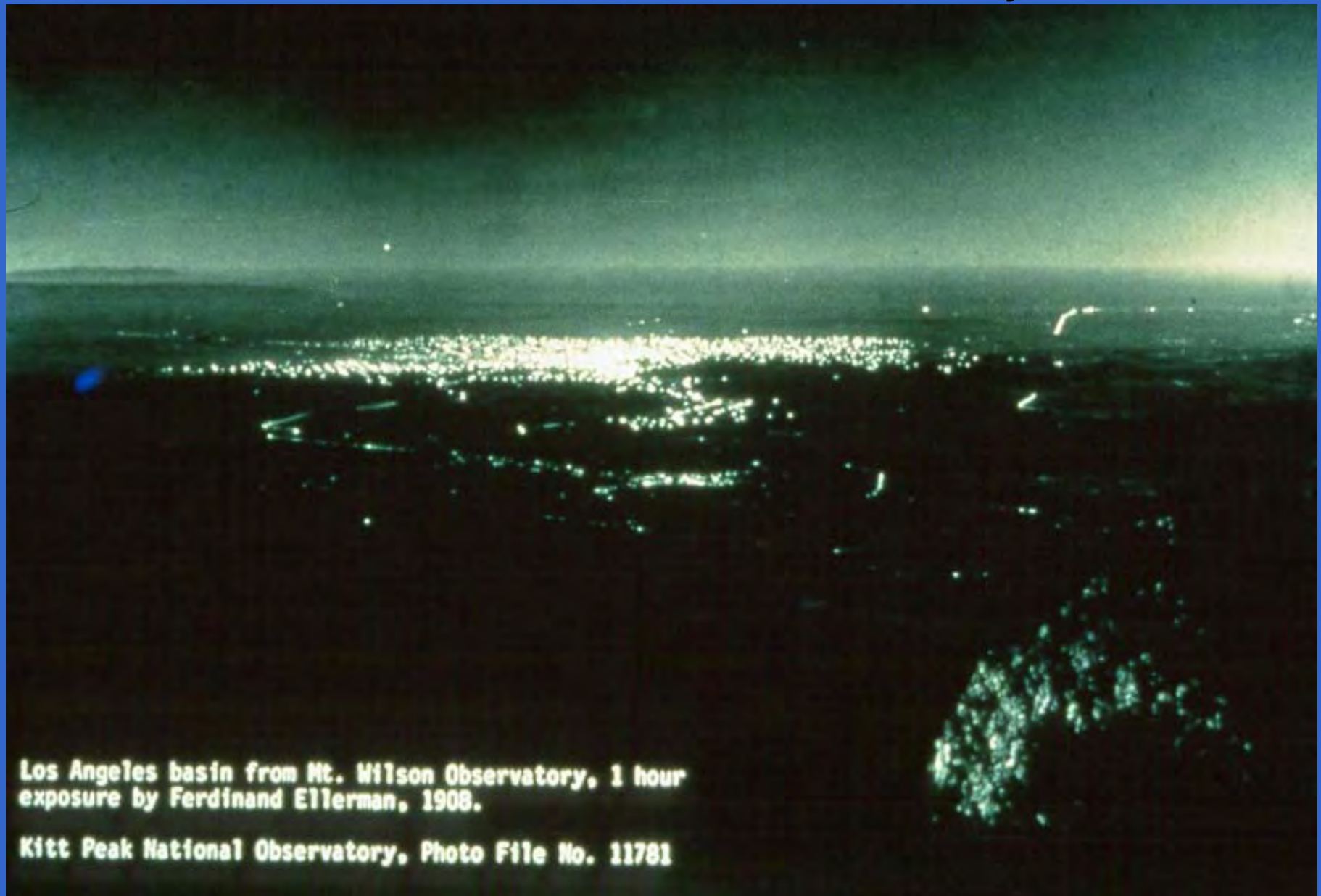
Image of Phoenix at night taken from the International Space Station

(~220 miles above) (NASA, ISS CEO project)

Phoenix/Casa Grande sky glow as seen from Kitt Peak National Obs.

March 28, 2008. (KPNO photo by J. Glaspey)

Los Angeles in 1908,
as seen from Mt. Wilson Observatory.



Los Angeles in 1988, as seen from Mt. Wilson.

Purpose of a Lighting Code:

- Promote good lighting practice,
  - And to limit obtrusive lighting.
- Promote good business.
- Promote the community.
- Help everyone see better.
- Save energy. Save money.
- Preserve dark skies for all.

U.S.News & WORLD REPORT

Turning Out the Lights
The dangers of a bright night are becoming more apparent

….

But a brighter world, it is becoming increasingly clear, has its drawbacks. A study released last month finding that breast cancer is nearly twice as common in brightly lit communities as in dark ones only added to a growing body of evidence that artificial light threatens not just stargazing but also public health, wildlife, and possibly even safety.

Those findings are all the more troubling considering that an estimated 30 percent of outdoor lighting—plus even some indoor lighting—is wasted. Ill-conceived, ineffective, and inefficient lighting costs the nation about $10.4 billion a year, according to Bob Gent of the International Dark-Sky Association, a nonprofit that aims to curtail light pollution, and it generates 38 million tons of carbon dioxide a year.

Code elements to promote good outdoor lighting

Fixture type -- put the light on the ground where it is needed and useful.

