THE STATE OF DELAWARE

DEPARTMENT OF TRANSPORTATION

LIGHTING DESIGN GUIDELINES

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Chapter One

Introduction

1.1. GENERAL

The mission of the Delaware Department of Transportation (DelDOT) is to provide a safe, efficient and environmentally sensitive transportation network that offers a variety of convenient, cost-effective choices for the movement of people and goods.

These guidelines outline the general practices, policies, and procedures that govern DelDOT roadway lighting designs.

1.2. PURPOSE OF ROADWAY LIGHTING

The principal purpose of roadway lighting is to provide improved driver visibility at night. Pedestrians and bicycle riders also benefit from improved visibility.

1.3. DESIGN GOAL

The design goal is to provide lighting systems which:

A. Provide the lighting level (average foot-candles) required
B. Provide the distribution balance (average-to-minimum ratio) required
C. Control the intrusion of light outside the design area
D. Control source glare by the design and/or the placement of the luminaires
E. Maintains the clear zone by using only shielded or breakaway devices therein
F. Minimize the number of poles that have a reasonable expectation of being struck by an errant road user
G. Help the road user determine the correct travel path
H. Provide for the needs of transit users and other pedestrians.
I. Are cost effective
J. Use methods and materials that effectively manage the impacts on environmentally sensitive resources

1.4. DESIGN RULES

In the furtherance of good design practice, the Department has adopted the Design Rules stated in these Guidelines to ensure that its Design Goal receives full consideration during the design and implementation of each lighting installation.

The establishment of optimal design values is necessary to provide uniform and proper levels of illumination on various roadway types. For consistency's sake and ease in lighting reviews, the accepted method of lighting analysis shall be the illuminance method.

Use Table 4-2 as a guideline for illuminance levels and uniformity.

1.5. REFERENCED PUBLICATIONS

The following publications are referenced in these Guidelines:

- AASHTO's *Roadside Design Guide*
- AASHTO's *Roadway Lighting Design Guide*
- Delaware's *State Code, Title 7, Chapter 71A*
- DelDOT's *Functional Classification Maps*
- DelDOT's *Road Design Manual*
- DelDOT's *Standard Construction Details*
- IESNA's *Lighting for Parking Facilities (RP-20-98)*

Chapter Two

Lighting Application Guidelines and Warrants

2. LIGHTING APPLICATION GUIDELINES AND WARRANTS

2.1. GENERAL

Lighting application guidelines and warrants have been established to provide a standard methodology for approving and installing lighting throughout the State.

Evaluating the need for lighting is a multi-step process. The Lighting Application Guidelines (Section 2.2) should be followed to determine if it is necessary to consider lighting.

Once it has been determined that lighting should be considered for a given facility, a warrant analysis shall be completed to evaluate the need for lighting.

2.2. LIGHTING APPLICATION GUIDELINES

Roadway lighting should be considered for new construction, reconstruction, or other projects that include any one of the following characteristics:

- Proposed roadway or alignment
- Proposed additional lanes or widening
- Modified intersection configuration
- Traffic Planning Study concludes that lighting may provide a safety benefit

Facilities with existing lighting are exempt from the warranting process. Lighting should not be eliminated for facilities that are being modified by an ongoing project unless roadways and/or pedestrian facilities are being eliminated or relocated.

All roundabouts, with the exception of those located wholly within commercial or residential developments, shall be illuminated. This includes roundabouts on external roadways that serve as development entrances. Roundabouts shall not require a warrant analysis. See Section 4.4.1 for roundabout lighting design criteria.

Typically, roadway lighting is not required to be considered for maintenance projects.

2.3. LIGHTING WARRANTS

In all cases, the installation of lighting or the continuation of lighting depends

upon the availability of authorized funds for this purpose. This limitation shall always prevail.

Please note that the qualifications listed below are guidelines; all projects shall be reviewed on a case-by-case basis.

Under the conditions noted:

- **"Shall"** requires an installation
- **"Should"** requires consideration for an installation
- **"May"** indicates that an installation is acceptable

Lighting **shall** be installed for:

A. Interstate and Controlled Access Highways (In conducting lighting analyses, freeways and interstates shall follow the same guidelines as expressways)

   1. Junctions among mainline routes
   2. Ramp terminals with the mainline route
   3. Ramp terminals with crossing roadways

B. Other Highways

   1. Intersections of U.S. Routes with U.S. Routes (Does not include Alternate or Business Routes)
   2. Intersections of U.S. Routes with Delaware Routes (Does not include Alternate or Business Routes)

C. Other Specialized Areas

   1. Toll Plazas
   2. Rest Areas
   3. Weigh Stations

Lighting **should** be installed for:

A. U.S. Routes

   1. Intersections of U.S. Routes with U.S. Alternate and Business Routes
   2. Intersections of U.S. Routes with Delaware Alternate and Business Routes

B. Delaware Routes

   1. Intersections of Delaware Routes with Delaware Routes
   2. Intersections of Delaware Route with Delaware Alternate or Business Route
   3. Intersection of Delaware Route with unnumbered road where the traffic volume on the Delaware Route is greater than 10,000 ADT and the nighttime crash percentage is greater than 40 percent
   4. Intersection of Delaware Route with unnumbered road where the traffic volume on the Delaware Route is greater than 11,000 ADT and the traffic volume on the unnumbered road is greater than 4,000 ADT

C. Other Locations

   1. Locations where crash patterns indicate that lighting may reduce crashes and where the percentage of nighttime accidents is 40 percent or greater
   2. At residential development entrances where the internal streets are lighted and there are at least 75 homes
   3. All public transit stops

Lighting **may** be installed for:

1. Intersections of Delaware Routes with unnumbered roads where the traffic volumes are greater than 8,500 ADT and 2,000 ADT, respectively
2. Locations where crash patterns indicate that lighting may reduce crashes and where the percentage of nighttime accidents is 35 percent or greater
3. Locations where better nighttime visibility is needed
4. At residential development entrances where there are at least 100 homes
5. At locations where a combination of favorable factors exist and Engineering Judgment indicates that lighting would be useful.

Chapter Three

Lighting Design Process

3. LIGHTING DESIGN PROCESS

3.1. GENERAL

The Roadway Lighting Design Process includes base plan preparation, photometric calculations, lighting plan preparation, cost estimates, lighting design report and implementation.

3.2. BASE PLAN PREPARATION

A base plan including topography, right-of-way (R/W) and utility information will be prepared for each lighting design location. When a CADD file does not exist, surveying should be included in the scope of work. Depending on the needs of the lighting project the surveying will include instrumental field work; deed search and R/W establishment; and locating underground and aerial utilities based on the field data and information obtained from utility companies. When a CADD file exists, field verification is required to update the plan to current conditions.

