920 Illumination

920.1 General

The primary function of illumination (roadway lighting) is to supplement vehicle headlights by providing additional visibility of the roadway and related features including roadway access points. Illumination is also provided to enhance the visual perception of conditions or features that require additional pedestrian or cyclist alertness during the hours of darkness. Roadway lighting should not be expected to produce a daytime equivalent in terms of visibility or illumination.

In some situations, roadway lighting is considered for reasons other than the nighttime enhancement of traffic operations. A local agency may find benefit in lighting for promoting a community, reducing crime and vandalism, or providing public comfort and convenience during times of darkness. In these cases, lighting may be considered where the local governmental entity finds sufficient benefits to pay an appreciable percentage of the cost of, or wholly finance, the installation, maintenance, and operation of the lighting facilities.

920.2 References

The following references are used in the planning, design, construction, and operation of roadway lighting installed on state highways. Conformance with federal and state laws and codes is required. Any reference to a design guide, code, law, or requirement refers to its latest version.

920.2.1 Federal/State Laws and Codes

- 17.4.2 New Mexico Administrative Code (NMAC), Requirement for Occupancy of State Highway System Right-of-Way by Utility Facilities.
- 18.31.6 NMAC, State Highway Access Management Requirements.
- New Mexico Statutes Annotated (NMSA) Sections 74-12-1 to 74-12-10, Night Sky Protection Act.

920.2.2 Design Guidance

- American Association of State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Design (LRFD) Specs for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, current edition.
- AASHTO Roadway Lighting Design Guide, 2005.
- A Policy on the Geometric Design of Highways and Streets (Green Book), AASHTO, current edition.
- American National Standard Practice for Roadway Lighting ANSI/IESNA RP-8-14, Illuminating Engineering Society of North America (IESNA), 2005.
- Design Guide for Roundabout Lighting, DG-19-08, IES, 2008.
- Guidelines for the Implementation of Reduced Lighting on Roadways, Federal Highway Administration (FHWA), 2014.
- Highway Safety Manual, AASHTO, current edition.
- Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD), United States Department of Transportation (USDOT), FHWA, current edition.
- National Electrical Code (NEC), National Fire Protection Association (NFPA), current edition.
- NFPA 502: Standard for Road Tunnels, Bridges, and Other Limited Access Highways, NFPA, current edition.
- NFPA 780: Standard for the Installation of Lightning Protection Systems, NFPA, current edition.
- New Mexico Department of Transportation (NMDOT) Standard Drawings.

The NMDOT is not currently using ANSI/IES RP-8-14, which classifies luminaires in terms of BUG rating.

- NMDOT Standard Specifications for Highway and Bridge Construction, current edition.
- Roadway Lighting Handbook, FHWA, August 2012.
- Roadside Design Guide, AASHTO, current edition.

920.3 Definitions

Terms used in the discussion of the planning and design of lighting systems are defined below.

- **Adaptive lighting system** - A design methodology in which roadway lighting illumination levels and times of operation are adjusted based on the needs of the roadway's users.
- **Associated facilities** - Parallel or connecting travel ways or access points used by pedestrians or other non-motorized transportation modes, such as bicycles.
- **Average initial horizontal illuminance** - The average level of horizontal illuminance on the pavement area of a traveled way at the time the lighting system is installed (when lamps are new and luminaires are clean), expressed in average footcandles for the pavement area.
- **Average maintained horizontal illuminance** - The average level of horizontal illuminance on the roadway pavement when the output of the lamp and luminaire is diminished by the maintenance factors, expressed in average footcandles for the pavement area.
- **Ballast** - A device used with an electric discharge lamp to obtain the necessary circuit conditions (voltage, current, and wave form) for starting and operating.
- **Bracket or mastarm** - An attachment to a lighting standard or other structure used for the support of a luminaire.
- **BUG rating** - The backlight, uplight, and glare of a luminaire. The NMDOT is not currently using this criteria for its roadway lighting.
- **Conventional lighting** - A highway lighting system in which the luminaires are typically mounted no higher than 50 feet.

- **Cross road** - A street crossing at an access controlled facility or intersecting street, either at-grade or grade separated, to a roadway.
- **Equipment factor (EF)** - Relates the actual field performance of a new luminaire to laboratory performance data. Generally, an EF of 0.90 to 0.95 is used for roadway lighting computations.
- **Footcandle** - The illuminance on a surface one square foot in area on which there is a uniformly distributed light flux of one lumen.
- **Glare** - The optical sensation produced by luminance within the visual field that is sufficiently greater than the luminance to which the eyes are adapted to cause annoyance or discomfort (discomfort glare), or loss in visual performance and visibility (disability glare).
- **Illuminance** - The density of the luminous flux incident on a surface. It is the quotient of the luminous flux divided by the area of the surface when the latter is uniformly illuminated. Illuminance is not observer or pavement dependent.
- **Illuminance method** - A method of roadway lighting design that determines the amount of light incident on the roadway surface.
- **Iso-footcandle diagram** - This diagram is available from the manufacturer of the light source and shows the horizontal footcandles on the pavement surface at various points away from the source. Mounting height must be known to properly use the diagram.
- **Lamp** - A generic term for a man-made source of light that is produced either by incandescence or luminescence.
- **Lamp lumen depreciation factor (LLD)** - A factor that indicates the decrease in a lamp's initial lumen output over time. For design calculations, the initial lamp lumen value is reduced by a LLD to compensate for the anticipated lumen reduction. This factor is usually found in test data or established by the state.
- **LED street light** - A luminaire that uses light emitting diodes (LEDs) as its light source.

- **Lighting project categories** - Defined as freeways, access controlled routes other than freeways, non-access controlled routes, intersections, pedestrian facilities, railroad grade crossings and park and ride facilities.
- **Lighting standard** - The pole with or without bracket or mastarm used to support one or more luminaire.
- **Lighting unit** - The assembly of pole or standard with bracket and luminaire.
- **Lumen** - A unit of measure of the quantity of light (luminous flux).
- **Luminaire** - A complete lighting unit consisting of a lamp or lamps together with the parts designed to distribute the light, to position and protect the lamps, and to connect the lamps to the power supply.
- **Luminaire dirt depreciation (LDD)** - Light loss depreciation due to accumulated dirt.
- **Luminance** - The luminous intensity of a surface in a given direction per unit of projected area of the surface as viewed from the direction (measured in footlamberts).
- **Luminance method** - A method of roadway lighting design which determines how bright the road is by determining the amount of light reflected from the pavement in the direction of the driver.
- **Luminous efficacy** - The quotient of the total luminous flux delivered from a light source divided by the total power input to the light source. It is expressed in lumens per watt.
- **Luminous flux** - The perceived power of light, measured in lumens.
- **Maintenance** - Includes replacement of damaged lighting standards and luminaires, lamp replacement due to lamp lumen depreciation, continuous electrical service, and future relocation of roadway luminaires and standards.
- **Maintenance factor (MF)** - A combination of factors used to denote the reduction of the illumination for a given area after a period of time compared to the initial illumination on the same area (MF = EF + LLD + LDD).