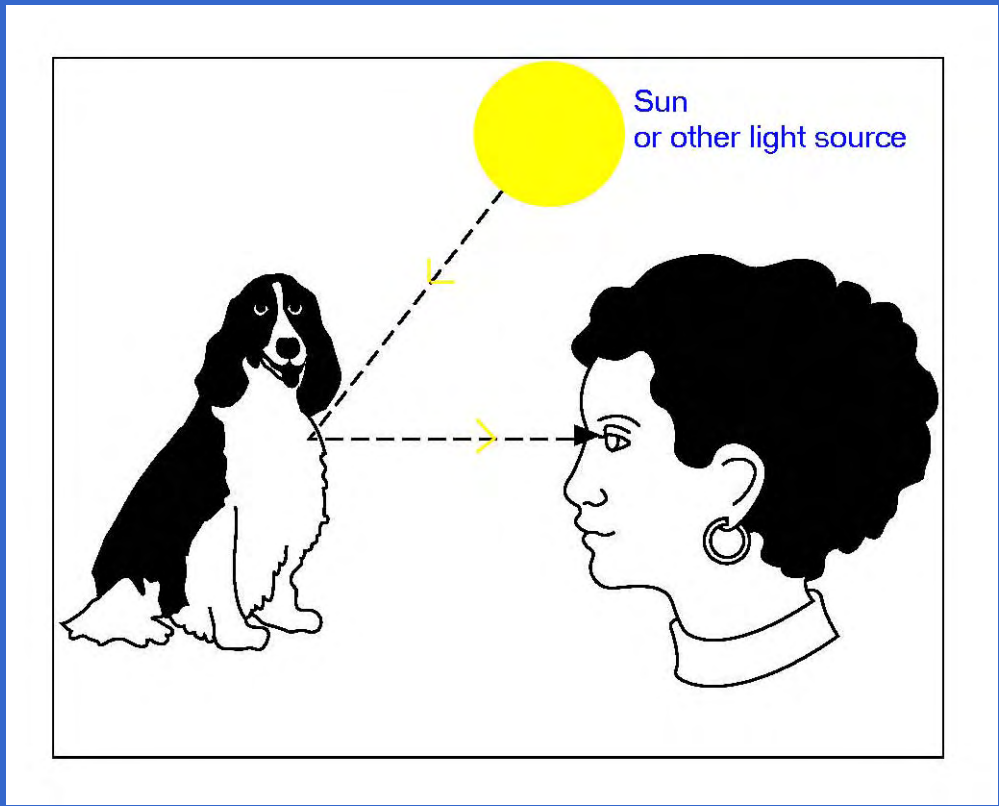
Amount of light -- prevent over-lighting with lumens limits

(but use what is necessary for the task).

A lighting budget also saves energy and money

Time of light use -- turn it off when not needed (curfew)

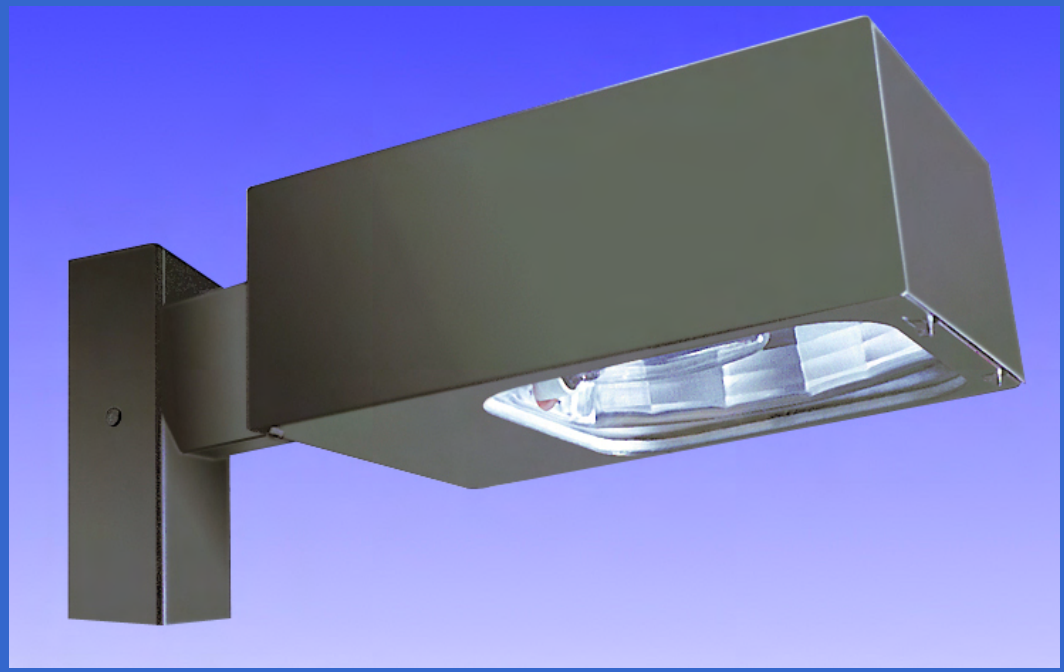
Color of light -- to protect most sensitive dark sky areas.

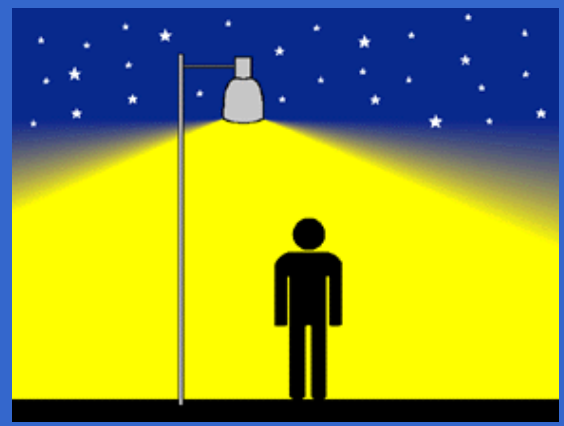


We see an object when light reflects from it into our eyes.

Glare bomb lighting a tree,
not doing a good job for the parking lot.