Other information that should be gathered during a field visit include, but are not limited to:

- Photographs
- Overhead utility line heights
- Potential electrical service sources
- Potential light locations

The base plan shall include the following topographical features:

- Traffic striping (stop bars, crosswalks, lane lines, etc.)
- Curblines
- Edge of pavement
- Islands
- Existing luminaires (pole type, luminaire type/wattage, mounting height, control equipment, etc.)
- Exisitng electrical service source
- Traffic signal equipment
- Utility poles
- Manholes

Once the base plan has been prepared, the Lighting Designer should evaluate existing lighting (if present) to determine if it meets the recommended lighting levels shown in Table 4-2.

3.3. PRE-SUBMISSION UTILITY COORDINATION

On DelDOT lighting projects, luminaires should be placed on utility poles, wherever feasible.

The Lighting Designer shall coordinate with the utility company to determine the feasibility of placing luminaires on existing and/or new utility-owned poles.

For projects with semifinal and final submissions, the utility coordination should begin prior to the semifinal submission. For other projects, utility coordination should occur prior to finalizing the Lighting Plans.

See Section 3.8 for information regarding final design implementation with a utility company.

3.4. PHOTOMETRIC CALCULATIONS

Roadway lighting photometric calculations shall be performed for all roadway lighting designs. The lighting should be designed to the recommended lighting levels shown in Table 4-2.

The point-by-point method of calculation shall be used. Grid spacing of 2' x 2' shall be used for intersection and roundabout designs. Grid spacing of 5' x 5' shall be used for interchange designs.

These calculations are typically performed by commercially-available computer software programs.

Photometric calculations shall be provided with all semifinal and final submissions.

3.5. LIGHTING PLAN PREPARATION

Roadway lighting plans will be used by the Contractor during the installation of the lighting equipment.

In addition to the features included in the base plan, the Lighting Plans shall include the following features:

- Lighting standard layout
- Lighting standard schedule
- Luminaire type and wattage
- Electrical design (conduits, junction wells, wiring)
- Electrical service source

Model lighting plans are available online at the Design Resource Center on DelDOT's website (http://www.deldot.gov/).

3.6. COST ESTIMATE

An Engineer's Estimate shall be prepared for each DelDOT roadway lighting design. Two material lists may be required, depending on how the project is being administered.

- Traffic Section Open-End Construction Contract Material List - includes items to be paid for and installed through the Traffic Section Open-End Construction Contract or other Traffic Section forces. Traffic statements will be prepared based on the latest DelDOT Traffic Section spreadsheet.
- Contractor Material List – Includes items to be furnished and installed by the Contractor. Also denotes equipment to be removed by the Contractor and delivered to any agency address.

The Engineer's Estimate must show the unit and total cost of each material separately as well as a combined total cost.

3.7. LIGHTING DESIGN REPORT

A Lighting Design Report shall be prepared for each DelDOT roadway lighting design. A typical report should be one to two pages in length, and should include the following information:

- Warranting conditions for lighting, if applicable
- Functional classification of roadway(s) being lit
- Recommended lighting levels (based on Table 4-2)
- Lighting levels achieved by the proposed design; if recommended lighting levels cannot be met, provide a thorough explanation as to why the levels could not be met, as well as a description of how the levels have been met to the extent practical

A sample lighting design report is included in Appendix C.

For projects with semifinal and final submissions, a draft lighting design report shall be included with the semifinal submission. For other projects, a draft lighting design report should be provided to DelDOT with the lighting plans. A final lighting design report shall be submitted with final lighting plans.

3.8. IMPLEMENTATION

Lighting designs that include luminaires installed on utility poles shall require coordination with the utility company for design approval. The Lighting Designer should also request a cost estimate from the utility company for the monthly tariff fees and construction costs associated with the utility pole-mounted luminaires.

For stand alone lighting projects, one set of the final lighting plans shall be signed by the appropriate Engineers. This record set shall be kept on file by DelDOT Traffic Section. A copy of the final lighting plans shall be sent to DelDOT North District Maintenance. A copy of the final lighting plans shall also be sent to the Archive Specialist in DelDOT's Quality Section for archiving.

If the design includes luminaires installed on utility poles, DelDOT shall provide a copy of the signed plans to the utility company along with a notice to proceed.

For lighting designs incorporated into larger projects, no separate lighting design signatures are required. The title sheet signatures shall suffice as the appropriate approval.

Chapter Four

Lighting Design

4. LIGHTING DESIGN

4.1. GENERAL

In the furtherance of good design practice, the Department has adopted the following Design Rules.

4.2. DESIGN CONSIDERATIONS

4.2.1. GENERAL

The following considerations should be reviewed by the Lighting Designer before a final design is developed.

4.2.2. UTILITY POLE MOUNTED LIGHTING

To the extent practical, lighting should be placed on existing utility poles placed for other purposes. The Lighting Designer shall investigate the option to add new utility poles for proposed luminaires.

All equipment proposed to be installed on a utility pole shall be in accordance with the utility company's standards.

4.2.3. LUMINAIRES

Cobrahead luminaires shall be considered standard for use in conventional roadway lighting installations. Other types of luminaires shall not be used unless approved by the Chief Traffic Engineer or his/her designee.

NEMA Identification decals shall be placed on the outside of the ballast housing on all roadway luminaire used in DelDOT roadway lighting projects. The decals shall include a color to indicate the type of light source as follows:

- Yellow = High Pressure Sodium
- Red = Metal Halide
- Light Blue = Mercury Vapor

The decals shall also include a number to indicate the lamp wattage as follows:

- 15 = 150 Watts
- 25 = 250 Watts
- 40 = 400 Watts

4.2.4. LAMPS

High Pressure Sodium (HPS) lamps shall be considered standard for use in DelDOT roadway lighting facilities. Other types of lamps shall not be used for roadway lighting unless approved by the Chief Traffic Engineer or his/her designee.

The following wattage lamps shall be considered standard for use in

conventional DelDOT roadway lighting facilities.

- 150 Watt HPS
- 250 Watt HPS
- 400 Watt HPS

Other wattage lamps shall not be used in DelDOT roadway lighting facilities unless otherwise directed by the Chief Traffic Engineer or his/her designee.

4.2.5. PHOTOMETRIC CONSIDERATIONS

Luminaires with Illuminating Engineering Society (IES) distribution types MC2 and MC3, as defined below, shall be considered standard for use in roadway lighting installations.