- **Mounting height** - The vertical distance between the roadway surface and the center of the apparent light source of the luminaire.
- **Public entity** - The federal government or any federal department or agency, a Native American tribe or pueblo or nation, the state, a county, municipality, public corporation or public district of this state and any school district or state educational institution in this state.
- **Slip base** - A pole support designed to resist wind and vibration loads while safely releasing upon impact from any direction.
- **Spacing** - The distance between successive lighting units measured along the centerline of the roadway.
- **Urban, suburban, and rural conditions** - Urban conditions refer to those areas adjacent to an urban roadway, as classified by the NMDOT. Suburban conditions exist in areas contiguous to urban areas, as classified by the NMDOT. Rural conditions refer to all other areas or as areas adjacent to rural roadways, as classified by the NMDOT.
- **Users** - Includes vehicle operators and other transportation modes which use the roadway and pedestrian ways within NMDOT right-of-way.
- **Veiling luminance** - A luminance superimposed on the retinal image that reduces contrast. It is this veiling effect produced by bright sources or areas in the visual field that results in decreased visual performance and visibility.
- **Visibility** - The quality or state of being perceivable by the eye. In outdoor applications, visibility is defined in terms of the distance at which an object can just be perceived by the eye.

920.4 Procedures

The lighting system design should be accomplished in a logical sequence as outlined below:

1. Analyze for lighting warrants and obtain recommendation for installation from NMDOT.
2. Obtain a Letter of Intent to Maintain from the local governmental entity having jurisdiction.

3. Determine availability and location of electric service from local electrical service provider.
4. Using lighting analysis software, determine luminaire type, mounting height, and spacing.
5. Document lighting analysis to show that lighting criteria are met.
6. Consider roadside safety for pole placement, and set final pole locations.
7. Select lighting equipment.
8. Size, design, and document the calculations for the electrical distribution system.
9. Complete plans, specifications, and estimates.
10. Obtain final approval and complete maintenance agreement with local government entity.

920.4.1 Warranting

The warrants in this section are for the purpose of justifying the installation of roadway lighting systems on state highways in New Mexico from a financial standpoint. It is generally recognized that roadway lighting contributes to improving safety, traffic movements, and general roadway use in urbanized areas. In rural areas, however, roadway lighting is normally confined to unique conditions where there are conflicting traffic movements that can be better delineated by nighttime illumination. In all cases, the justification of lighting on state highways requires the concurrence of the NMDOT and the local governing entity (agency having jurisdiction of the particular roadway section).

Warranting conditions have been established to provide a basis to justify the installation of fixed-source lighting from a financial standpoint. Lighting warrant studies on candidate state highway sections shall be conducted in accordance with AASHTO's Roadway Lighting Design Guide.

Lighting warrant studies may be performed by a public entity, the entity's qualified consultant engineer, or NMDOT staff. The District Engineer or designee and the General Office Traffic Section shall be responsible for the review of these studies and recommend candidate improvements.

Meeting a warrant does not in itself mean that lighting must be installed.

Meeting a warrant does not in itself mean that lighting must be installed.

920.4.1.1 Freeway Lighting

1. Complete freeway interchange lighting is considered to be warranted based on the criteria contained in the latest edition of AASHTO's Roadway Lighting Design Guide, under the section titled "Complete Interchange Lighting."
2. Partial interchange lighting is considered to be warranted based on the criteria contained in AASHTO's Roadway Lighting Design Guide, under the section titled "Partial Interchange Lighting."
3. Continuous freeway lighting is considered to be warranted based on the criteria described in the latest edition of AASHTO's Roadway Lighting Design Guide under the section entitled "Continuous Freeway Lighting."
4. Lighting at freeway ramps, gores, and cross roads is considered warranted if either 1 or 2 above is satisfied.

920.4.1.2 Lighting for Access Controlled Routes other than Freeways

1. Interchange lighting is considered to be warranted under the same criteria as in Section 1, 2, or 4 above.
2. Intersection and roadway section lighting is considered to be warranted based on the criteria for sections described below.

920.4.1.3 Lighting for Non-Access Controlled Routes

Lighting may be provided for highway sections based on the following guidelines.

1. If replacement lighting is needed on highway sections that currently have continuous lighting, it should be upgraded to current appropriate AASHTO guidelines.
2. On new roadway sections or where no continuous lighting exists, continuous lighting may be provided if one of the following conditions is satisfied:
   a. The subject section satisfies volume criteria as shown in Exhibit 920-1.

Exhibit 920-1

Volume Warrant Criteria for Lighting on Non-Access Controlled Routes

Major Street Number of Through Lanes	Vehicles per Hour on Major Street, Both Directions
1	750
2	900

This warrant is satisfied when, for each of eight hours of an average day the above traffic volumes exist. This warrant applies to urban and suburban areas. If the subject route is located within a built up area of an isolated community with a population of less than 10,000, the warrant is 70 percent of the above.

b. Continuous lighting in urban areas may be warranted if the ratio of nighttime crashes to daytime crashes is 2:1 or more in the previous three-year period, with five or more total reported crashes. Also, the volume warrant above should be satisfied to the extent of 70 percent or more of the traffic volumes shown above in Exhibit 920-1.

c. Continuous lighting is not normally installed on non-access controlled facilities in rural areas. In special cases, continuous lighting may be installed in rural areas based on a documented safety need that may be improved with lighting. Traditionally these needs are justified by a benefit-cost evaluation which indicates a benefit/cost ratio greater than one. Highway safety funds have been used in the past to program such a project.

920.4.1.4 Existing Intersection

Street lighting may be installed at an existing intersection if one of the following conditions is met:

1. During any single hour which may be in darkness (consider winter months), volumes at the intersection meet or exceed the volumes required to satisfy MUTCD Warrant 1 - Eight-Hour Vehicular Volume (Condition A or B) or Warrant 4 - Pedestrian Volume.
2. Four or more nighttime crashes have occurred in any recent 12-month period.

3. When a traffic signal or an intersection flashing beacon is installed.
4. Where a combination of sight distance, or horizontal or vertical curvature of the roadway, channelization, or other factors constitute a potentially confusing or unsatisfactory condition that may be improved with lighting. A project report evaluating the need should include an investigation of the factors constituting those conditions.

920.4.1.5 New Intersection

Per 18.31.6 NMAC, illumination should be provided at all signalized intersections in accordance with AASHTO's Roadway Lighting Design Guide or as otherwise approved by the NMDOT.

Lighting may be installed at new intersections if it is forecast that any of the warrants listed above will be satisfied within five years after the opening of the project to traffic. Lighting should be installed and operational before or upon the installation of a roundabout.

920.4.1.6 Railroad Highway Grade Crossing

Lighting may be installed at railroad-highway grade crossings.

920.4.1.7 Pedestrian Facilities

Lighting for pedestrian facilities may be considered at urban or suburban crossing locations where conflicts with vehicular traffic constitute a potentially confusing or unsatisfactory situation. Such situations could include crosswalk locations where a substantial amount of documented nighttime pedestrian or bicycle activities take place. Other locations where lighting is considered warranted include pedestrian overpasses and tunnels.

920.4.1.8 Park-and-Ride Lots

Lighting of these facilities is desirable but not mandatory. An evaluation should be performed to determine if it is feasible and cost effective.

920.4.1.9 Rest Areas

Lighting should be installed at rest areas for safety and security, if it is feasible and cost effective.

920.4.1.10 Lighting Other Areas

The lighting of other areas will be considered on a case-by-case basis and is largely dependent on the desires and needs of the operating entity, including its willingness to provide for future maintenance and operation of the lighting system. A study to determine the need for lighting should include the feasibility of providing electrical service. Special areas to be lighted may include truck weighing stations and inspection and enforcement areas.

920.4.1.11 Lighting Based on Safety Analysis

In some circumstances, a new lighting installation may be warranted where a safety analysis using the FHWA Highway Safety Manual suggests that providing lighting may reduce the incidence of crashes.