Full Cut-Off (FCO)



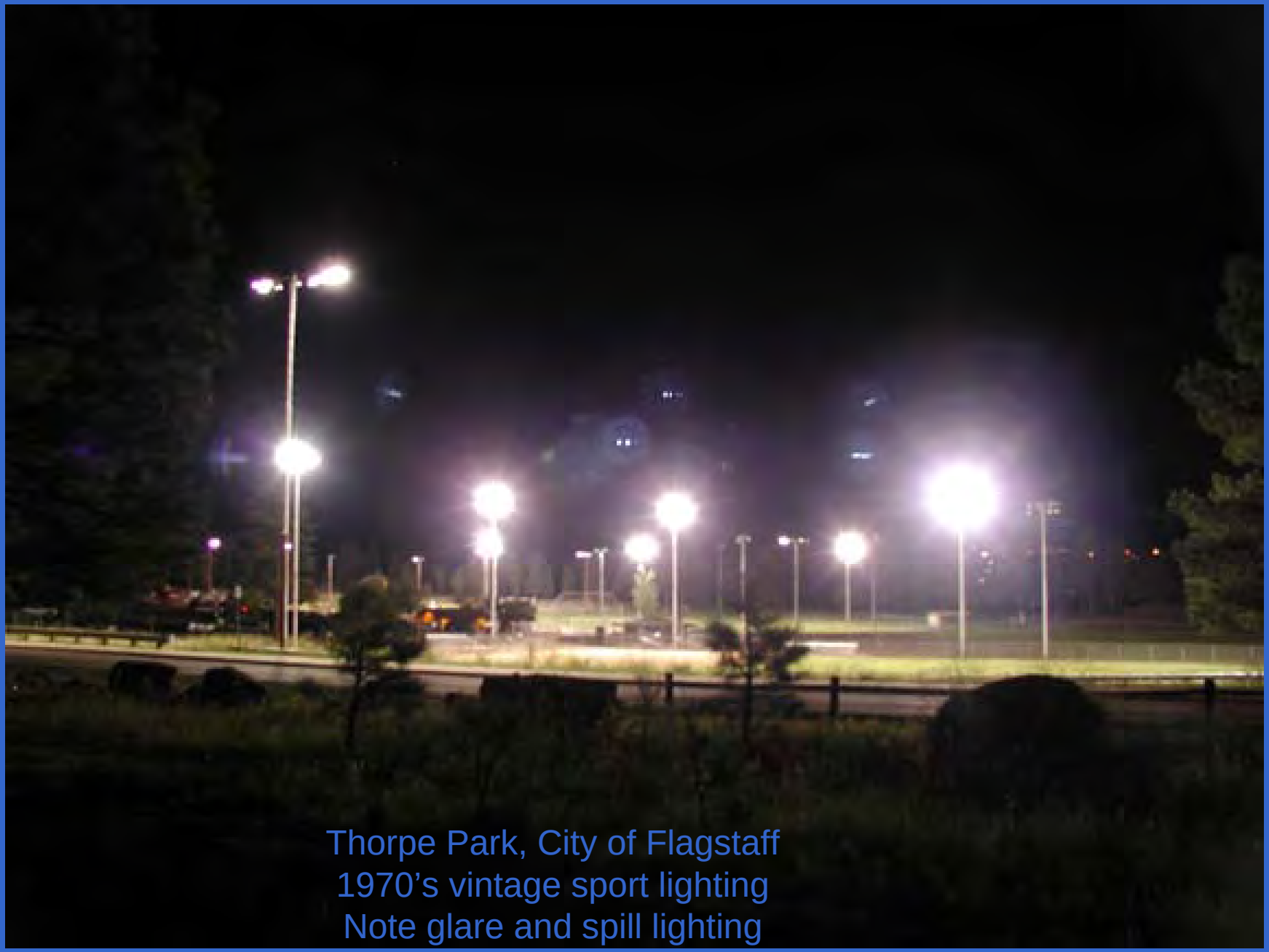


A full cutoff lighting fixture in the fog,
showing the excellent control of light output.

A full cutoff “shoe box” street or area lighting fixture, with an HPS lamp.

The Biggest Complaints

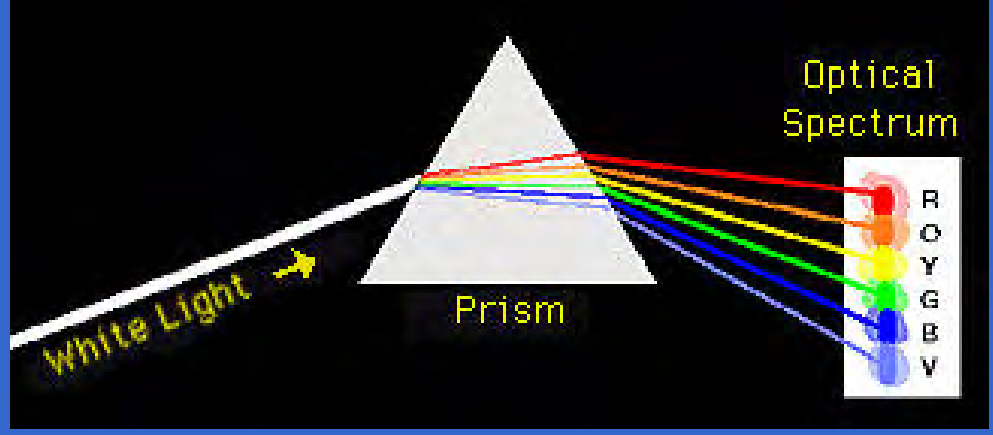
- Too much light.
  - neighbor's lights.
- Glare.
  - Wall packs, "security" lights, floodlights.
- Can't see well anymore.
- Light trespass
- Not comfortable; it's obtrusive light.



Thorpe Park, City of Flagstaff
1970’s vintage sport lighting
Note glare and spill lighting

Thorpe Park, City of Flagstaff
Modern sport lighting circa 2006

Benefits:
Light levels on playing field are twice previous.
Players and spectators can see better.
No light trespass into surrounding neighborhood.
Better energy efficiency.
Everyone wins.



White light passing through a prism.

Photo courtesy NASA

Continuous spectrum of white light.