- M – Medium Vertical Light Distribution
- C – Cutoff Optics
- 2 or 3 – Lateral Light Distribution Type II or III

4.2.5.1. Vertical Light Distribution

Luminaires with a medium vertical light distribution shall be considered standard for use in roadway lighting installations. Luminaires with other types of vertical light distribution shall not be used unless otherwise directed by the Chief Traffic Engineer or his/her designee.

4.2.5.2. Light Control

Revised 8/2010

DelDOT prefers the use of cutoff luminaires with a sag lens for all roadway lighting designs. Full cutoff luminaires, which typically use a flat lens, are allowable under the state's outdoor lighting law, but are typically not preferred due to maintenance concerns. Therefore, full cutoff luminaires should only be used for DelDOT owned and maintained lighting facilities with approval of the Chief Traffic Engineer or his/her designee.

Revised 8/2010

Use of semi- and non-cutoff luminaires are restricted by the state's outdoor lighting law, as noted in the Delaware State Code, Title 7, Chapter 71A. Semi- and non-cutoff luminaires are only allowed under the following conditions:

Revised 8/2010

- The new or replacement outdoor lighting fixture is to be installed and operated on roadways and supporting interchanges that are classified by the Department of Transportation's Functional Classification Maps as interstates or other freeways / expressways within the urbanized boundaries and other principal arterials that are designed to interstate or freeway/expressway standards in nonurbanized areas; or
- As to maintenance of existing lighting systems, the change to a cutoff luminaire would require the redesign and reconstruction of the system to compensate for the different lighting characteristics of these fixtures.
- A compelling safety interest exists that cannot be addressed by another method;
    - For this condition, in the event that the Lighting Designer finds that cutoff luminaires will not be sufficient for a conventional roadway lighting design , the Lighting Designer shall provide calculations proving that a design with cutoff

Revised 8/2010 luminaires will not meet the recommended lighting levels shown in Table 4-2.

Revised 8/2010 For new installations and major retrofit projects, if one of the above conditions are met, semi-cutoff luminaires are preferred over non-cutoff luminaires if the proper lighting levels are met.

4.2.5.3. Lateral Light Distribution

Luminaires with Type II and Type III lateral light distributions shall be considered standard for use in DelDOT roadway lighting installations. Luminaires with other types of lateral light distribution shall not be used unless otherwise directed by the Chief Traffic Engineer or his/her designee.

4.2.5.4. Light Loss Factor

The Light Loss Factor (LLF) is a combination of the following three components:

- Lamp Lumen Depreciation (LLD)
- Lamp Dirt Depreciation (LDD)
- Lamp Ballast Depreciation (LBD)

The Lamp Lumen Depreciation is typically assumed to be 0.9. The Lamp Dirt Depreciation is typically assumed to be 0.9, unless in an exceedingly dirty environment. The Lamp Ballast Depreciation is typically assumed to be 0.93.

LLD x LDD x LBD = LLF
0.9 x 0.9 x 0.93 = 0.75

The Light Loss Factor should be assumed to be 0.75, unless the Lighting Designer is aware of specific information that would dictate otherwise.

4.2.6. LUMINAIRE MOUNTING HEIGHTS

Typical luminaire mounting heights on utility poles are 25’ above ground level. The Lighting Designer shall coordinate with Utility Company for luminaire mounting heights on specific poles.

For intersection and roundabout lighting designs, typical luminaire mounting heights for DelDOT lighting poles are 30’ above ground level.

For interchange and freeway lighting designs, typical luminaire mounting heights for DelDOT lighting poles are 40’ above ground level.

4.3. AREA TO BE ILLUMINATED

4.3.1. GENERAL

Prior to performing a lighting calculation, it is necessary to define the area of roadway that shall be illuminated. The area of roadway to be lit differs based on the nature of the roadway or intersection.

Lighting areas at simple intersections or suburban development access intersections which are less than 300 feet apart should be joined into a continuous system. Where more than one such system exists within 1,000 feet, consideration should be given to joining the sections into a continuous system.

Lighting areas for complex intersections and business access points which are less

than 400 feet apart should be joined into a continuous system. Where more than one such system exists within 1,000 feet, consideration should be given to joining the sections into a continuous system.

Lighting areas on a non-access controlled highway at an interchange, which are less than 400 feet apart, shall be joined into a continuous system, Where more than one gap exists within 1,500 feet, consideration should be given to joining the sections into a continuous system.

Lighting areas on an interstate or controlled access highway at an interchange, which are less than 500 feet apart, shall be joined into a continuous system. Where more than one gap exists within 2,500 feet, consideration should be given to joining the sections into a continuous system.

4.3.2. INTERSECTIONS

For the purposes of lighting designs, intersections can be classified as one of two types:

- Simple intersections
- Complex intersections

Simple intersections are the default intersection lighting treatment classification. However, intersections that feature the following criteria should be treated as complex intersections:

- Channelized Turn Lanes
- Four or more total lanes in a single direction, including through and turn lanes

An intersection may also be classified as complex by the Chief Traffic Engineer or his/her designee based on other considerations, which may include the following:

- Nighttime crash rates
- Skew and/or curve of the intersection
- Vehicle speeds

4.3.2.1. Simple Intersections

The area within stop bars shall be the area of illumination for a simple intersection. This area shall include the entirety of any crosswalks at the intersection. If a stop bar is not present on an approach, the area of illumination should extend to the end of the corner radius.

See Figure A-1 in Appendix A for a typical simple intersection lighting layout and area of illumination.

Typically, simple intersections can be satisfactorily lit with two luminaires installed on diametrically opposed corners of the intersection. More than two luminaires may be required to meet the design lighting levels.

4.3.2.2. Complex Intersections

Lighting designs for complex intersections typically include two pole spacings upstream of the intersection, and one light spacing downstream of the intersection.

Crosswalks and yield-controlled right turn lanes shall be included in the area of illumination.

See Figure A-2 in Appendix A for a diagram of a typical complex intersection lighting layout and area of illumination.

4.3.2.3. Intersection Light Levels

Recommended lighting levels for roadways are shown in Table 4-2.

If both of the intersecting roadways are continuously lit, the intersection should be lit to the sum of the recommended lighting levels for the roadways.

If the intersecting roadways are not continuously lit, the intersection should be lit to the higher recommended lighting level of the two roadways.

4.3.3. INTERCHANGES

Interchange lighting designs include the illumination of all or some of the following areas at an interchange:

- Gores
- Weaving Areas
- Ramps
- Ramp Terminals

For off-ramp terminals, lighting shall begin where the deceleration lane reaches its full width and continue one pole spacing downstream of the end of the gore area on the mainline.

For on-ramp terminals, lighting shall have, on the mainline, one pole spacing prior to the gore of the entrance ramp, and shall continue to where the full width of the acceleration lane ends and the taper begins downstream of the gore area.