920.4.1.12 Other Considerations for Warranting Roadway Lighting

In addition to meeting one of the warrants above, in order for a lighting system to be considered the following two conditions must be met:

- The highway section must be within the city limits or jurisdiction of the local government entity making a request.
- The local government entity must be willing to execute an agreement in which it agrees to provide all operating and maintenance costs.

The warrant procedures and request for approval shall be documented and forwarded to the NMDOT Traffic Support Section for review and recommendation as a possible candidate for improvements. Note that the fact that a location meets a warrant does not obligate the NMDOT to provide funding for the requested highway lighting project. NMDOT’s objective is to identify those roadways that should be considered in the process of setting priorities for the allocation of available funding for roadway lighting projects.

920.4.2 Design Analysis

The design of a roadway lighting system must effectively address factors such as initial cost, maintenance, operating cost, and provision of a uniform and adequate level of illumination for users of the roadway. In general, the lighting layout selected is largely dependent on local preference and maintenance capabilities (e.g., established rates, maintenance stockpiles). Accordingly, the design must be coordinated with the responsible local maintaining entity and its utility organizations. The FHWA Lighting Handbook and the information contained in the sections below are also good references in selecting a lighting layout. The final selection of the lighting layout shall be approved by the NMDOT Traffic Section.

920.4.2.1 Continuous Lighting Systems

The most common type of street and highway lighting consists of specifically designed roadway lighting luminaires mounted on poles placed adjacent to the roadway and capable of providing continuous illumination for the roadway over a substantial distance.

Roadway luminaires are designed to provide an elongated lighting pattern, longitudinally with the roadway. In addition, most roadway luminaires also push the light pattern perpendicular to the roadway, forming what are commonly referred to as the street-side and the house-side along its longitudinal axis. The most important variables affecting the design are the light source, light source size, and mounting height selected. These variables must be matched in the design process with the light uniformity required.

Standard urban street lighting commonly uses poles with a 30-foot mounting height. Because of their wider roadways, freeways and multilane divided highways require taller mounting heights. For freeways, 40 feet is the usual mounting height because it substantially reduces the number of poles required and is still accessible for maintenance without highly specialized equipment. The goal of the design should be to minimize the number of poles while using luminaires that provide acceptable uniformity and glare control. Reducing the number of poles can reduce initial costs and maintenance efforts, and improve daytime aesthetics and safety.

The same luminaires and poles used for continuous lighting are used singularly or in small groups for intersection, partial-interchange, or spot safety lighting applications.

920.4.2.2 High-Mast Lighting

High-mast lighting implies an area type of lighting with groups of luminaires mounted on free-standing poles at mounting heights typically ranging from 100 to 150 feet. At these mounting heights, several high-output luminaires develop highly uniform light distribution. Because of its ability to illuminate a relatively large area per single support, high-mast lighting is confined to complete interchanges, rest areas, and parking areas, and for possible continuous lighting on highways having wide cross sections and a large number of traffic lanes.

The principal benefits of high-mast applications are the ability to provide excellent uniformity of illumination and reduce glare with a substantially smaller number of poles. Normal mounting heights permit the use of luminaires that direct the light more downwardly and yet maintain a large area of coverage. This distribution of light can reduce both discomfort and disability glare, and provide better performance under adverse weather conditions such as rain, fog, or dust storms.

The locations benefiting most from high-mast lighting are complex interchanges, where conventional continuous lighting of the turning, crossing, and intersecting road and ramps can create a confusing visual field for the driver. High-mast lighting of such an interchange provides for the illumination of the areas between the roadway and ramps which can provide the proper visual perspective as in daylight conditions and improve the driver's ability to make advance decisions and judge distances.

High-mast lighting contributes to aesthetics and safety by reducing the number of poles that would be required for a conventional system and allowing poles to be located out of the recovery area adjacent to the driving lanes. Also, their remote location eliminates the need for maintenance vehicles to obstruct traffic on the roadway or to have maintenance personnel work near high-speed traffic lanes. High-mast lighting equipment, however, is more complex than conventional lighting. Because of their height, high-mast poles require lowering devices to allow luminaire servicing, and these require special design and maintenance considerations.

920.4.2.3 Light Sources

New factors that are having an increasing influence on roadway lighting design include light pollution in the night environment and the need for electrical energy conservation. The impact of stray light on nighttime skies and its unwanted intrusion on private property is an area of growing public sensitivity. The need for energy conservation is not only related to its supply but also to maintenance and operating costs, which have risen dramatically for many local governing entities. Therefore, the designer should consider the latest advances in lighting equipment and design and specify roadway lighting systems that provide optimum optical light controlled by today's standards and that are energy efficient.

In New Mexico, where lighting is installed it shall comply with the Night Sky Protection Act, which specifies the use of full cutoff luminaires. A luminaire light distribution is designated as full cutoff when there is no light at or above an angle of 90 degrees above horizontal, and the candlepower per 1000 lamp lumens does not numerically exceed 10 percent at an angle of 80 degrees above horizontal.

In accordance with the New Mexico Night Sky Protection Act, the NMDOT specifies only full cutoff luminaires.

The NMDOT primarily uses LED or high-pressure sodium (HPS) lamps for highway lighting. While other types of lamps have been used in the past, they are being replaced by these types of lamps.

Light-Emitting Diodes (LEDs)

The NMDOT prefers to use LED lamps for roadway lighting. LEDs produce a directional narrow beam of light making them ideal for traffic signals, barrier lighting, and other directional light source applications. LED efficacies are increasing constantly, making LED luminaires effective for all types of lighting applications. Because LEDs are monochromatic, white light is difficult to produce unless different colors are combined. LEDs have extremely long lives (100,000 hours), consume very little energy, and are dimmable.

LED luminaires are preferred by the NMDOT for roadway lighting.

HPS

HPS lamps were previously the most commonly used light source for new installations by the NMDOT, but are now being replaced by LEDs. However, HPS lamps are still preferred by some local entities (specifically in southern New Mexico) for new and replacement installations. HPS lamps provide excellent luminous efficiency, good lumen maintenance, long life (20,000 hours), and an acceptable color. The arc tubes of HPS lamps have a very small diameter and are available in a wide range of lumen outputs. This type of light source permits the use of luminaires with good optical control for a wide range of applications.

HPS lamps do have several disadvantages. The most important is the lack of short wavelength light such as blue and green light. As a result, HPS lamps render color poorly, and one's peripheral vision under nighttime exterior lighting conditions does not respond well to the color of HPS light. White light can be two to twenty times more effective for peripheral vision detection than HPS. Because short wavelength light controls the pupil, HPS lamps may cause objects to be out of focus or fuzzy.

Metal Halide

The NMDOT no longer uses metal halide lamps for roadway lighting.

Induction

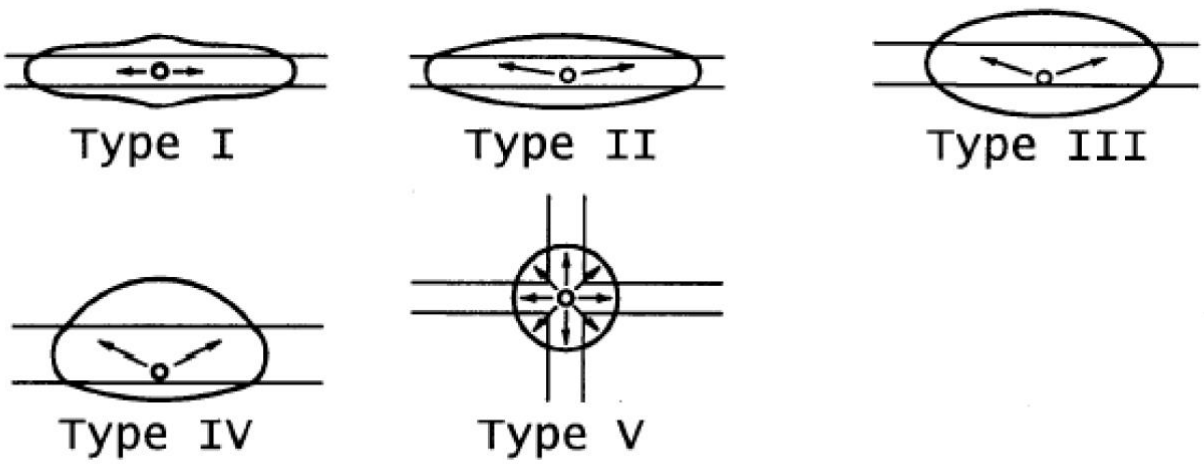
The NMDOT is not currently using induction lamps for roadway lighting.

