231 Lighting

231.1 General

Roadway lighting benefits motorists by improving their ability to see roadway geometry and other vehicles at extended distances ahead. Intersection lighting allows for greater visibility of pedestrians that may be in the crosswalk. The design and layout of lighting should complement the basic highway design.

Light poles are permitted in the median only when lighting from the outside cannot meet the criteria shown in ***Table 231.2.1*** without being supplemented by median lighting. Additionally, the barrier requirements in ***FDM 215.2.9*** must be met.

This chapter provides the process and criteria to be used in the development of lighting designs on the SHS.

231.1.1 Structural Supports

AASHTO's LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals and the ***FDOT Modifications to LRFDLTS-1*** provide structural design criteria.

Refer to ***FDM 261*** for information regarding structural support requirements. Refer to ***FDM 326*** for information regarding Lighting Plan requirements.

231.1.2 Attachments to Barriers

Refer to ***FDM 215*** for information regarding proposed attachments to bridge traffic railings, concrete median barrier walls, concrete shoulder barrier walls or the evaluation of existing attachments.

231.1.3 Voltage Drop Criteria

When determining conductor sizes for lighting circuits, the maximum allowable voltage drop from the service point on any one circuit is 5%.

231.1.4 Grounding

The grounding requirements for lighting systems, as shown in the ***Standard Plans*** are as follows:

(1) Install 20’ of ground rod at each conventional height light pole and at each pull box.

(2) Install 40’ of ground rod at each electrical service point.

(3) At each high mast pole, install an array of 6 ground rods 20’ in length, as shown in the ***Standard Plans***, ***Index 715-010***.

The above lengths of ground rod will be installed at each pole, pull box and service point, and the cost will be incidental to the unit or assembly being installed.

231.1.5 Underdeck Bridge Lighting

The light levels for underdeck lighting should be equal to the adjacent roadway lighting. The only luminaire to be used for underdeck lighting is a wall mount fixture located on the pier or pier cap.

231.2 Design Criteria

Use the illuminance method for all lighting design. The design values for light levels given by the ***AASHTO Roadway Lighting Design Guide*** are maintained values. These maintained values have been adjusted for Department assigned light loss and maintenance factors. These values are provided in ***Table 231.2.1*** as required light level criteria.

The ***AASHTO Roadway Lighting Design Guide*** permits either the illuminance technique or the luminance technique to be used in the design of highway lighting. The luminance technique requires a complex design process and knowledge of the reflective characteristics of the pavement surface used. These reflective characteristics change as the pavement ages and with variations in weather conditions. It is for these reasons that the luminance technique is not allowed.

Mounting height (M.H.) for conventional lighting is the vertical distance from the roadway surface at the edge of the travel lane to the light source, regardless of lateral placement of the pole. Pole setback is the horizontal distance from the edge of the travel lane to the pole.

Table 231.2.1 Lighting Initial Values

Roadway Classification	Illumination Level Average Foot Candle		Illumination Uniformity Ratios		Veiling Luminance Ratio
Or Project Type	**Horizontal (H.F.C.)**	**Vertical (V.F.C.)**	**Avg./Min.**	**Max./Min.**	**$L_{V(MAX)}/L_{AVG}$**
Conventional Lighting					
Limited Access Facilities	1.5	N/A	4:1 or Less	10:1 or Less	0.3:1 or Less
Major Arterials	1.5				
Other Roadways	1.0				
High Mast Lighting					
All Roadway Classifications	0.8 to 1.0	N/A	3:1 or Less	10:1 or Less	N/A
Signalized Intersection Lighting					
New or Reconstruction	3.0 Std. 1.5 Min.	1.5 Std. 1.2 Min.	4:1 or Less	10:1 or Less	N/A
Lighting Retrofit	1.5 Std. 1.0 Min.	1.5 Std. 1.0 Min.			
Midblock Crosswalk Lighting					
Low Ambient Luminance	N/A	2.3	N/A	N/A	N/A
Medium & High Ambient Luminance		3.0			
Sidewalks and Shared Use Paths					
Facilities Separated from the Roadway	2.5	N/A	4:1 or Less	10:1 or Less	N/A
Sign Lighting					
Low Ambient Luminance	15-20	N/A	N/A	6:1	N/A
Medium & High Ambient Luminance	25-35				
Rest Area Lighting					
All Roadways and Parking Areas	1.5	N/A	4:1 or Less	10:1 or Less	N/A

Table 231.2.1 Lighting Initial Values cont.