Poles placed on the mainline after the gore of the off-ramp or before the gore of the on-ramp must be positioned so as to have sufficient safety distance. A distance of 100 feet from the physical nose of the gore is typical.

Off-ramps on curved roadways should have extended lighting on the mainline, in accordance with engineering judgment.

Lighting levels on the crossroad approaches should not be reduced through the interchange. In addition, all crossroad ramp terminals should have intersection lighting.

Interchange lighting designs can be divided into two treatments:

- Partial interchange lighting
- Full interchange lighting

Partial interchange lighting is the preferred design treatment.

The Lighting Designer shall have a pre-design meeting with DelDOT Traffic Section prior to performing a lighting design for an interchange.

4.3.3.1. Partial Interchange Lighting

Partial interchange lighting is the lighting of only the critical points of an interchange. The critical points are areas where potential conflicts or hazards are present. The points typically include:

- Nose of Gore
- Weaving Areas
- Ramp Terminals

See Figures A-3 and A-4 in Appendix A for diagrams of Partial Interchange Lighting. Typically, the deceleration and acceleration lanes should be lit its entire length that it is at its full width. Typically, one pole spacing is placed after the gore area for exit ramp areas and one pole spacing is placed before the gore area for entrance ramp areas.

The initial pole placed should be located at the nose of the physical gore for both entrance and exit ramp areas. Subsequent light poles should be based on the location of the initial pole.

Where the spacing between the terminal point light luminaires is two-pole spacings or less, the lighting along the ramp should be continuous.

Where ramps share common weaving areas, such as cloverleaf interchanges, the weaving area shall be lighted.

4.3.3.2. Full Interchange Lighting

Full interchange lighting is the lighting of the entire interchange, including, but limited to the following:

- Nose of Gore
- Weaving Areas
- Ramp Terminals
- Entire length of Ramps

4.4. SPECIAL CASES

4.4.1. ROUNDABOUTS

All roundabouts, with the exception of those located wholly within commercial or residential developments, shall be illuminated. This includes roundabouts on external roadways that serve as development access points.

Lighting for roundabouts that are within commercial or residential developments shall be the responsibility of the Developer and/or the Development Corporation in accordance with Section 4.4.2.

Roundabouts should be lit to a level that is 1.3 to 2 times the values used on the best lit approach. The Average-to-Minimum Uniformity Ratio should be 3:1 or better.

Roundabouts should be lit from the outer edge of the roadway. Placing light poles in the central island and splitter islands should be avoided.

Lighting on the roadways approaching roundabouts should be designed to the recommended lighting levels shown in Table 4-2. Roadway approaches to multi-lane roundabouts should be lit for a minimum of 400 feet.

Pedestrian crosswalks should be lit such that pedestrians are in positive contrast and visible to approaching vehicles. Typically, this can be achieved by placing a light pole 10 to 30 feet before the crosswalk.

See Figure A-5 in Appendix A for a diagram of a typical roundabout lighting layout and area of illumination.
The Lighting Designer should consider other factors that may affect the lighting needs at a roundabout, including illuminated objects in the center island.

4.4.2. DEVELOPMENT ACCESS POINTS

When required or desired, lighting at development access points is the responsibility of the Developer and/or the Development Corporation, unless the intersection meets “Should” or “Shall” warrants without considering the development.

4.4.3. TUNNELS AND UNDERPASSES

Tunnel and underpass lighting should be designed in accordance with AASHTO guidelines.

The Lighting Designer shall have a pre-design meeting with DelDOT Traffic Section prior to performing a tunnel lighting design.

On continuously lighted roadways and interchanges, the lighting of underpasses shall be at the same level as the roadway.

4.4.4. BRIDGES AND OVERPASSES

On continuously lighted roadways and interchanges, the lighting of bridges and overpasses shall be at the same level as the roadway.

Historical or decorative bridge lighting that is not warranted for safety installation shall be designed according to engineering judgment and in accordance with the applicable portions of these Guidelines.

4.4.5. PARKING LOTS

Parking lot lighting, including lighting for Park and Ride lots and Park and Pool lots, should be designed in accordance with IESNA's *Lighting for Parking Facilities (RP-20-98).*

4.4.6. TOLL AND SERVICE PLAZAS AND HIGH MAST LIGHTING

The Lighting Designer shall have a pre-design meeting with DelDOT Traffic Section prior to performing a toll plaza or service plaza lighting design, or any lighting design that includes high mast lighting.

4.4.7. PEDESTRIAN LIGHTING

The Lighting Designer shall consider the effect of pedestrian lighting on vehicular traffic on adjacent roadways. Whenever pedestrian lighting is proposed for pedestrian facilities located adjacent to a roadway, the roadway shall be illuminated in accordance with Section 4.5.

4.4.8. OFF-ROADWAY BICYCLE AND PEDESTRIAN PATHS

Lighting of off-roadway bicycle and pedestrian paths may be considered when the path is expected to have night usage and when an outside Agency agrees to own and maintain the lighting system, and fund the continuing electric costs.

4.4.9. DECORATIVE ROADWAY LIGHTING

All decorative roadway lighting shall be approved by the Chief Traffic Engineer or his/her designee.

DelDOT is investigating the adoption of standards for decorative roadway lighting poles and luminaires.

The use of non-standard decorative roadway lighting poles and luminaires on DelDOT projects shall not be permitted unless approved by the Chief

Traffic Engineer or his/her designee. If an outside Agency agrees to own and maintain the decorative lighting, then non-standard decorative poles and luminaires may be used.

4.4.10. BUS STOPS / CROSSWALKS

Luminaires should be placed so that the pedestrian crosswalks are illuminated by at least two lighting units to ensure lighting in the event of a failure of one lighting unit. At isolated locations this is typically accomplished by placing a unit on each side of the roadway at the crosswalk. In a system, the crosswalk may be between two luminaires on the same side of the roadway.

The initial lighting design shall be 0.8 foot-candle in the crosswalk. The waiting area initial lighting design shall be not less than 1.0 foot-candle.

When the bus stop is not immediately adjacent to the crossing point, lighting shall be continuous from the stop to the crossing point.

4.4.11. NIGHTTIME HIGH CRASH LOCATIONS

Lighting should be placed so that the approaching vehicle's driver can see the onset of a problem or problem area and can be carried through it. Multiple lighting units should be used to ensure lighting in the event of a unit failure.

4.4.12. OVERHEAD SIGN LIGHTING

Overhead guide signs installed in Delaware are made from Type IX retroreflective sheeting or better. Therefore, overhead sign lighting shall not be used.

4.5. LIGHT LEVELS

4.5.1. AREA CLASSIFICATIONS

The following definitions are found in AASHTO publication "Roadway Lighting Design Guide," 2005, and shall be used with Table 4-2.