920.4.2.4 Luminaire Light Distributions

The IESNA defines roadway and area lighting luminaires by their photometric properties and distance to the half maximum candela trace and the maximum candela value. The classifications help designers choose the proper product for their requirements; they are not a photometric specification but a method to group luminaire types. Manufacturers provide precise electronic photometric data (.ies files) for various lamp-luminaire combinations that can be used in determining the amount and direction of luminous flux by using lighting design software.

The lateral classification describes the lateral light distribution with regards to the lighted area width described as multiples of the mounting height (MH). The width of the half-maximum candela trace within the longitudinal distribution range (short, medium or long) is used. These are illustrated in Exhibit 920-2.

Exhibit 920-2
Lateral Light Distribution Patterns



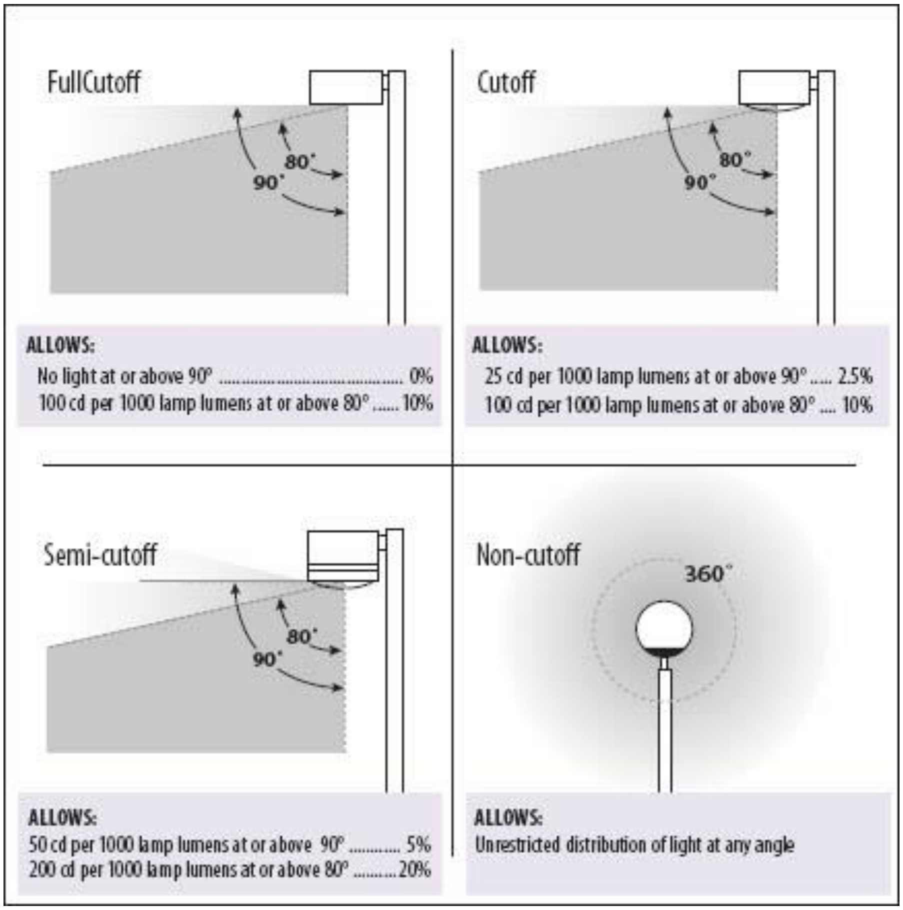
In addition to these types, the light distribution can also be classified as short, medium, or long. This refers to the luminaire's vertical light distribution and is based on where the maximum intensity (candela value) points to in relation to the luminaire pole.

Control of Stray Light

Disability and discomfort glare are largely a result of light emission into the driver's eye. For design purposes, it is necessary that luminaires be classified according to their relative glare effects.

Luminaires may be classified according to the roadway shielding classification system, shown in Exhibit 920-3, and categorized as full cutoff, cutoff, semi-cutoff, and non-cutoff. In accordance with the New Mexico Night Sky Protection Act, all luminaires must be full cutoff luminaires. A luminaire light distribution is designated as full cutoff when there is no light at or above an angle of 90 degrees above horizontal, and the candlepower per 1000 lamp lumens does not numerically exceed 10 percent at an angle of 80 degrees above horizontal. As well as significantly reducing upward stray light, cutoff can have the effect to driver of reducing discomfort glare.

Exhibit 920-3
Roadway Shielding Classification System Categories



Source: www.lithonia.com

When a roadway is adjacent to or passes through a residential area, possible lighting trespass may need to be evaluated. In some cases, additional shielding on the luminaires may be required. The design of these additional shields should be as specified or recommended by the luminaire vendors, and should, when possible, be included in the calculations.

Backlight, Uplight, and Glare (BUG) Rating

In its technical memo "Luminaire Classification System for Outdoor Luminaires" (TM-15-11), the IESNA discusses a new way to evaluate stray light produced by an outdoor luminaire. The Luminaire Classification System defines the distribution of light from a luminaire within three primary solid angles: back light, uplight, and forward light. These classifications allow designers to choose the proper product to control spill light, light trespass, and

The NMDOT is not currently using BUG rating as a criterion for design or as a specification for its luminaires.

sky glow. This classification system is called a BUG rating. It is intended to be used in conjunction with the IES distribution classifications described earlier (Type I, II, III, IV, V and short, medium, long), but supersedes the previous IES shielding classifications (full cutoff, cutoff, semi-cutoff, and non-cutoff).

The NMDOT is not currently using BUG rating as a criterion for the design of roadway lighting or as a specification for its luminaires.

920.4.2.5 Illumination Design Criteria

The suggested lighting design values are contained in the AASHTO Roadway Lighting Design Guide. Average maintained illuminance levels in each table are minimum levels when the output of the luminaire is diminished by the maintenance factors (should represent the lowest level of illumination expected in the anticipated operational cycle, just before relamping and luminaire cleaning). The average illuminance levels are for the illuminance of the traveled way, or on the pavement area between curb lines of curbed roadways only. Levels higher than the levels in the tables must be justified on factors other than the safe and efficient flow of traffic.

Suggested lighting design values for NMDOT roadways are contained in the AASHTO Roadway Lighting Design Guide.

Roadway and Walkway Classifications

- **Freeway** - A divided major highway with full control of access and with no crossings at grade.
- **Limited access** - A divided major arterial highway for through traffic with full or partial control of access and generally with interchanges at major crossroads.
- **Major** - The part of the roadway system that serves as the principal network for through traffic flow. The routes connect areas of principal traffic generation and important rural highways entering the city.
- **Collector** - The distributor and collector roadways serving traffic between major and local roadways. These are roadways used mainly for traffic movements within residential, commercial, and industrial areas.
- **Local** - Roadways used primarily for direct access to residential, commercial, industrial, or other abutting property. They do not include roadways carrying through traffic. Long local roadways

will generally be divided into short sections by collector roadway systems.