Roadway Classification	Illumination Level Average Foot Candle		Illumination Uniformity Ratios		Veiling Luminance Ratio
Or Project Type	**Horizontal (H.F.C.)**	**Vertical (V.F.C.)**	**Avg./Min.**	**Max./Min.**	**$L_{V(MAX)}/L_{AVG}$**
Wildlife-Sensitive Conventional Lighting					
Limited Access Facilities	0.8-1.0	N/A	4:1 or Less	10:1 or Less	0.3:1 or Less
Arterials and Collectors	1.0-1.5	N/A			
Signalized Intersection - New	1.5-3.0	1.0 Min.	4:1 or Less	10:1 or Less	N/A
Signalized Intersection - Retrofit	1.0-1.5	1.0 Min.			
Note: Illumination Uniformity Ratios do not apply to V.F.C					

Do not tilt cobra head type fixtures. Pole top mounted fixtures may be tilted up to 5 degrees for roadway lighting projects. Pole top mounted fixtures may be tilted in excess of 5 degrees when used at weight stations, agricultural stations and rest areas.

Lights installed within the clear zone must be breakaway or shielded by an approved barrier unless they are bridge or barrier wall mounted. Refer to ***FDM 215*** for additional information on roadside safety design.

Specify mounting heights for conventional lighting in accordance with ***Table 231.2.2***. Ensure that the maximum candela of the design luminaire does not exceed the maximum candela for the associated minimum mounting height.

Table 231.2.2 Minimum Mounting Heights Based on Maximum Candela

Minimum Mounting Height (ft.)	Maximum Candela of Luminaire		
	Long Distribution	Medium Distribution	Short Distribution
20 or Less	5,000	10,000	15,000
25	10,000	15,000	20,000
30	15,000	20,000	25,000
35	20,000	25,000	30,000
40	25,000	30,000	35,000
45	30,000	35,000	40,000
50	35,000	40,000	45,000

Note:

Distribution refers to the longitudinal distribution of the luminaire.

231.2.1 Wildlife-Sensitive Conventional Lighting

For conventional lighting near a wildlife area of concern (as determined by the Office of Environmental Management), incorporate the following design requirements:

(1) Where feasible, orient luminaires away from the wildlife area of concern.

(2) Design lighting system using luminaires from the Wildlife-Sensitive Conventional Lighting category of the APL.

(3) Use the criteria for Wildlife-Sensitive Conventional Lighting from ***Table 231.2.1*** in accordance with the requirements of ***FDM 231.3***.

231.3 Design Methodology

Use the polygon method for all photometric calculations. Establish illumination points within the polygon at the following intervals:

(1) For Roadway Segments: 15 feet longitudinally and 5 feet transversely along the roadway

(2) For Signalized Intersections: 5 feet longitudinally and 5 feet transversely along the roadway.

Refer to ***RCI Features & Characteristics Handbook***, Urban Classification – Feature 124 for additional information concerning urban designations Urban 1 through Urban 5.

231.3.1 Analysis Zones

Establish independent analysis zones for each signalized intersection and for each roadway segment between signalized intersections. Roadway lighting for roadway segments, signalized intersection segments, and pedestrian lighting are to meet the criteria shown in ***Table 231.2.1.***

Analyze signalized intersection segments using one analysis zone bounded by the back of sidewalks and the signalized intersection stop bars on each approach.

The termini for each roadway segment will be either the lighting project limits, or the signalized intersection stop bars. The boundary of each roadway segment is described as follows:

Flush Shoulder Roadways:

(1) Analyze divided roadway segments with grassed medians using two analysis zones; i.e., one for each direction of travel. Each zone will be bounded by the outside and median shoulder breaks.

(2) Analyze multi-lane undivided roadway segments using two analysis zones; i.e., one for each direction of travel. Each zone will be bounded by the outside shoulder break and the centerline of the roadway.

(3) Analyze two and three lane roadway segments as one analysis zone bounded by the outside shoulder breaks.