4.5.1.1. 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 as those that are within, the central part of a municipality.

4.5.1.2. Intermediate

That portion of a municipality which 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 recreational centers.

4.5.1.3. Residential

A residential development, or a mixture of residential and commercial establishments, characterized by a 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.

4.5.2. ROADWAY CLASSIFICATIONS

Roadway classifications use in Table 4-2 shall be based on the DelDOT Functional Classification Maps, available on the DelDOT website.

4.5.3. RECOMMENDED LEVELS

Recommended light levels are shown in Table 4-2. Table 4-2 is adapted from AASHTO publication "Roadway Lighting Design Guide," 2005.

Table 4-2: Illuminance Design Values

Roadway and Walkway Classification	Off-Roadway Light Sources	Illuminance Method		
		Average Maintained Luminance	Minimum Illuminance	Illuminance Uniformity Ratio
	General Land Use	(foot-candles) (min)	(foot-candles)	avg/min (max)
Principal Arterials - Interstate and other freeways	Commercial	0.6 to 1.1	0.2	3:1 or 4:1
	Intermediate	0.6 to 0.9	0.2	3:1 or 4:1
	Residential	0.6 to 0.8	0.2	3:1 or 4:1
Other Principal Arterials (partial or no control of access)	Commercial	1.6	As uniformity ratio allows	3:1
	Intermediate	1.2		3:1
	Residential	0.8		3:1
Minor Arterials	Commercial	1.4		4:1
	Intermediate	1.0		4:1
	Residential	0.7		4:1
Collectors	Commercial	1.1		4:1
	Intermediate	0.8		4:1
	Residential	0.6		4:1
Local	Commercial	0.8		6:1
	Intermediate	0.7		6:1
	Residential	0.4		6:1
Alleys	Commercial	0.6		6:1
	Intermediate	0.4		6:1
	Residential	0.3		6:1
Sidewalks	Commercial	1.3		3:1
	Intermediate	0.8		4:1
	Residential	0.4		6:1
Pedestrian Ways and Bicycle Ways [1]	All	2.0		3:1

Notes:
1. Assumes a separate facility. For Pedestrian Ways and Bicycle Ways adjacent to roadway, use roadway design values.
2. There may be situations where a higher level of Illuminance is justified. The higher values for freeways may be justified when deemed advantageous by DelDOT to mitigate off-roadway sources.
3. Physical roadway conditions may require adjustment of spacing determined from the base levels of Illuminance indicated above.
4. Table adapted from AASHTO publication "Roadway Lighting Design Guide," 2005.
5. Illuminance values shown are equal to values for R2-R3 surface materials requirements as defined by AASHTO. The values shown in Table 4-2 shall be used for design unless otherwise directed by the Chief Traffic Engineer or his/her designee.

4.6. LIGHTING STRUCTURES

4.6.1. POLE TYPE

All DelDOT-owned and maintained poles used for lighting installations shall be aluminum.

Standard DelDOT lighting poles shall allow for the following luminaire mounting heights:

- 30' luminaire mounting height
- 40' luminaire mounting height

Standard DelDOT davit arm bracket lengths shall be as follows:

- 8’
- 12’
- 15’

4.6.2. POLE BASES

DelDOT Standard Type 6 pole bases are typically used with conventional DelDOT lighting poles. Consideration should be given to the geotechnical characteristics present for each application.

Pole bases for high mast lighting poles shall be designed on a case-by-case basis.

4.6.3. TRANSFORMER BASES

The installation of breakaway transformer bases with lock washers shall be considered standard for all aluminum lighting poles with the exception of high mast poles.

Breakaway transformer bases shall be installed even if the pole is located behind shielding devices.

4.6.4. POLE LOCATION

The following considerations should be reviewed by the Lighting Designer before the lighting layout is finalized:

- When off-roadway mounted luminaires are used, consideration should be given to 20-foot maximum lateral reach of bucket trucks. Bucket trucks should be able to remain on the shoulder of the road and still service the pole.
- Sidewalks, crosswalk ramps and unpaved sidewalks must not be blocked. Free passage of a wheelchair is the determinate.
- Lighting poles should be placed no less than five feet from the edge of the shoulder in an open drainage section. Poles should not be placed in an area where they will interfere with the drainage flow.
- Lighting poles should not be placed on channelizing islands, medians, or in the gore area of the mainline, as they are much too prone to knockdowns, endangering the motoring public. For interchanges, a distance of 100 feet from the physical nose of the gore is typical.
- Lighting poles on bridges should be located within the protection of the bridge railings or parapets.
- There must be sufficient clearance between high-powered utility lines and installed lighting poles as specified within the National Electrical Code and the National Electrical Safety Code.

4.6.4.1. Poles located in Clear Zone

The installation of unshielded non-breakaway lighting poles within the clear zone for the sole purpose of supporting highway lighting is not acceptable. Poles placed within or along the clear zone must be breakaway or shielded.

While breakaway devices offer a reasonable alternative to striking a “harder” object, alternatives which reduce the potential of striking even these objects should be considered, since both shielding devices and breakaway devices can damage vehicles when struck.

Where shielding devices, such as guardrail, are required for needs other than lighting, protection of lighting poles should still be considered. When such lighting poles are located behind guardrail, the distance necessary for rail deflection must be considered. All guardrails shall be installed in accordance with DelDOT's *Road Design Manual* and DelDOT's *Standard Construction Details*.

Further information on the placement of poles can be found in AASHTO's *Roadside Design Guide*.

Chapter Five

Electrical Design

5. ELECTRICAL DESIGN

5.1. GENERAL

The guidelines contained in this Chapter shall be considered the minimum standards acceptable to DelDOT. It is understood that specific design variables may demand that the minimums be increased to ensure proper design.

The Lighting Designer is responsible for designing an electrical system that is in accordance with the National Electrical Code (NEC).

Lighting systems that are owned and maintained by an agency other than DelDOT shall be designed to the standards of the owner/maintainer of the system.

5.2. ELECTRICAL SERVICE

Electrical service should be provided by the nearest sufficient utility pole or manhole. Service may be provided underground or overhead. The Lighting Designer shall coordinate with the utility company regarding the source, location, and type of service.

Lighting designs for intersections should be designed with 120/240 Volt single phase, three wire service. Lighting designs for interchanges should be designed with 277/480 Volt three phase, four wire service.

Other services shall not be permitted unless otherwise directed by the Chief Traffic Engineer or his/her designee.

5.3. LIGHTING CONTROL CENTERS

The following lighting control centers are typically used on DelDOT lighting installations:

- 60 Amp lighting control center
- 100 Amp lighting control center
- 200 Amp lighting control center

The Lighting Designer shall select the appropriate lighting control center based on the total load of the lighting system.