- **Sidewalks** - Paved or otherwise improved areas for pedestrian use, located within public street right-of-way that also contain roadways for vehicular traffic.
- **Pedestrian ways** - Public sidewalks for pedestrian traffic generally not within rights-of-way for vehicular traffic roadways. Included are pedestrian overpasses, pedestrian tunnels, walkways giving access to park or block interiors, and crossings near centers of long blocks.
- **Bicycle lanes** - Any facility that explicitly provides for bicycle travel.

Area Classification

- **Commercial** - That portion of a municipality in a business development where ordinarily there are large numbers of pedestrians and a heavy demand for parking space during periods of peak traffic or a sustained high pedestrian volume and a continuously heavy demand for off-street parking space during business hours. This definition applies to densely developed business areas outside of, as well within, the central part of a municipality.
- **Intermediate** - That portion of a municipality that is outside of a downtown area but generally within the zone of influence of a business or industrial development, often characterized by moderately heavy nighttime pedestrian traffic and a somewhat lower parking turnover than is found in a commercial area. This definition includes densely developed apartment areas, hospitals, public libraries, and neighborhood recreation centers.
- **Residential** - A residential development, or a mixture of residential and commercial establishments, characterized by few pedestrians and a low parking demand or turnover at night. This definition includes areas with single-family homes, townhouses, and/or small apartments. Regional parks, cemeteries, and vacant lands are also included.

920.4.2.6 Illumination Analysis Procedure

The NMDOT prefers that the lighting analysis for its projects be based on the illumination method. The illumination method of lighting analysis relies on the amount of light flux reaching the pavement and the uniformity of the light on the pavement surface.

The NMDOT uses the illumination method for lighting analysis.

Selection of Light Source and Size

The type of light source and size selected determines the lumen output, efficiency, energy requirements, lamp life, color, optical controllability, temperature sensitivity, and environmental effects. Currently, the light source most used in new or replacement NMDOT applications is LED; however, HPS lamps are still being used in some locations. In all cases, the local maintaining entity must concur with the final selection of the luminaire.

Selection of Mounting Height

In addition to its effect on the lighting pattern, mounting height considerations include safety, economics, and aesthetics. Increased mounting heights used with higher-output lamps can be used to produce the same level of illumination as lower mounting heights and smaller lumen output lamps. As the mounting height is increased, increased spacing between the luminaire supports may also be used, as long as uniformity and level of illumination are maintained. Greater spacing provides safety benefits by reducing the number of roadside objects to which the motorist is exposed. Economic benefits may also be accrued because the primary cost of a lighting system is based on the number of poles and the accompanying equipment that is needed. Thus, a substantial savings may be realized even though taller poles are more expensive to purchase. Also, the cost of new service vehicles needed for maintaining luminaires on taller poles may be recouped by savings related to the smaller number of luminaires required.

To a large degree, pole height, pole spacing, and light source size are interrelated. With high-mast lighting, as the pole height is increased, the periphery of the illuminated area becomes larger. At the same time, the illumination level at a point below the luminaire assembly decreases because of the inverse relationship between illumination and mounting height. To rebuild the illumination level to what it was at the lower mounting height, additional luminaires must be added. Thus, increased mounting heights spread the light over a greater area, but additional luminaires must be added to preserve the level of illumination. While the number of luminaires per pole is increased, the number of poles is decreased, resulting in approximately the same number of luminaires being used. The benefit of the increased mounting height is improved uniformity, which results when the light from each luminaire assembly is spread over a larger area.

Due to the additional mounting height of high-mast lighting compared to conventional lighting, only the larger light sources can be used effectively. Even with these larger light sources, it is not practical to place only one luminaire on a single pole; thus, several luminaires are usually used in one assembly. This type of configuration provides packages ranging from a minimum of 300,000 lumens to 800,000 or more. Both LED and HPS luminaires can produce the large quantity of lumens required for a high-mast installation.

Increased mounting height may, but will not necessarily, reduce direct glare, discomfort glare, and disabling veiling luminance. It increases the angle between the luminaire and the line of sight to the roadway; however, luminaire light distributions and candlepower also are significant factors. Glare is dependent on the flux reaching the observer’s eye from all luminaires in the visual scene. Glare is not, however, a function only of the size and height of the light source. Luminaire construction and offset from the roadway are also important in controlling glare from lighting systems. The designer should aim to control glare by meeting the requirements of the AASHTO Roadway Lighting Design Guide, unless otherwise directed by NMDOT.

The relationship of light source size (lumen output) and mounting height can be determined from some general guidelines. As light sources increase in output, the mounting height can be increased while maintaining the same level of illumination on the roadway. Exhibit 920-4 shows common practice for mounting height and lumen combinations:

Exhibit 920-4
Common Practice for Mounting Height/Lamp Lumen Output

Mounting Height	Lamp Lumens
30 feet	15,000 to 30,000
40 feet	30,000 to 50,000
50 feet	50,000 to 60,000
100 feet or more (high-mast)	300,000 to 1,000,000

In summary, the correct matching of mounting height with light source size should result in meeting minimum illumination, uniformity criteria, and veiling glare ratio (not used for high-mast installations), while being responsive to economic and safety criteria. Here again, the local maintaining entity must concur with the final selection of mounting height and lamp size.

Selection of Luminaire Type

In the previous analysis step, the type and size of light source and the mounting height were chosen. This establishes the number of lumens that can be expected. In the next step of the analysis, we are concerned with selecting a type of luminaire that will distribute the luminous flux over the pavement in a desired pattern.

In the selection of luminaire type, the main factors are the width of the roadway to be lighted and the location of the luminaire relative to the roadway. As discussed earlier in this chapter, luminaires are classified in accordance with IES standards in terms of their light distributions.

The vertical distributions referred to as short, medium, and long refer to how far down the roadway the main beam of light from the luminaire reaches. The selection of vertical distribution is largely controlled by the amount of source glare that is to be permitted. Long distributions should never be used because they produce excessive glare. Medium distribution is the most common type specified because it balances good uniformity with acceptable glare.

Lateral light distributions used for continuous roadway lighting are Types II, III, and IV. For most applications either Type II or Type III is specified. Type III is used for wider roadways and where lighting on median areas is considered; however, Type III luminaires tend to provide a very uneven light uniformity along the outside edge of the roadway. In some cases, Type II distributions may provide a more uniform appearance when used with high mounting heights (40 to 50 feet). Type II should be used on ramps and two-lane roads.

Unless otherwise specified, the light distribution for luminaires on NMDOT projects shall be in accordance with the NMDOT Standard Specifications for Highway and Bridge Construction. All new luminaires specified for use on the New Mexico highway system shall be full cutoff.

High-mast lighting systems provide the advantage of "redundancy" due to the fact that all of the luminaires are aimed at the same location, providing overlapping light patterns. If an outage occurs in one luminaire, the illumination level will be proportionally decreased, but will not result in a dark area. The decision to use either a symmetric or asymmetric distribution should be determined by the particular design (e.g., lighting a series of rectangular shaped areas may be better with asymmetric distribution).

In summary, the width of the area to be lighted, the configuration of luminaires, and the mounting height all affect the type of light distribution that will produce the best uniformity of lighting while minimizing glare. Much of the lighting analysis involves examining various combinations of these factors in an effort to identify the best combination. The designer is cautioned to refer to the manufacturers' data to determine the availability of certain lamp/distribution combinations for particular luminaires.