Curbed Roadways:

(4) Analyze divided roadway segments with grassed medians using two analysis zones; i.e., one for each direction of travel. Each zone will be bounded by the back of sidewalk and the back of the median curb.

(5) Analyze multi-lane undivided roadway segments, including roadways with two-way left turn lane, using two analysis zones; i.e., one for each direction of travel. Each zone will be bounded by the back of sidewalk and the centerline of the roadway.

Limited Access Facilities:

Establish independent analysis zones for the mainline roadway segments, ramp segments and crossroad segments at interchanges.

The termini for each mainline roadway segment will be the lighting project limits. Logical termini for the other segments will be determined by the designer. The boundary of each segment is described as follows:

(1) Analyze divided mainline roadway with grassed median using two analysis zones, one for each direction of travel; i.e., one zone for each direction of travel. Each zone will be bounded by the outside and median shoulder breaks.

(2) Analyze barrier separated mainline roadway as one analysis zone bounded by the outside shoulder breaks of each direction of travel.

(3) Analyze each ramp segment as one analysis zone bounded by the shoulder breaks. For interchange lighting where there is no continuous mainline roadway lighting, the average illuminance criteria must be maintained to the end of the ramp tapers.

(4) Analyze crossroad segments based on the criteria given above for flush shoulder or curbed roadways.

231.3.2 Signalized Intersections

Criteria for lighting at signalized intersections is provided in ***Table 231.2.1***. This criteria applies to signalized intersections located within urbanized areas but may be used in other locations at the District's discretion.

Vertical illuminance is the primary design value to be used to measure pedestrian visibility. Research has determined that visibility of pedestrians in crosswalks at intersections is a function of the following:

(1) Background illuminance

(2) Luminaire location in relation to the approach vehicle

(3) Luminaire mounting height

(4) Distance from the luminaire to the crosswalk

(5) Photometrics of the luminaire

The vertical illuminance calculation method to be used at intersections will be the variable light meter aimed toward the driver's location. This calculation will provide the vertical illumination level of a pedestrian which the driver sees approaching the crosswalk. This type of vertical illumination calculation is outlined in the ***IESNA Design Guide for Roundabout Lighting (DG-19-08)***. When performing this calculation, the driver's location from the crosswalk must be established. Use the stopping sight distance for the nearside approach based on the posted speed of the near approach roadway. Use the stopping sight distance for the turning movement approaches based on the operating speed for each specific turning radius.

The vertical illuminance must be calculated for three movements for each intersection approach. The first is the thru movement and the near side crosswalk; the second is the right turn movement and crosswalk on the adjacent side street; and the third is the left turn movement and the crosswalk on the side street. ***Figures 231.3.1*** through ***231.3.3*** indicate each of these three movements and the corresponding crosswalk area that must be analyzed. The vertical illuminance grid points are to be on a line centered in the crosswalk with a horizontal point spacing of 1.65 feet at a height of 5 feet above the pavement. The grid points are oriented toward the approaching driver, which is different from the vertical grids for sidewalks where the grids are parallel to the main pedestrian flow.

See ***FDM 231.3.2.1*** for projects where pedestrian lighting improvements are desired, but the existing intersection infrastructure will remain and be supplemented to achieve the desired improvements.

231.3.2.1 Intersection Lighting Retrofit

For existing signalized intersections where a full signal upgrade is not occurring, the existing infrastructure restricts the placement of additional lighting fixtures necessary to meet the New and Reconstructed criteria of ***Table 231.2.1***. Lighting Retrofits should be considered at signalized intersections on corridors that have a history of nighttime pedestrian crashes. Lighting Retrofits may be included with RRR and minor intersection improvement projects that do not include full signal upgrades.

For Lighting Retrofits, supplement with additional lighting fixtures as necessary to meet the Lighting Retrofit criteria shown in ***Table 231.2.1***. The vertical illuminance calculation only applies to the near side movement (see ***Figure 231.3.1)***.

When the maintaining agency converts existing light fixtures to LED fixtures, and no other lighting improvements are scheduled, the agency is not required to meet the Lighting Retrofit criteria shown in ***Table 231.2.1***.