Lighting systems that include lighting control centers shall use a central photocell. Luminaires that are fed directly shall have individual photocells.

Lighting control centers shall be installed on a concrete base. Pole-mounted lighting control centers are not acceptable.

5.4. CIRCUITRY

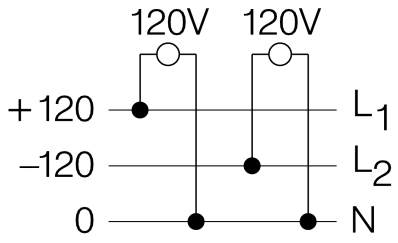
Revised 8/2010

Consecutive luminaires shall be connected to alternating circuits to provide for a balanced load throughout the system.

Revised 8/2010

When 120/240V, single phase, three wire service is provided, DelDOT prefers the use of the 120 Volts. A dual-pole common trip circuit breaker shall be provided in the service cabinet for each single phase, three wire service. Three wire system circuits shall be run together in two groups, as shown in Figure 5-1.

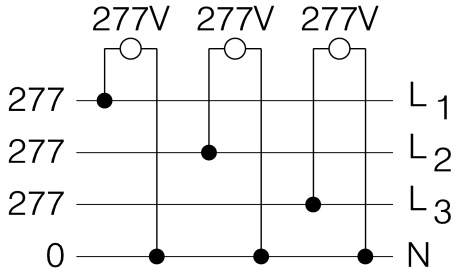
Figure 5-1: Circuitry for 120/240V Service



Revised 8/2010

When 277/480V, three phase, four wire service is provided, DelDOT prefers the use of 277 Volts. A three-pole common trip circuit breaker shall be provided in the service cabinet for each three phase, four wire service. Circuits shall be run together in three groups, as shown in Figure 5-2.

Figure 5-2: Circuitry for 277/480V Service



5.5. WIRING

Wiring shall be sized in accordance with the National Electrical Code (NEC). Minimum wire size used in DelDOT lighting conduit shall be No. 8 AWG.

Changing of wire sizes within pole bases shall not be considered acceptable. This does not apply to wires going up the pole to luminaires.

Changing of wire sizes within junction wells is acceptable if there is sufficient space for a proper splice.

Fuse kits shall be installed in above ground condulets.

5.6. GROUNDING AND BONDING

All DelDOT lighting conduit runs shall have a size No. 8 AWG (minimum) bare copper conductor which is bonded into a continuous run from the source. **Revised 1/2010**

All metal light standards shall be bonded to ground by use of a ¾" x 10' (minimum) ground rod, or as shown on the DelDOT Standard Pole Base Construction Details.

5.7. VOLTAGE DROP

Voltage drop calculations shall be performed to ensure that adequate voltage is present at each luminaire in the circuit. The maximum voltage drop shall not exceed 5% from the electrical service source to the farthest lighting pole in each circuit.

Voltage drop calculations shall be performed to ensure that the design conforms to the NEC.

5.8. CONDUIT

All conduit used on DelDOT lighting installations shall be Rigid Galvanized Steel (RGS).

Conduit used in DelDOT lighting installations shall be provided in two standard sizes:

- 2.5" diameter for intersection lighting installations
- 3" diameter for interchange lighting installations

Other sizes of conduits shall not be used in DelDOT lighting installations unless approved by the Chief Traffic Engineer or his/her designee.

The minimum size of conduit used in DelDOT lighting projects shall be 2".

Fill calculations shall be performed to ensure that the design conforms to the NEC.

5.9. JUNCTION WELLS

Type 1 Junction Wells shall be considered standard for DelDOT lighting projects. If more than four conduits are entering a junction then a Type 4 Junction Well shall be used.

5.10. LUMINAIRES ON TRAFFIC SIGNAL POLES

In instances where roadway luminaires are proposed to be placed on traffic signal poles, separate electrical systems, including service disconnects, shall be provided for the traffic signal equipment and the lighting equipment. Additionally, the electrical system for lighting equipment shall not be shared with any camera or other traffic-related equipment.

Lighting system wiring for luminaires on signal poles shall be installed in a conduit riser on the signal pole. Conduit risers shall be 2.5" diameter, rigid galvanized steel conduit.

Luminaires and associated mounting arms shall not be installed on existing or proposed signal poles without a structural analysis to ensure that the pole can handle the additional load.

Only DelDOT-owned and maintained luminaires shall be permitted to be installed on DelDOT signal poles.

Chapter Six

Typical Design Preferences

6. TYPICAL DESIGN PREFERENCES

6.1. GENERAL

This Chapter presents a summary of typical DelDOT preferences for intersection, roundabout, interchange, and freeway lighting designs.

6.2. INTERSECTION AND ROUNDABOUT LIGHTING

Table 6-1 contains typical design variables for use on DelDOT intersection and roundabout lighting designs. The Lighting Designer should use judgment and lighting design principles when performing lighting designs.

Table 6-1: Typical Intersection and Roundabout Design Variables

Variable	Typical DelDOT Preference
Utility Pole Luminaire Mounting Height	25’ or higher
Aluminum Pole Luminaire Mounting Height	30’
Luminaire Type	Cobrahead
Lamp Type	High Pressure Sodium (HPS)
IES Distribution Type	MC2; MC3
Luminaire Wattage	150; 250
Service	120/240 Volts, single phase, 3-wire
Conduit Size	2.5”

See Figure A-1 in Appendix A for a typical simple intersection lighting layout and area to be illuminated.

See Figure A-2 in Appendix A for a diagram of a typical complex intersection lighting layout and area to be illuminated.

See Figure A-5 in Appendix A for a diagram of a typical roundabout lighting layout and area to be illuminated.

6.3. INTERCHANGE AND FREEWAY LIGHTING

Table 6-2 contains typical design variables for use on DelDOT interchange and freeway lighting designs. The Lighting Designer should use good judgment and lighting design principles when performing lighting designs.