Photo courtesy NASA

Hydrogen spectrum

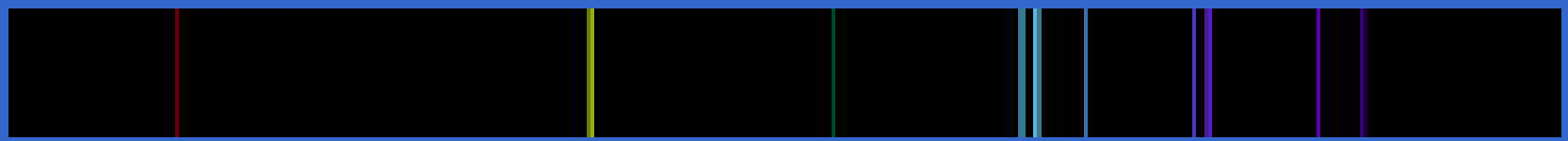
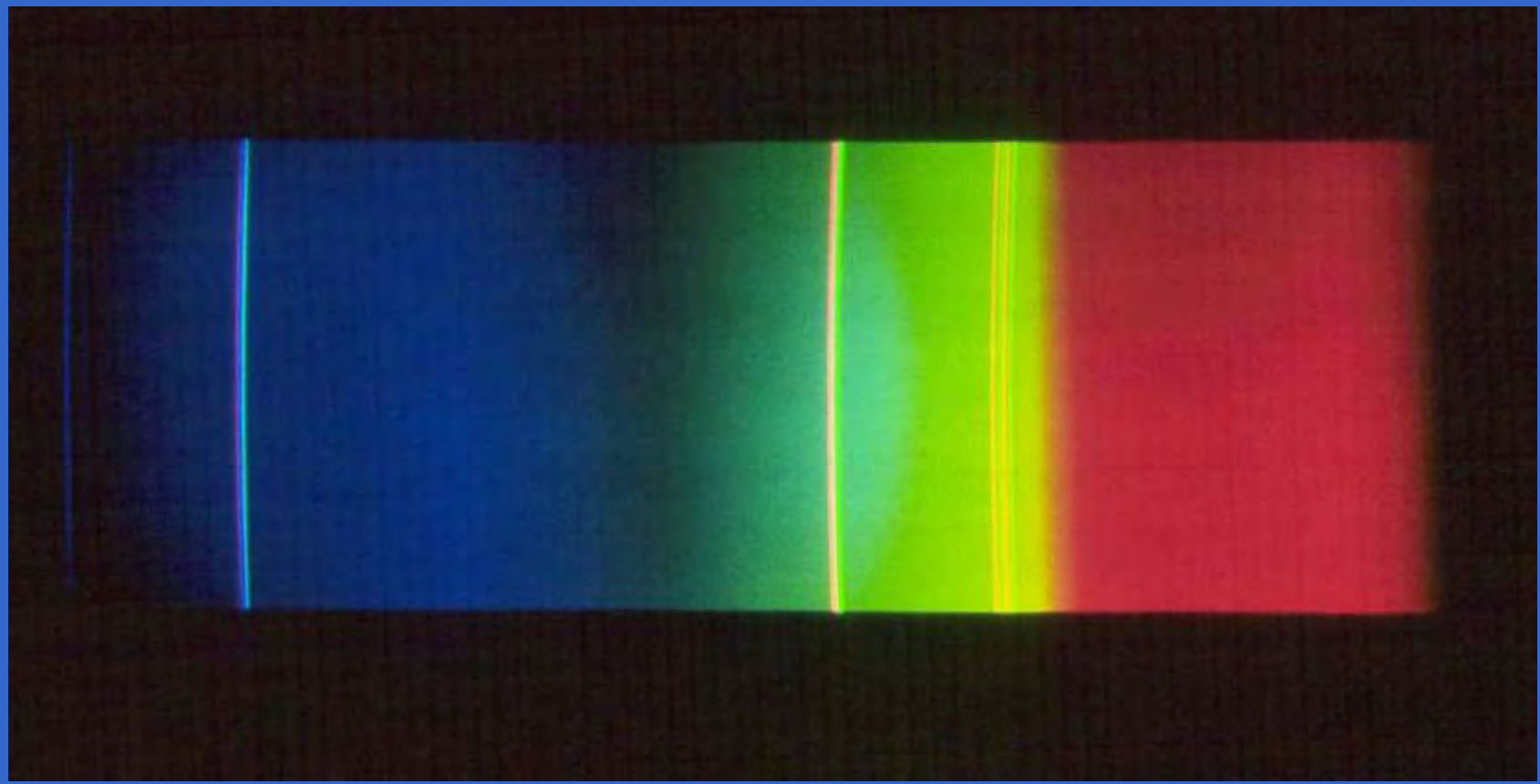