Luminaire Support Spacing and Location

Thus far in the analysis process, a lamp/luminaire combination has been selected and a tentative mounting height has been chosen. The next step is to select the lateral and longitudinal mounting dimensions. The lateral dimension, or the distance from the roadway edge to the luminaire, is mainly governed by the need to place the luminaire over the roadway. Safety considerations and right-of-way restrictions require the use of various length mastarms in order to correctly locate the luminaire support while leaving the luminaire at its desired position.

With high-mast lighting, the location of the luminaire supports within the lighted area relative to the nearby roadway is also important. Good high-mast lighting design should begin with focusing attention on critical areas where luminaire supports should or should not be placed. Once this step has been completed, other less-critical poles may be fitted in to complete the total design.

For a high-mast lighting layout, the designer should begin with a plan view of the area to be lighted and should tentatively locate the luminaire supports according to the following design considerations:

- Masts should be located so that the highest localized levels of illumination fall in the traffic conflict areas (e.g., ramp terminals), and located a sufficient distance from the roadway to position the greatest uniformity of illumination on the pavement surface.
- Masts should be at least 50 feet from the edge of the travel lanes or the clear zone distance, whichever is greater, unless the supports are protected by a barrier system.

In designing a lighting system, it is important to maximize spacing of luminaires consistent with good illumination design. From the standpoint of economy and safety, the minimum number of luminaires and luminaire supports should be used while satisfying the illumination quantity and quality criteria.

Luminaire spacing should be based on analysis using software such as AGi32. This software program will use photometric data for the light source provided by lighting equipment manufacturers, which will include the lamp lumen output (LL, the initial lumen output of a lamp.)

As time passes, the efficiency of every luminaire is reduced. The designer needs to estimate this reduction to properly estimate the light available at the end of the maintenance life of the lamp. Lamp lumen depreciation and luminaire dirt depreciation values must be estimated and used in the software analysis. The overall adjustment factor is called the maintenance factor (MF). This factor may range from 0.50 to 0.90, with the typical range being from 0.65 to 0.75. Default values are 0.70 for LED and 0.65 for HPS luminaires.

The maintenance factor (MF = EF + LLD + LDD) is a combination of factors used to denote the reduction of the illumination for a given area after a period of time compared to the initial illumination on the same area. It is based on the following:

- **Equipment factor (EF)** - To compensate for the normal production tolerances of commercially available luminaires, it is common practice to estimate the equipment loss at five to 10 percent (i.e., EF = .95 to .90). This information should be provided by the manufacturer.
- **Lamp lumen depreciation factor (LLD)** - As the lamp progresses through its service life, the lumen output of the lamp decreases. This is an inherent characteristic of all lamps. The initial lamp lumen value is factored by a lumen depreciation factor to compensate for the anticipated lumen reduction. This assures that a minimum level of illumination will be available at the end of the assumed lamp life, even though lamp lumen depreciation has occurred. This information should be provided by the manufacturer.
- **Luminaire dirt depreciation factor (LDD)** - Dirt on the exterior and interior of the luminaire, and to some extent on the lamp, reduces the amount of light reaching the roadway. Various degrees of dirt accumulation may be anticipated, depending upon the area in which the luminaire is located. Dust, industrial plant emissions, and vehicle exhaust (especially from large diesel trucks) are among the sources that contribute to the accumulation of dirt on the luminaire. Higher mounting heights tend to reduce vehicle-related dirt accumulations.

Checking for Design Adequacy

Lighting analysis software will provide the designer with metrics for the proposed layout including average maintained illuminance and minimum illuminance. From these, the uniformity ratio, comparing the average illumination level to the minimum illumination level, can be calculated. The lighting analysis software will also provide the veiling luminance ratio. (Note that the veiling luminance ratio cannot easily be calculated for high-mast lighting and is therefore not required.) These metrics can then be compared to the values in the AASHTO Roadway Lighting Design Guide. If the values are within the acceptable range for the particular area and type of roadway, the illumination design may be acceptable. Otherwise, the analysis should be repeated using other luminaire and pole configurations.

The results of the lighting analysis shall be documented in a memo for submittal to the NMDOT Traffic Design Section. NMDOT may request that the calculations be accompanied by an iso-footcandle diagram showing lighting levels at the quarter-lane lines, or schematics of the project being lighted.

920.4.3 Lighting System Design

In general, lighting systems installed on state highways should conform in equipment and design to the NMDOT Standard Specifications for Highway and Bridge Construction, and the latest NMDOT Standard Drawings. Specific criteria for the selection and design of lighting equipment include the following:

- Luminaires shall provide a light distribution in accordance with American National Standards Institute (ANSI) and IESNA photometric standards.
- Luminaire supports shall be designed in accordance with AASHTO "LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals."
- Electrical distribution and service systems for lighting installations shall conform to the requirements of the NEC.

920.4.3.1 Pole Placement Considerations

The placement of luminaire poles should allow sufficient illumination of the traveled way and special roadside features without reducing roadside safety. However, the placement will be influenced by physical conditions, which include roadway geometry, utility poles, spacing of access points, right-of-way limitations, roadway bridge structures, and other overhead structures (signs, overpasses). It is generally more economical to use higher mounting heights with high lumen output luminaires providing longer spacing intervals. This permits more design flexibility in avoiding roadside obstacles, spanning problem areas, and reducing the overall number of poles. The ultimate mounting is limited by the width of the roadway to be lighted, the range of the luminaire distribution, the local ability to maintain, and possible light trespass concerns.

In addition to the illumination patterns the following factors should be considered for placing luminaire poles:

- Access to luminaires for servicing
- Vehicle-pole collision probabilities
- System glare aspects
- Visibility (day and night) of traffic control devices (signs, signals)
- Daytime aesthetic appearance
- Overhead utilities and trees
- Locations at intersections to allow for joint use with traffic signals
- Compatibility with special roadside features for pedestrian and bicycle access, including compliance with ADA access requirements

Roadside Safety

In addition to the considerations above, there should be adequate right-of-way, driveway control, and utility clearance to allow for the placement of a proposed lighting system in accordance with roadside safety requirements. In some cases, additional right-of-way, driveway control, and/or utility relocations may be required before lighting can be installed.

The designer should take into account the following safety considerations when determining the location of light poles:

- Breakaway poles are preferred except in situations where a falling pole could cause more damage than that caused by an automobile striking a rigid pole. For example, non-breakaway poles should be considered in an area where substantial pedestrian traffic exists or is expected, or where overhead electric lines are close.
- Poles should be placed outside the roadside clear zone (refer to the Roadside Design Guide). Poles placed within the clear zone

shall be provided with a breakaway device or, if a non-breakaway pole is used within the clear zone, it shall be shielded by guardrail.

- All breakaway devices shall comply with all applicable AASHTO requirements for structural supports and may be one of the several forms that have been approved for use as a breakaway device (see NMDOT Standard Specifications for Highway and Bridge Construction and latest Standard Drawings for lighting).
- All poles that require a breakaway device shall be served by underground wiring.
- Poles should desirably be located to provide adequate safety clearance in the gore areas of the exit and entrance ramps.
- Poles should desirably be placed on the inside of sharp curves and loops. However, they shall have sufficient clearance to avoid being struck by trucks if the radius is superelevated.
- The hazards to be encountered while performing future maintenance on the lighting equipment should be considered in determining pole locations.
- Poles should be placed to minimize interference with the driver's view of the roadway or any highway signs.
- Poles should be placed behind flexible railings or rigid barriers if they are present.
- Poles that are shielded by a guardrail should be offset a distance of at least four feet to allow the railing to deflect without hitting the pole. If this clearance distance is not available, such as in extreme side-slope conditions, or if the pole is located within 75 feet of the approach end of the flexible railing, a breakaway device should be added.
- Poles that are shielded by a rigid or non-yielding barrier type will not require a breakaway device unless the pole is located within 75 feet of the approach end of the barrier.
- Poles may be located either on top of or behind retaining walls. Poles mounted on top of retaining walls will require that special consideration be given to the retaining wall design.