Table 6-2: Typical Interchange and Freeway Design Variables

Variable	Typical DelDOT Preference
Aluminum Pole Luminaire Mounting Height	40’
Luminaire Type	Cobrahead
Lamp Type	High Pressure Sodium (HPS)
IES Distribution Type	MC2; MC3
Luminaire Wattage	250; 400
Service	277/480 Volts, three phase, 4-wire
Conduit Size	3.0”

Appendix A
Figures

Figure A-1: Simple Intersection, Typical Lighting Layout and Area to be Illuminated

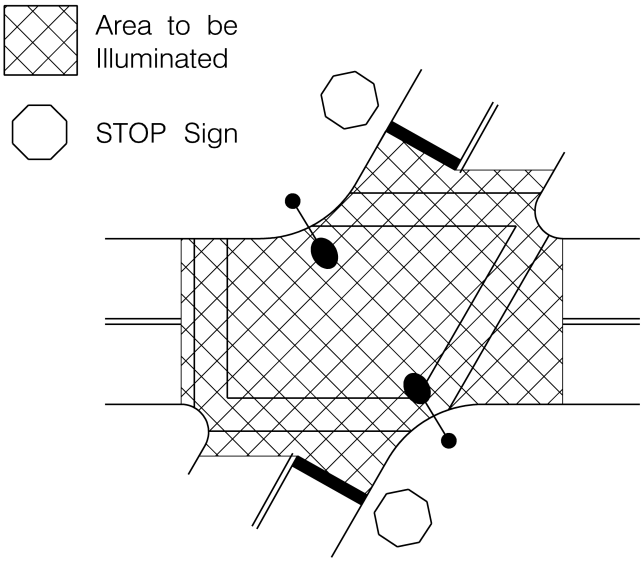


Figure A-2: Complex Intersection, Typical Lighting Layout and Area to be Illuminated

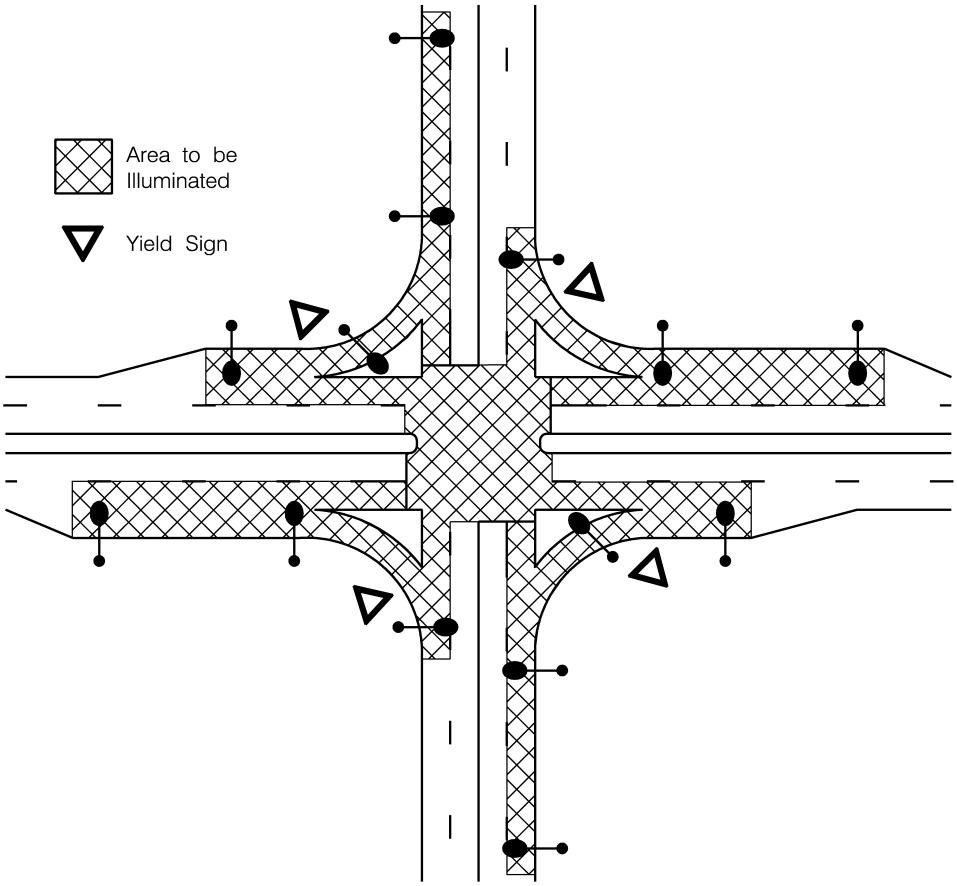


Figure A-3: Exit Ramp Area, Partial Interchange Lighting, Typical Lighting Layout and Area to be Illuminated

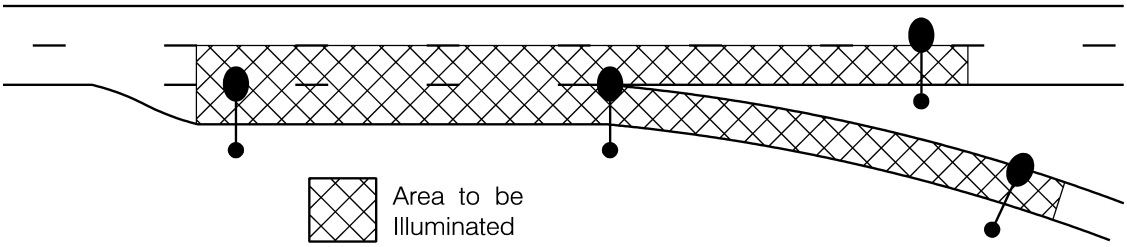


Figure A-4: Entrance Ramp Area, Partial Interchange Lighting, Typical Lighting Layout and Area to be Illuminated