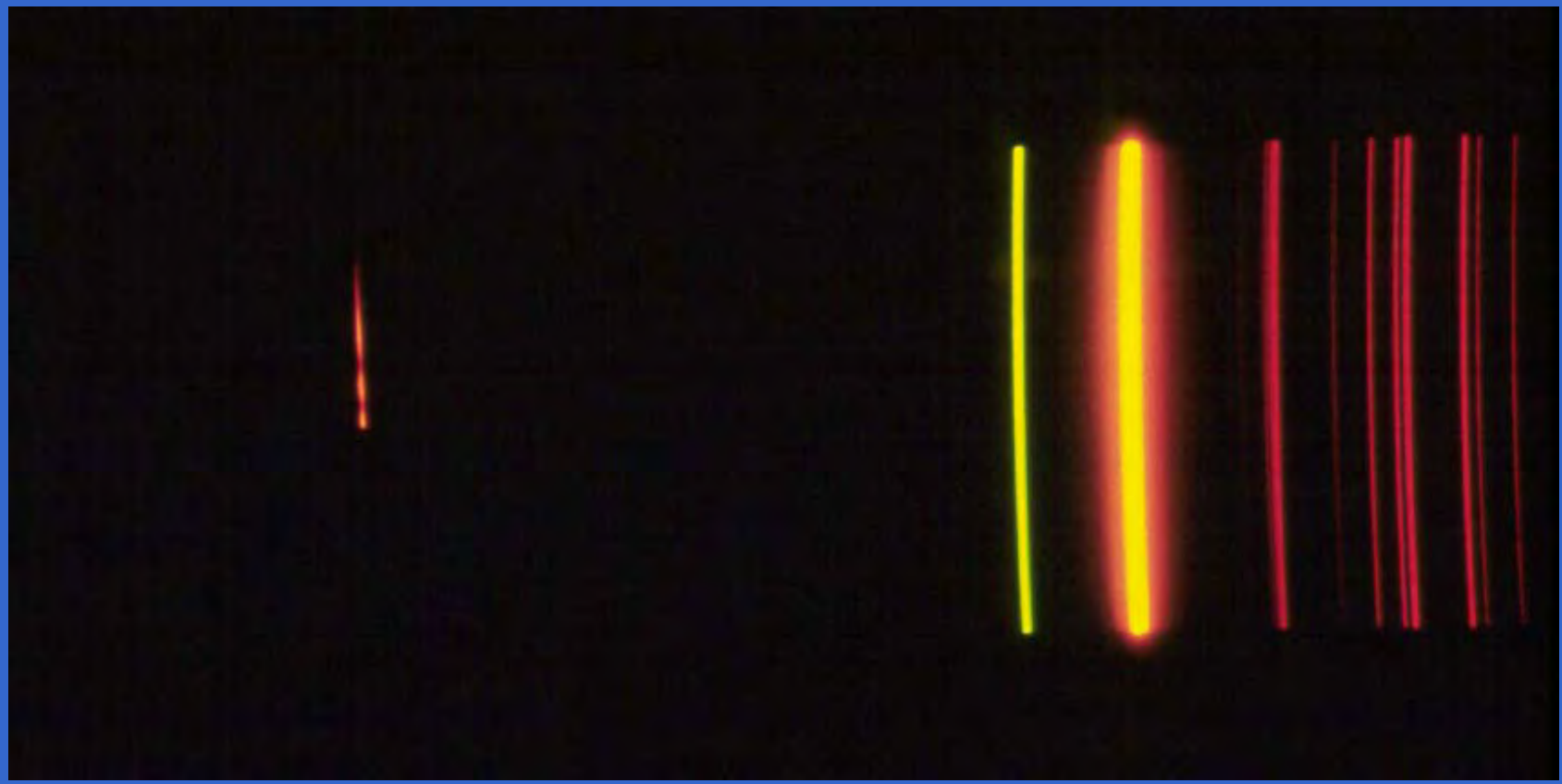
Photo courtesy NASA

Helium spectrum

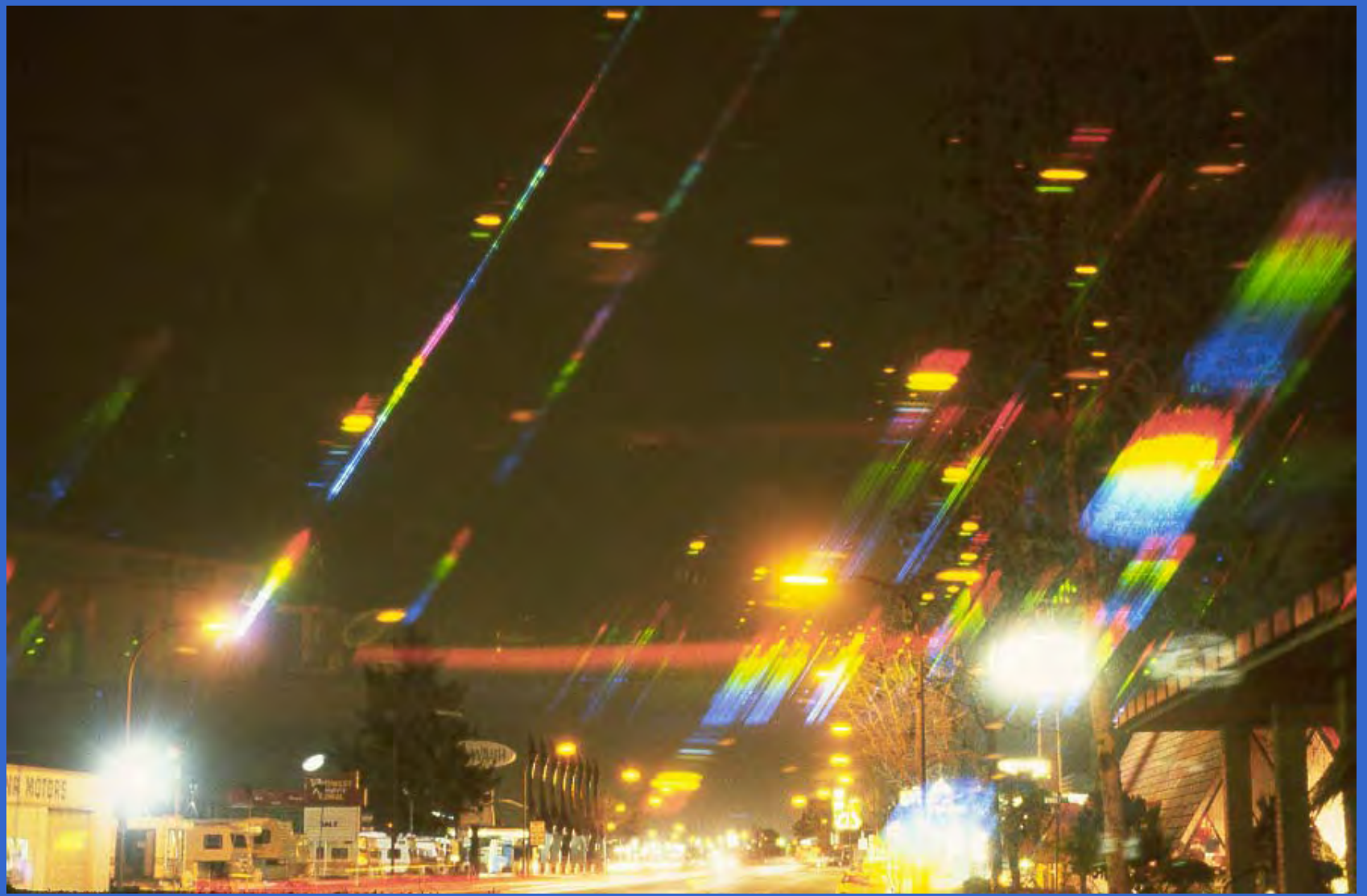
The spectral output of a typical fluorescent lamp.



The spectral output of a low pressure sodium lamp.



A photo of a street in Redwood City, CA,
with a transmission grating in front of the lens.



City of Flagstaff Signs & Lighting Regulations

CHAPTER 10-08. SIGNS AND LIGHTING

DIVISION 10-08-001 SIGN REGULATIONS.