- Poles should not be installed within three feet of the face of the barrier curb to the centerline of the pole.
- Poles may be placed in median locations where median barriers are used or where the median width is sufficient to provide clear zone setback from both directions.
- Poles with a breakaway device should have the top of the footing constructed as close to ground level as possible to ensure the proper action of the breakaway device and to prevent damage to the foundation or the underside of an impacting vehicle. In order for the breakaway device to perform properly, it must be installed in accordance with the latest AASHTO Breakaway Specifications, the manufacturer's recommendations, and the NMDOT Standard Drawings.
- Poles, either with or without breakaway devices, should be located in such a manner that they will not interfere with the functional operation of any impact attenuator or other safety breakaway device.
- The construction of a special feature such as a curb, barrier, or other obstacle primarily to protect a light pole will not be allowed, unless approved by NMDOT prior to construction.
- Unprotected high-mast towers shall be at least 50 feet from the edge of the travel lanes or the clear zone distance, whichever is greater.
- Access for service vehicles shall be provided for high-mast towers and service poles.

Overhead Structures

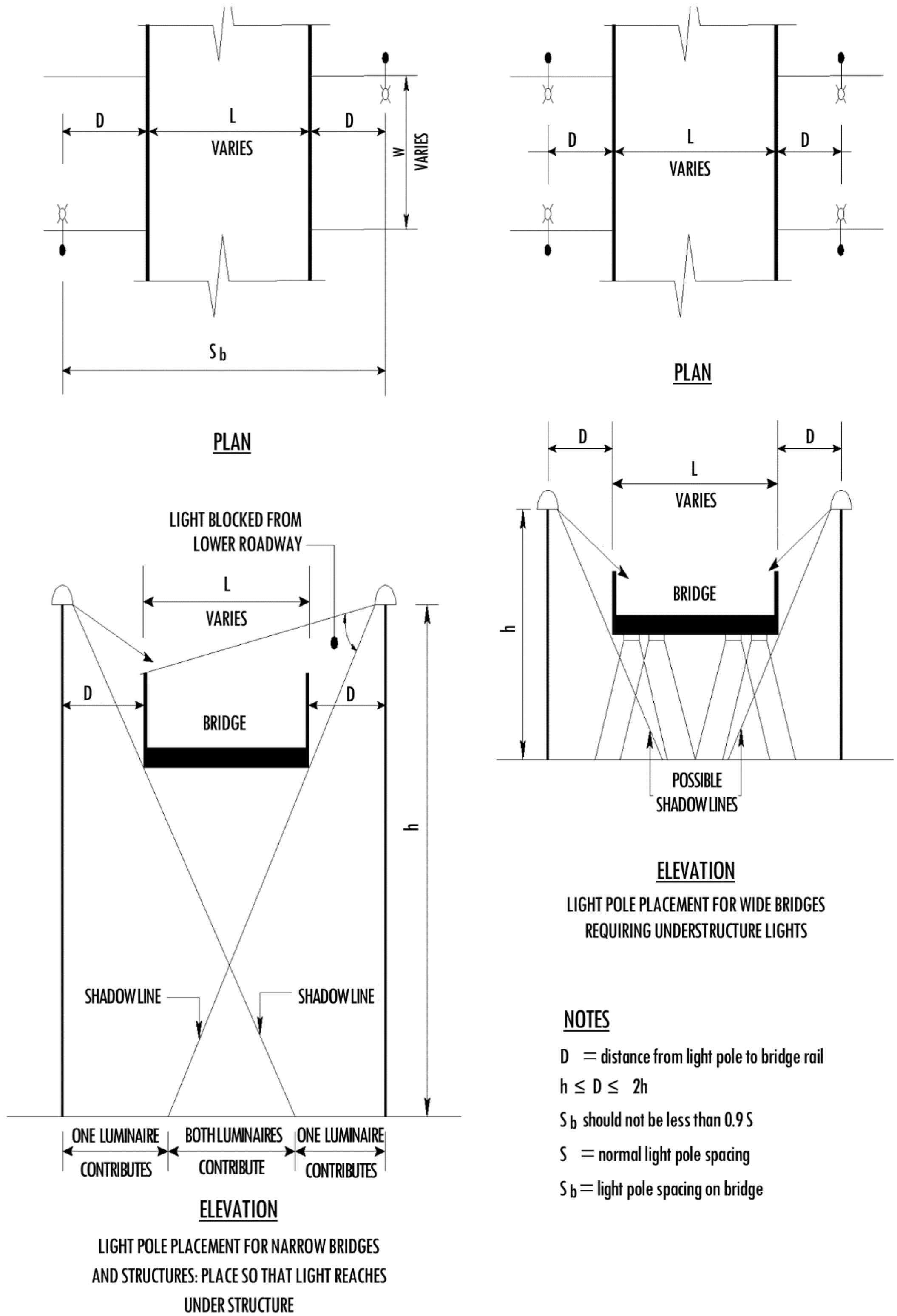
Short underpasses such as those encountered where a roadway goes under a two- or four-lane roadway can generally be lighted satisfactorily with properly positioned standard luminaires. Exhibit 920-5 offers guidance on the placement of luminaires near narrow bridges and overhead structures.

Luminaires on the lower roadway should be positioned so that there are no large discontinuities in the pavement illumination on either side of the overpass and the design illumination is maintained. Care also must be taken to minimize glare on the roadway going over the lighted roadway, from luminaires placed for the lower roadway illumination. (Where an unlighted roadway crosses over a lighted roadway, the overpass for the unlighted roadway should be lighted.) Longer underpasses, where such overlapping of the illumination from the street luminaires cannot be accomplished, may require the addition of underpass luminaires mounted to the understructure.

Bridge Structures

For continuous lighting of a roadway, part of which is on a bridge structure (overpass or drainage separation) that is longer than the design luminaire spacing, one or more luminaire poles will be required on the structure. Generally, the same luminaire spacing is required on the structure as on the roadway on both sides; however, the structure design itself will normally place physical limitations on the exact location of the luminaires. Typically, the luminaire poles will be rigidly mounted to the pier caps. The spacing of lighting on bridge structures will then be required to vary from the design, but desirably it will not exceed the design spacing, ensuring the minimum design illumination and uniformity. In extreme cases, where it is very difficult or costly to obtain the minimum luminaire spacing, longer spacing may be permitted; however, this spacing should not exceed 20 percent of the standard spacing used off of the bridge. When the bridge structure is within an interchange, especially a complex interchange with numerous structures, the high-mast lighting option should be considered to eliminate the need for lighting on structures.

Exhibit 920-5
Illumination Shadow Lines



920.4.3.2 Lighting Equipment

A variety of options are available to the designer in selecting lighting equipment that will meet the desired design criteria. The designer must ensure that the selected equipment meets NMDOT Standard Specifications for Highway and Bridge Construction and designs and is compatible with the local maintenance entities' preferences. Specialized equipment and designs can significantly increase the installation and maintenance costs, thereby reducing the cost effectiveness of the lighting system. The designer is encouraged to contact the Traffic Section for an approved products list.