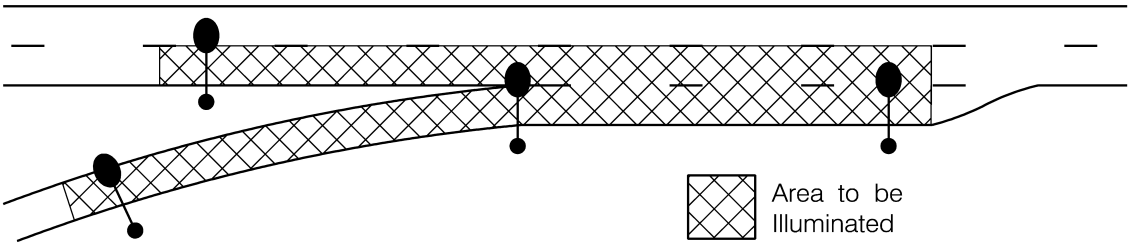
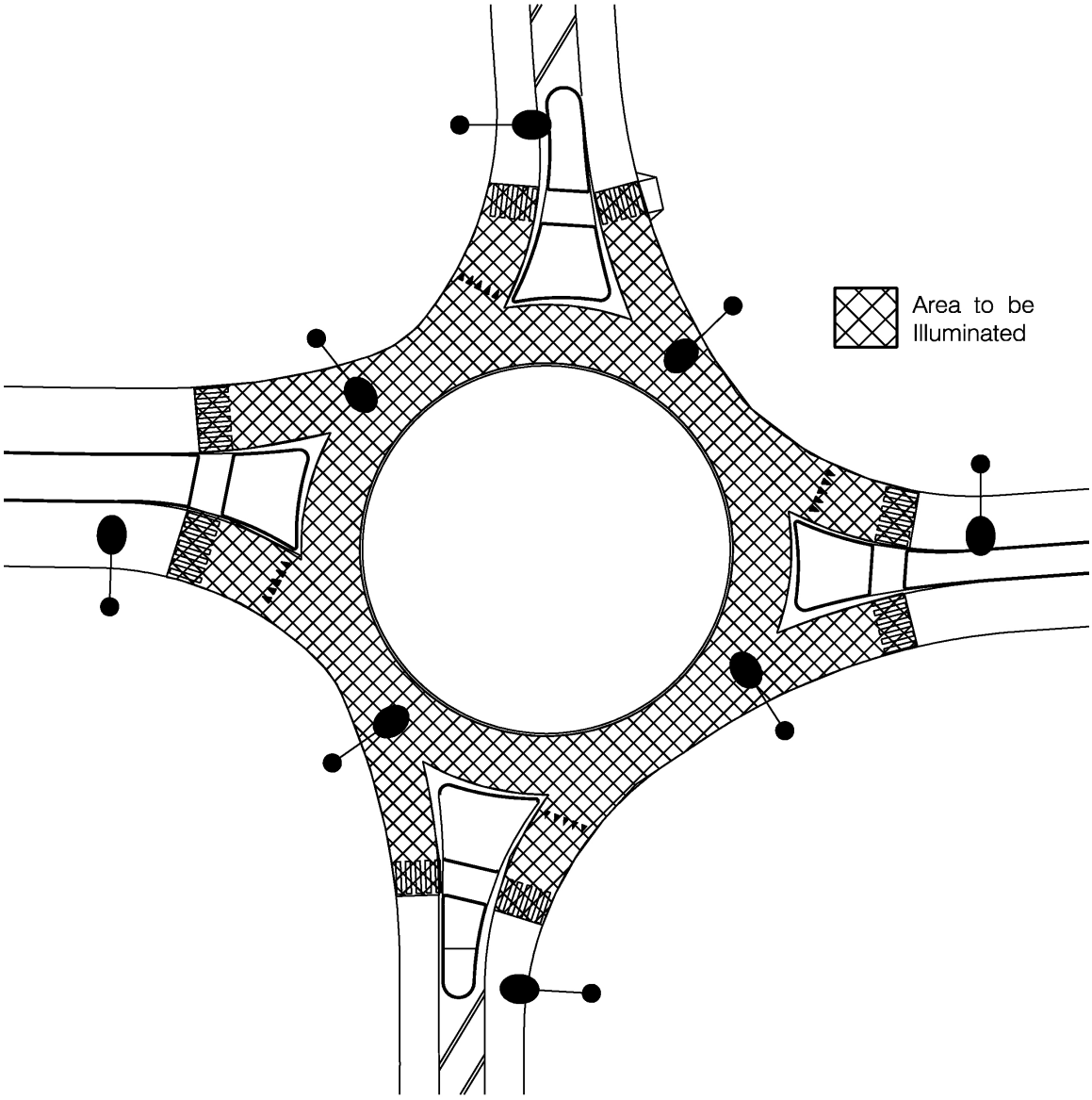


Figure A-5: Roundabout, Typical Lighting Layout and Area to be Illuminated



Appendix B

Utility Company Contact Information

The following is a list of agencies that provide electrical service in the state of Delaware. The Lighting Designer should contact the applicable agency to coordinate the lighting design when lights are proposed to be placed on utility poles and when electrical service is required for a proposed DelDOT-maintained lighting system.

Agency	Phone Number
Delmarva Power	(800) 375-7117
Delaware Electrical Cooperative	Sussex County (302) 349-9090 Kent County (302) 398-9090 New Castle County (800) 282-8595
City of Dover – Electrical Department	(302) 736-7091
City of Lewes – Public Works Department	(302) 645-6228
Town of Middletown – Public Works Dept.	(302) 378-2211
City of Milford – Electric Department	(302) 422-1110
City of Seaford – Public Works Department	(302) 629-8307
Town of Smyrna – Electric Department	(302) 653-3493

Appendix C

Sample Design Report

LIGHTING DESIGN REPORT

Project:	Main Street and Side Street Intersection
City:	Newark
County:	New Castle
Date:	1/1/2009
Designed by:	Lighting Designer, Agency
Reviewed by:	Lighting Reviewer, Agency

Background

DelDOT initiated a Traffic Engineering Study to evaluate the intersection of Main Street (N001) at Side Street (N002). The Study recommended that lighting be installed at the intersection.

Lighting Design Criteria

According to DelDOT's Functional Classification Map, Main Street is a principal arterial and Side Street is a minor collector. Based on Table 4-2 in DelDOT's Lighting Design Guidelines, recommended lighting levels for non-interstate, principal arterials in residential areas are an average maintained illuminance of 0.8 foot-candles with a uniformity ratio (avg:min) of 3:1.

Due to the lack of channelized turn lanes and at most only two lanes in a single direction, this intersection is considered to be a simple intersection, for the purposes of highway lighting. DelDOT's Lighting Design Guidelines recommend that lights be installed on diametrically opposed corners of a simple intersection.

Proposed Design

The proposed lighting design is shown on the attached Highway Lighting Plan.

The proposed lighting design consists of two light fixtures with 8-foot mounting arms installed on proposed wooden utility poles located on the northeast and southwest corners of the intersection.

The proposed luminaire is a cobra head style. The luminaire is a cutoff style with a Type III lateral light distribution. The lamp will be 250 Watts, High Pressure Sodium (HPS).

The proposed luminaire will provide an average maintained illuminance of 1.1 foot-candles and a uniformity ratio (avg:min) of 2.7:1 in the intersection. The average illuminance value for the intersection meets the recommended value. The uniformity ratio meets the recommended value.

SAMPLE

Discussion

The proposed design includes fixtures mounted on utility-owned wooden poles for two main reasons:

1. Existing aerial utility lines limit potential locations for DelDOT-owned poles, especially on the southwest corner of the intersection.
2. No additional maintenance responsibilities are placed on DelDOT Maintenance by placing the light fixtures on utility-owned poles.

Summary

The proposed lighting is shown on the attached Highway Lighting Plan. The design consists of two light fixtures diametrically located at the intersection. The fixtures are to be installed on proposed wood poles. The light fixtures, luminaries and poles are to be owned and maintained by Delmarva Power. The proposed lighting design meets the illuminance recommendation, and the recommended uniformity.

SAMPLE