10-08-001-0001. PURPOSE AND INTENT:
The City Council finds that the natural surroundings, climate, history, and people of the City of Flagstaff combine to provide the Flagstaff community with unique charm and beauty. This Division has been adopted to assure that signs installed in the City of Flagstaff are compatible with the unique character and environment of the community.
(Entire Division adopted by Ord. 1946, 6-17-97)

Common forms of sign lighting regulation

Internally illuminated signs

Sign size (larger signs emit more light)

Sign color (darker colors emit less light)

How long is sign lit? (curfew)

Externally illuminated signs

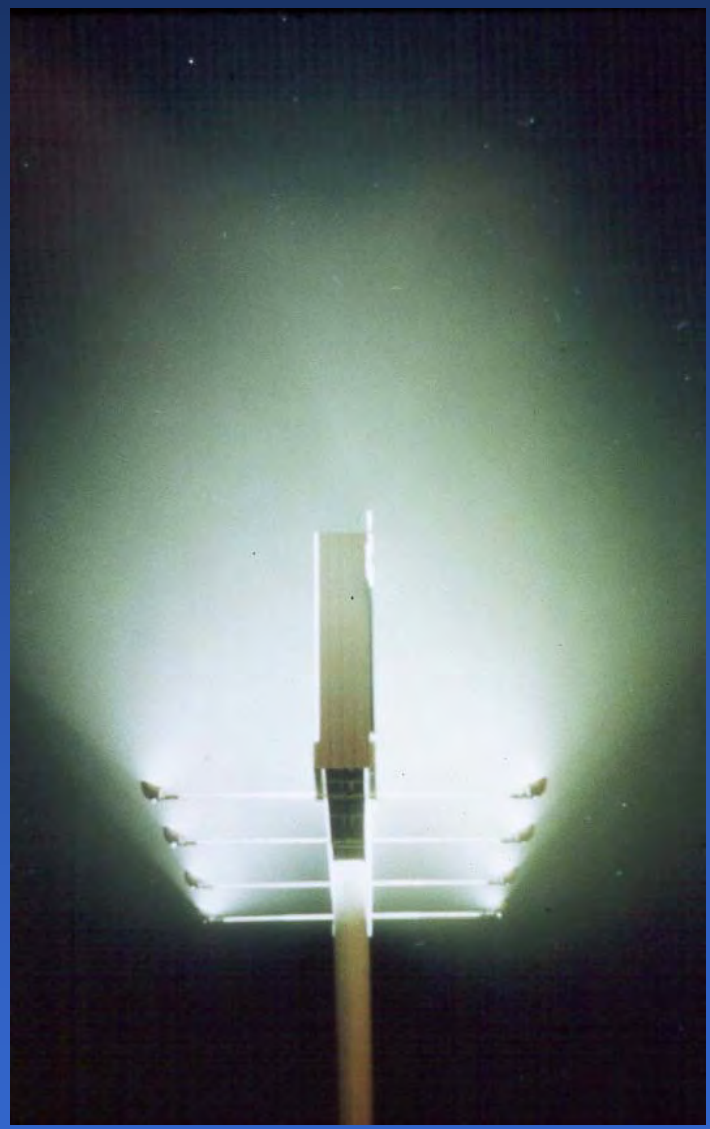
Type of light fixtures (full cut off)

How mounted (top mounted)

How much (lumens limit)

How long is sign lit? (curfew)

A billboard, seen from the side.



Externally illuminated sign

Cortaro & I-10

10 - Brown
100 - White Letters

240 - White

1 - Blue
125 - White Letters

100 - Yellow

0 - Blue
50 - White Letters

2 - Red
125 - White Letters

250 - White

10 - Green
125 - White Letters

0 - 100

110 - White

Internally illuminated sign

Cortaro & I-10


Parking lot lights are OFF
Signs illuminate the parking lot
ARIZONA PAVILIONS
CINEMAS
chili's

Pima County Lumens Cap Table

Table 401.1
Maximum Total Outdoor Light Output Requirements
Lumen Caps: Mean Lumens per Net Acre (4)

	Lighting Area as Defined in Chapter 3					
Commercial and industrial "Option 1" (1)(2) (mostly LPS lighting)	**E3**	**E3a**	**E2**	**E1c**	**E1b(5)**	**E1a(5)**
Total (full cut-off LPS, plus full cut-off non-LPS)	450,000	350,000	200,000	125,000	48,000	18,000
Limit on non-LPS full cut-off.	45,000	35,000	18,000	6,000	3,000	3,000
Limit on unshielded component (LPS or non-LPS)	12,000	9,000	6,000	3,000	3,000	0
Commercial and industrial "Option 2" (1)(2) (full cut-off for all lighting)	**E3**	**E3a**	**E2**	**E1c**	**E1b(5)**	**E1a(5)**
All lighting must be full cut-off	300,000	150,000	65,000	25,000	25,000	12,500
Limit on unshielded component	0	0	0	0	0	0
Commercial and industrial "Option 3" (1)(2) (full cut-off for most lighting)	**E3**	**E3a**	**E2**	**E1c**	**E1b(5)**	**E1a(5)**
Total (full cut-off plus unshielded)	200,000	100,000	50,000	25,000	12,500	12,500
Limit on unshielded component	12,000	9,000	6,000	3,000	3,000	0
All residential zoning (3)(4)	**E3**	**E3a**	**E2**	**E1c**	**E1b(5)**	**E1a(5)**
Total (full cut-off plus unshielded)	55,000	39,000	24,000	15,000	12,000	12,000
Limit on unshielded component	12,000	9,000	6,000	3,000	3,000	3,000

PHILIPS

PHILIPS

Extended Service Lamps

Comparative Data

	Extended Service:		Standard:	
Watts	Avg Hours	Avg Lumens	Avg Hours	Avg Lumens
40	2500	415	1500	480
60	2500	740	1000	890
75	2500	1000	750	1220
100	2500	1480	750	1710

Philips Lighting Company
P.O. Box 6800 ▪ Somerset, NJ 08875-6800
A Division of North American Philips Corporation

Made in U.S.A.