Light Poles (Standards)

Light standards are the most common supports used to provide illumination for highway facilities. The NMDOT typically uses 30-foot, 40-foot, or 50-foot Type V light standards with a 10-foot arm length (single or double arm) and slip bases. On state highways, alternative light standards, including decorative poles, may be considered if requested by the local public entity, provided they agree to pay any additional costs associated with this change.

It should be noted that the NMDOT maintenance yards typically do not stockpile decorative poles or poles other than the typical Type V standard to use as a replacement in the event of a knockdown.

For high-mast installations, the NMDOT uses a Type VI standard with a 75-, 100-, 120-, or 150-foot tapered steel tube pole. Luminaires mounted on a high-mast pole will require a lowering device for maintenance.

Light Pole Foundations

The designer shall verify that the standard foundation drawings for the light poles are appropriate for the particular situation; i.e., the conditions are within the design parameters shown in the NMDOT Standard Drawings. Where conditions require a custom foundation design it shall be submitted to the State Bridge Engineer for approval.

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Luminaires

In recent years there has been a transition from HPS luminaires to LED luminaires for highway lighting. NMDOT Traffic Section staff will direct the designer on which LED luminaires may be used on a project.

Electrical and Service Systems

The electrical distribution system encompasses the equipment that performs the following functions:

- Distributing electrical energy to individual luminaires.
- Energizing and de-energizing the system or portions of the system.
- Transforming commercial power where necessary into a form usable by the luminaire.

The location (and feasibility) of the electrical service connection point with the local electrical utility system must be established during preliminary design activities to:

- Establish the feasibility of obtaining electrical energy for a proposed lighting system or right-of-way easements that the electrical utility may need for line extensions.
- Establish any costs and/or fees for the electrical utility to provide electrical energy at the project site and at the proper secondary supply voltage.
- Establish the exact point(s) the electrical service can be provided within the project area right-of-way so the distribution system can be properly designed and sized.

The electrical utility service feed may be underground or by overhead lines that would require the installation of a service pole and/or service riser. Between the electrical service point and the luminaire electrical distribution system is a control center. This includes the switching gear, photoelectric controls, and required protection devices and terminals, normally enclosed in a ground-mounted cabinet. The lighting control cabinet may or may not have provision for metering, dependent on the agreement between the local maintenance entity and the local utility, as to the means of rate measurement. The electrical service(s) and lighting control cabinets should conform to the latest NMDOT Standard Drawing and be sized in accordance with each specific project's requirements.

The lighting secondary electrical distribution systems used on New Mexico highways are multiple circuits, commonly a 240-volt, two-wire (plus ground) single-phase system. In some cases, a 480-volt system may be used, but a 120-volt system should not be used because of excessive voltage drops. Also, a three-phase system may be used as a high-mast distribution system for some applications. The exact voltage selected is typically what is commonly used locally, and in all cases shall be concurred with by the local maintenance entity and the utility provider. The luminaires must be specified to operate at the selected secondary distribution system voltage.

All secondary lighting distribution systems used on New Mexico highways (except some privately owned lighting systems placed on electrical utility poles) should be installed underground in a conduit system. A pull box should be provided at each junction of three or more conduits, and at access points in a buried conduit line spaced no further than 300 feet apart. All material and installation of the conduit, wiring, and protection devices should be as specified in the NMDOT Standard Specifications for Highway and Bridge Construction

Circuit Design

The electrical design of secondary lighting distribution systems involves the selection and sizing of the conductors. Some knowledge of electricity and power distribution is required of the designer to make these determinations.

The required conductors are sized by determining the voltage drop caused by the design electrical load. The voltage drop in any electrical circuit is directly dependent upon the operating current - a function of the lamp wattage and the operating voltage, and wire resistance - a function of the length and size of the conductor. For design purposes, the maximum allowable voltage drop for the most distant luminaire in a circuit to the service point should not exceed 10 percent, assuming a magnetic-regulator (mag-reg) ballast is used.

Voltage drop calculations shall be submitted to the NMDOT Traffic Section for review and approval prior to the completion of the design.

920.4.3.3 Plan Layout

The plan layout of the lighting system should be drawn at a scale of 1″ = 100′. The layout should include areas showing the position of the luminaires, the poles, and the electrical distribution/service system. Match lines should be used with multiple sheets.

Features shown on the lighting plans should include:

- Pavement outlines, existing and proposed, with lane widths and curbs
- Sidewalks, wheelchair ramps (existing and proposed), crosswalks, and lane lines
- Identification of all roads
- Driveways and drainage structures
- Utilities
- Location of any railroad crossing
- Arrows showing pavement lane use
- North arrow
- Location of any signal poles, controller, and conduit
- Location of luminaires, poles, and number identification of each
- Pull box locations
- Electrical distribution
- Title block stating location
- Locations of signs
- Existing lighting and removals
- Barrier systems
- Right-of-way limits

920.4.3.4 Work on Existing Illumination Systems

There are design considerations that need to be addressed when performing even the most minimal work on an existing illumination system. An existing electrical system is acceptable for use under the design requirements and NEC rules that were in effect at the time of installation. When modifying an existing electrical service or transformer, the designer is responsible for bringing the whole system up to current NEC design standards. Existing conductors and components that no longer meet current NEC requirements are to be replaced and the whole circuit is to be designed to current standards. This may mean replacing the whole circuit back to the nearest circuit breaker.

Excess roadway lighting or roadway lighting not in use may be removed when approved by the appropriate District Engineer or Designee and the General Office Traffic Section. The requesting public entity shall be responsible for the associated removal costs.

920.4.4 Agreements

Prior to completion of design and letting, the NMDOT will prepare a lighting agreement or Joint Powers Agreement. In accordance with NMDOT policy, all lighting on state roadways, including installation projects partially or fully federal/state funded, is to be maintained by the appropriate local municipality or county entity. The agreement will stipulate that the local public entity will take responsibility for all energy and maintenance costs for lighting. If an agreement cannot be executed between the public entity and the NMDOT, the NMDOT will not assume responsibility for the lighting installation.

A permit shall be required from the NMDOT if a public entity or private owner intends to install lighting on state highway right-of-way. The costs of installation, maintenance, electrical usage, and relocation shall be borne by the public entity and/or private property owner, and it shall be so stipulated in the permit. The lighting installation shall be subject to NMDOT review and approval. The lighting installation may be performed by the public entity, a contractor, or an electrical utility.

The NMDOT may assume responsibility for 100 percent of the roadway light installation cost if the facility on the highway system satisfies a warrant listed earlier in this chapter. NMDOT participation in project construction cost shall be limited to the use of NMDOT-approved standard equipment in accordance with

NMDOT specifications and design procedures. The public entity shall be responsible for any incremental cost difference due to different design practices or the use of other than NMDOT standard equipment. All equipment used on state facilities shall be an approved product.

If the subject location does not satisfy any of the warrants listed earlier in this chapter, the NMDOT may participate in funding for the below-ground portion of the street lighting. The public entity shall be responsible for the above-ground portion and related energy and maintenance costs.

920.5 Documentation

The installation of roadway lighting on a NMDOT facility may require the following documentation to be prepared and submitted to the NMDOT Traffic Section:

- Warrant study
- Recommendation for installation from NMDOT Traffic Section
- Letter of intent to maintain from local public entity
- Light levels/uniformity analysis and an iso-footcandle diagram
- Voltage drop calculations
- State Bridge Engineer approval of custom-designed light pole foundation (if applicable)
- Lighting agreement
- Permit for installation of lighting equipment in NMDOT right-of-way