HX-A192C-S
810838

2 Lamps

SEDONA OUTDOOR LIGHTING APPLICATION

City of Sedona • 102 Roadrunner Drive • Sedona, AZ 86336
928-282-1154

Permit # B: _____
Date Received: _____
Approved: Not Approved:
Staff Initial: _____

1. **Applicant Information:**

   Name _____

   Mailing Address _____

   Phone No._____

2. **Site Identification:**

   Business Name (*if applicable*) _____

   Location _____

   Assessor's Parcel Number __ __ __ - __ __ - __ __ __

3. **Lumen Information (non-residential and multi-family uses):**

   Gross acres of entire site _____

   Acres for Public Right-of-Way - (_____)

   Net Acreage of Site _____ X 100,000* = _____
   (Total Lumens Permitted)

4. **Type of Shielding and Lumens Proposed:** *(see Lumen Calculation Table)*

Fully Shielded Fixtures:	**Lumens Proposed:** _____
Partially Shielded Fixtures:	**Lumens Proposed:** _____
	TOTAL LUMENS PROPOSED: _____ *(fully and partially shielded fixtures)*

* Total outdoor light output shall not exceed 100,000 lumens per net acre for all development except single-family residential uses. This cap is not intended to be achieved in all cases or as a design goal. Instead, design goals should be the lowest levels of lumens necessary to meet the lighting requirements of the site. Partially shielded light fixtures are limited to a

Lighting Inventory and Lumen Calculation Table

List all new or proposed lighting first, then any existing light. Include any lighting proposed for external illumination of signs. Attach photometric data sheet or manufacture's product description for all lights, both new and existing (must include lumens). If such data is not available for existing fixtures that will be retained, include photographs of the fixtures showing sufficient detail determine the shielding characteristics. Please include a Site Plan identifying all proposed and existing lighting fixtures.

Lamp Type Key:

LPS	Low Pressure Sodium
HPS	High Pressure Sodium
MH	Metal Halide
FL	Fluorescent
IN	Incandescent (including quartz-halogen)

Shielding Key:

F	Fully Shielded
P	Partially Shielded
U	Unshielded

Plan Key (ID)	Light Class (1, 2 or 3)	Lamp Type (LPS, HPS, MH, FL, IN)	Initial Lumens	No. of Units	Shielding (F, P or U)	Watts (each)	New or Existing (N or E)	Total Lumens
TOTAL LUMENS:								

Plan Key identification in first column must correspond to labeling on site plan map.

Applicant Signature _____ Date _____

L:ISFORMS/LIGHT.DOC

SAMPLE

Lumen Calculation Table

Lamp Type Key:

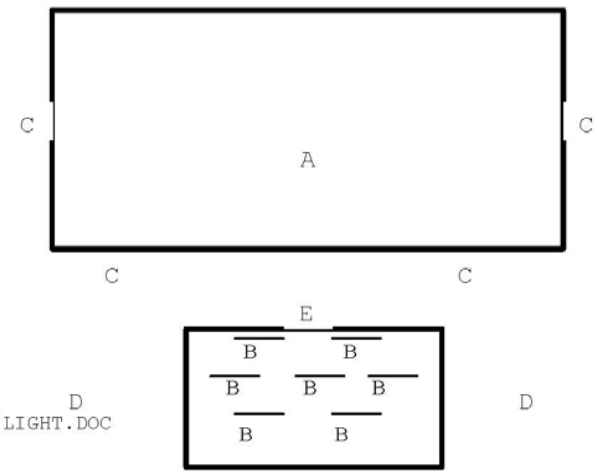
LPS	Low Pressure Sodium
HPS	High Pressure Sodium
MH	Metal Halide
FL	Fluorescent
IN	Incandescent (including quartz-halogen)

Shielding Key:

F	Fully Shielded
P	Partially Shielded
U	Unshielded

Plan Key (ID)	Light Class (1, 2 or 3)	Lamp Type (LPS, HPS, MH, FL, IN)	Initial Lumens	No. of Units	Shielding (F, P or U)	Watts (each)	New or Existing (N or E)	Total Lumens
A	Interior	NA	NA	NA	NA	NA	NA	NA
B	1	FL	2,975	7	F	35	N	20,825
C	1	IN	1,750	6	F	100	N	10,500
D	2	LPS	13,500	2	F	135	N	27,000
E	1	MH	16,000	2	F	250	N	32,000
TOTAL LUMENS:								90,325

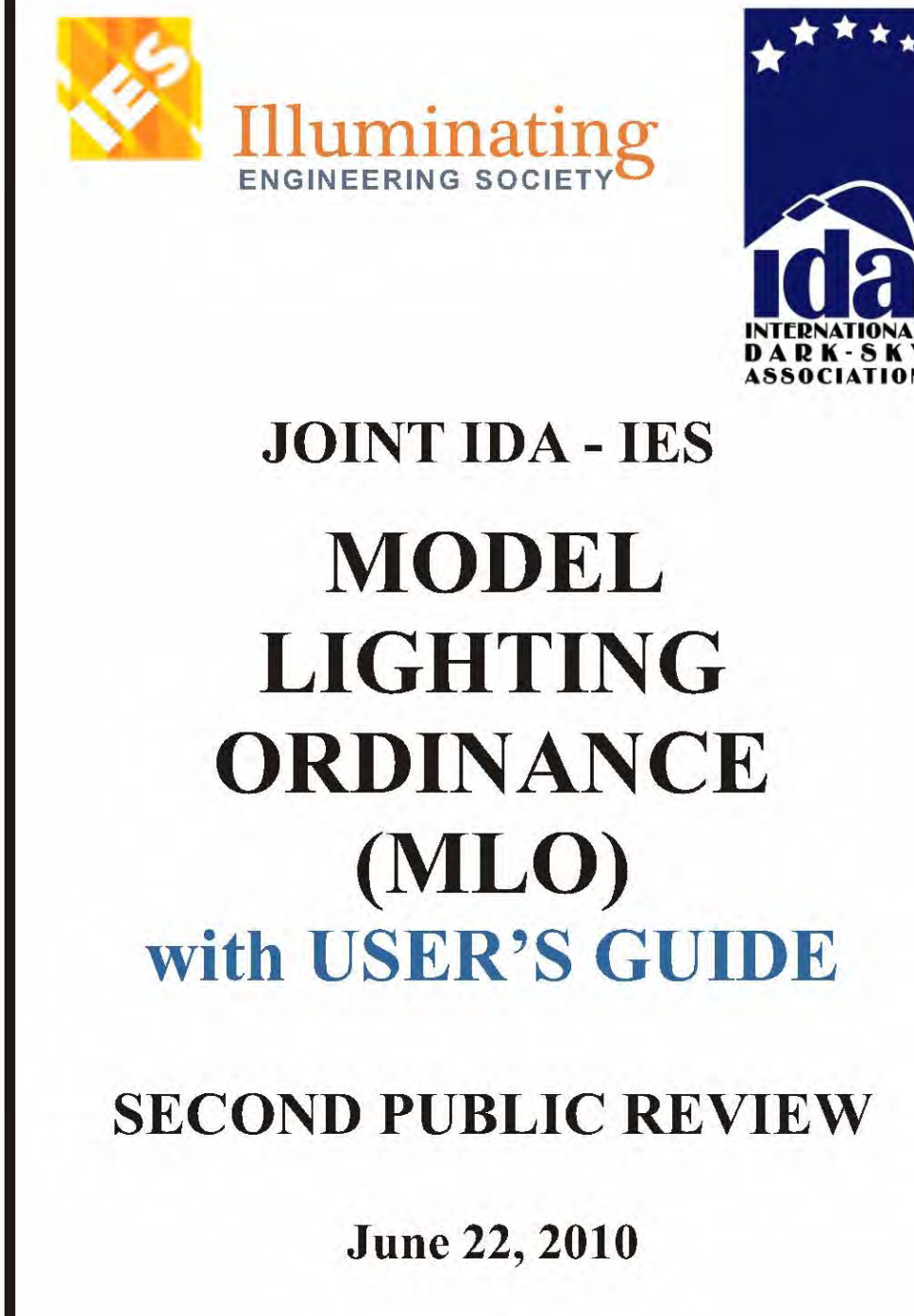
Plan Key identification in first column must correspond to labeling on site plan map.



- Still under review
- Uses Lighting Zones (5)
- Two methods of application:

  Prescriptive Method (much like MAG Pattern Code)
  and
  Performance Method for complex projects (Requires professional designer.)

- MLO uses BUG rating for lighting fixtures in place of shielding classifications
- **BUG** = **B**acklight, **U**plight, **G**lare
- Fixture has to be measured photometrically to determine BUG rating.
- Has changed from watt to lumen-based during first review cycle.



Pinal County proposed Code revisions:

(Some notable differences from MAG Pattern Code)

3602.16 LIGHTING POWER DENSITY (LPD): The LPD for a project site is defined as the watts of exterior lighting per square foot of area (Watts/Ft_2) for the different sections of the project site (parking lot, walkways, building entries, etc.). This is the metric established by the International Energy Conservation Code (IECC), and will therefore be utilized as one of the factors for determining conformance with the IECC and this Article.

3602.19 LUMEN DENSITY (LD): The LD for a project site shall be defined as the initial lumens of the lamps/light-sources utilized by the exterior lighting per square foot of area (Lumens/Ft_2) for the project site. This metric is another factor that will be utilized for determining compliance with this Article.

[*Blue text shows proposed revisions/additions*.]

Pinal County

Article 36

OUTDOOR LIGHTING Zoning Ordinance

603.6 LIGHTING ARTICLE MATRIX

Lighting Zones

Shielding

Color Temperature

Light Trespass

Mounting Heights

Power Density

Lumen Density

Lighting Zone	Operating Hours, LPD Limit & LD Limit	Light Sources and Fixture Shielding	Mounting Height & Pole Color	Perimeter illuminance Levels	Uplighting
1 Low Ambient Light Areas	Security Lighting only after 10:00 PM or 1-hour after Close of Business. LPD = 50% of IECC Limit LD = 9 Lumens/Ft^2	Light Sources L.T.E. 3,000K Color Temperature Full-Cutoff fixtures only HSS on Perimeter Fixtures adjacent to Residential	6' height when L.T.E. 30' from Residential Property Line. 15' height when G.T. 30' Dark and Non-Reflective Colors	0.30 VFC maximum Normal Business and 0.10 VFC Security Only, at a Residential Prop. Line	L.T.E. 1,800 Initial Lumens Turn off at 10:00 PM. or 1-hour after Close of Business
2 Medium Ambient Light Areas	Security Lighting only after 10:00 PM or 1-hour after Close of Business LPD = 75% of IECC Limit LD = 14 Lumens/Ft^2	All Light Sources Semi-Cutoff and Cutoff fixtures when L.T.E. 1,800 Initial Lumens Full-Cutoff when G.T. 1,800 Initial Lumens HSS on Perimeter Fixtures adjacent to Residential	6' height when L.T.E. 30' from Residential Property Line. 15' ht when G.T. 30'. and when L.T.E. 150' 25' ht. when G.T. 150' Dark and Non-Reflective Colors.	0.80 VFC maximum Normal Business and 0.30 VFC Security Only, at a Residential Prop. Line	L.T.E. 3,500 Initial Lumens Turn off at 10:00 PM. or 1-hour after Close of Business
3 High Ambient Light Areas	Security Lighting only after 10:00 PM or 1-Hour after Close of Business. LPD = 100% of IECC Limit LD = 19 Lumens/Ft^2	All Light Sources. Semi-Cutoff and Cutoff fixtures when L.T.E. 3,500 Initial Lumens Full-Cutoff when G.T. 3,500 Initial Lumens HSS on Perimeter Fixtures adjacent to Residential External HSS adjacent to Residential after 10:00 PM.	15' height when L.T.E. 150' from Residential Property Line 30' ht. when G.T. 150' Dark and Non-Reflective Colors.	1.50 VFC maximum Normal Business and 0.80 VFC Security Only, at a Residential Property Line	L.T.E. 6,500 Initial Lumens. Turn off at 10:00 PM. or 1-hour after Close of Business

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