231.3.3 Roundabouts

Signalized intersection lighting criteria in ***Table 231.2.1*** applies to roundabouts where pedestrian features are provided. Use conventional roadway lighting criteria for roundabouts where pedestrian traffic is not anticipated. Calculate the vertical illuminance for the crosswalk on each near side approach and for each right turn movement in accordance with the methodology outlined in ***FDM 231.3.2***.

231.3.4 Midblock Crosswalks

Lighting criteria for midblock crosswalks are provided in ***Table 231.2.1***. Calculate the vertical illuminance for the crosswalk on each near side approach in accordance with the methodology outlined in ***FDM 231.3.2***.

231.3.5 Sidewalks and Shared Use Paths

Lighting criteria for sidewalks and shared use paths are provided in ***Table 231.2.1***. These values are intended for facilities separate from the roadway. Use illumination levels of the roadway for facilities within the range of the proposed or existing light poles.

Figure 231.3.1 Vertical Illuminance Calculation for Near Side Movement

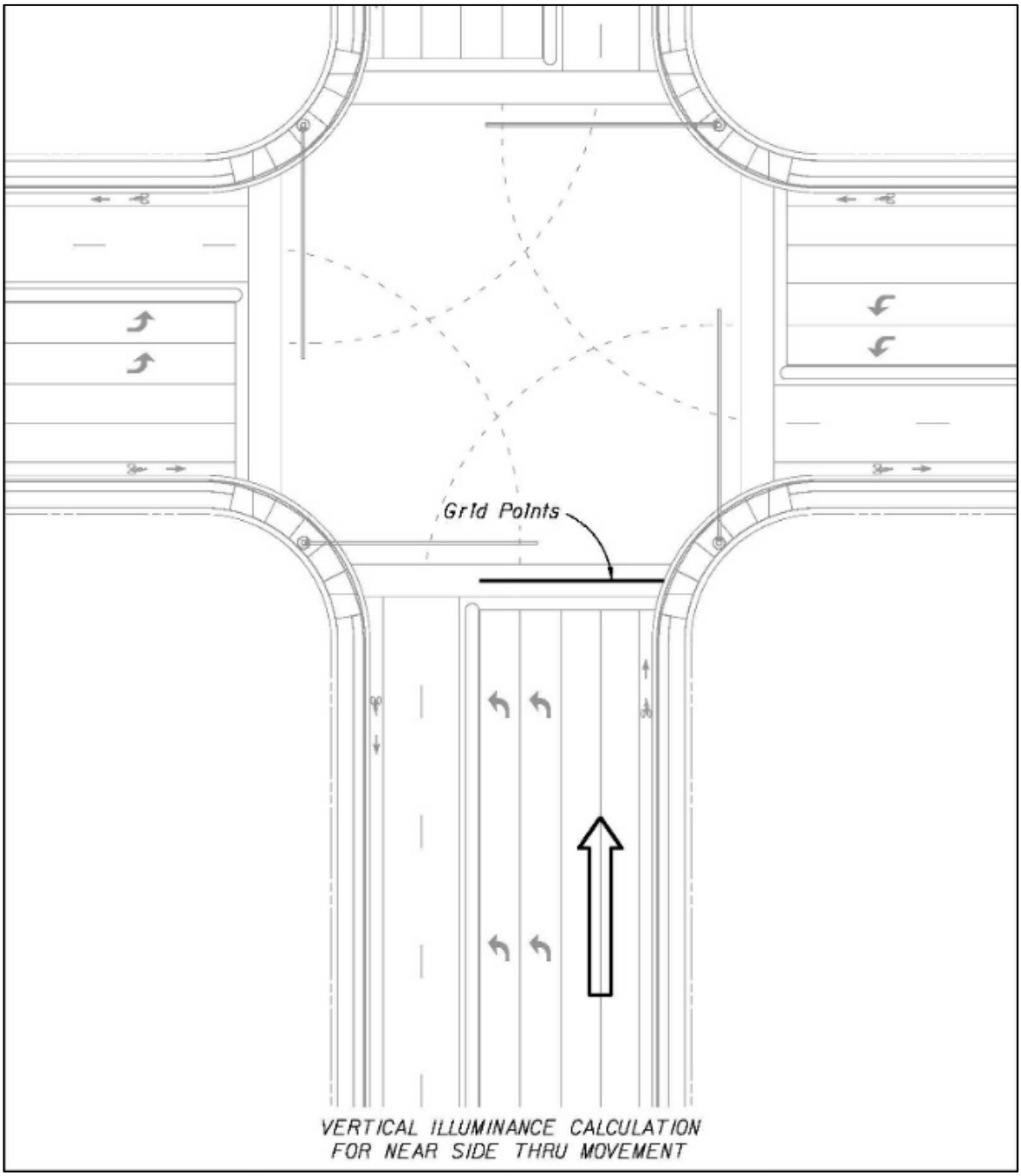


Figure 231.3.2 Vertical Illuminance Calculation for Right Turn Approach

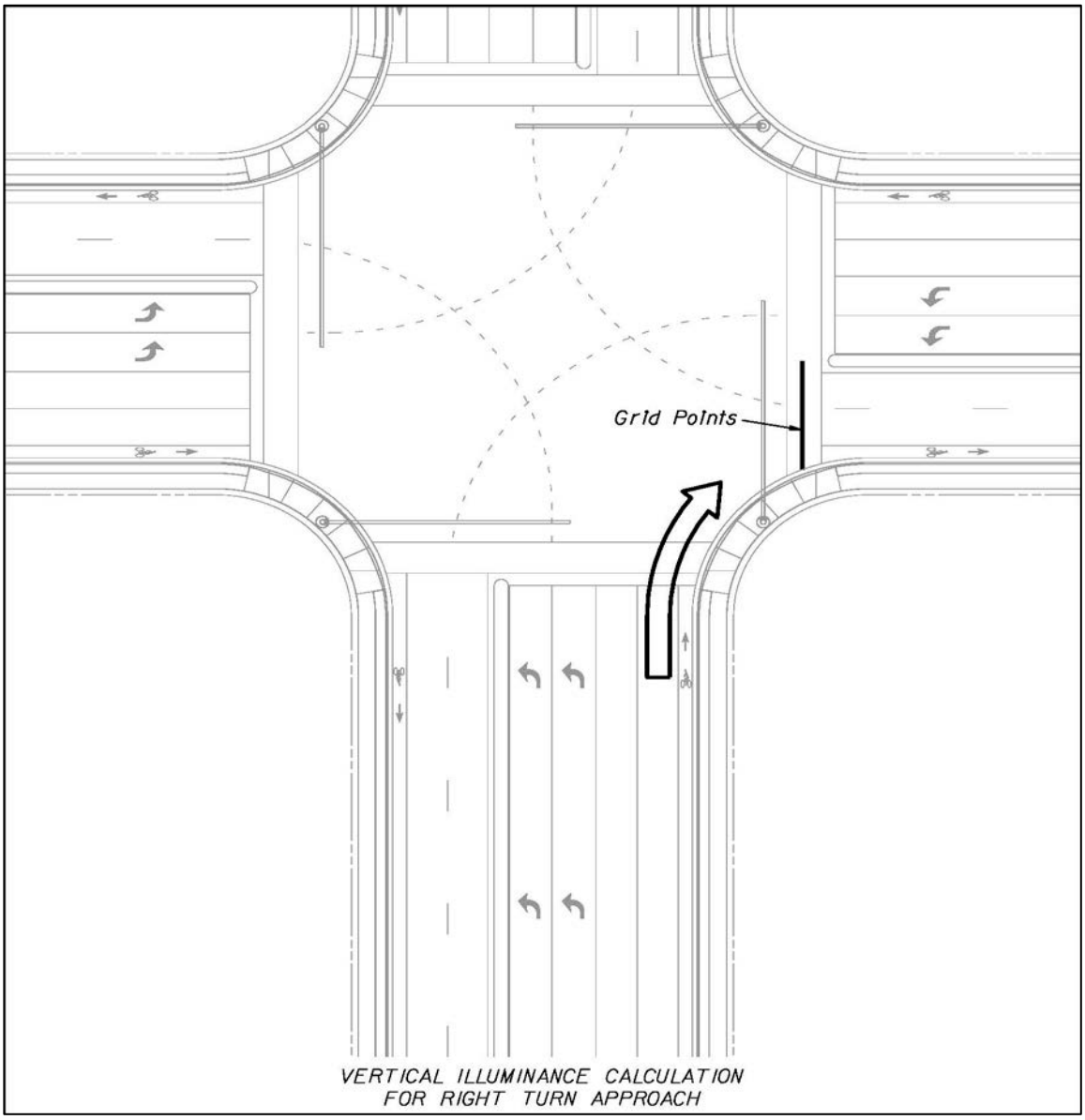


Figure 231.3.3 Vertical Illuminance Calculation for Left Turn Approach

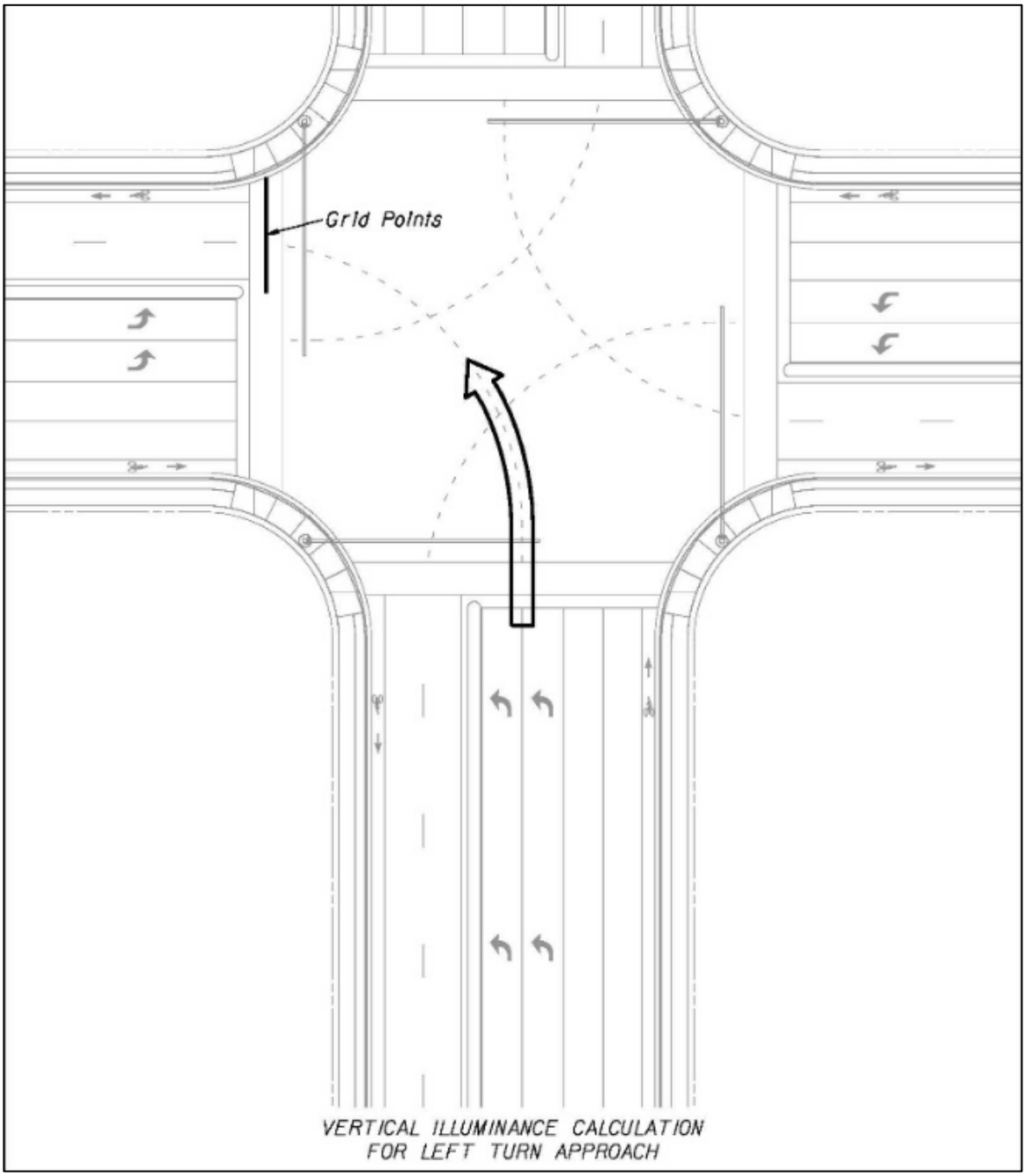
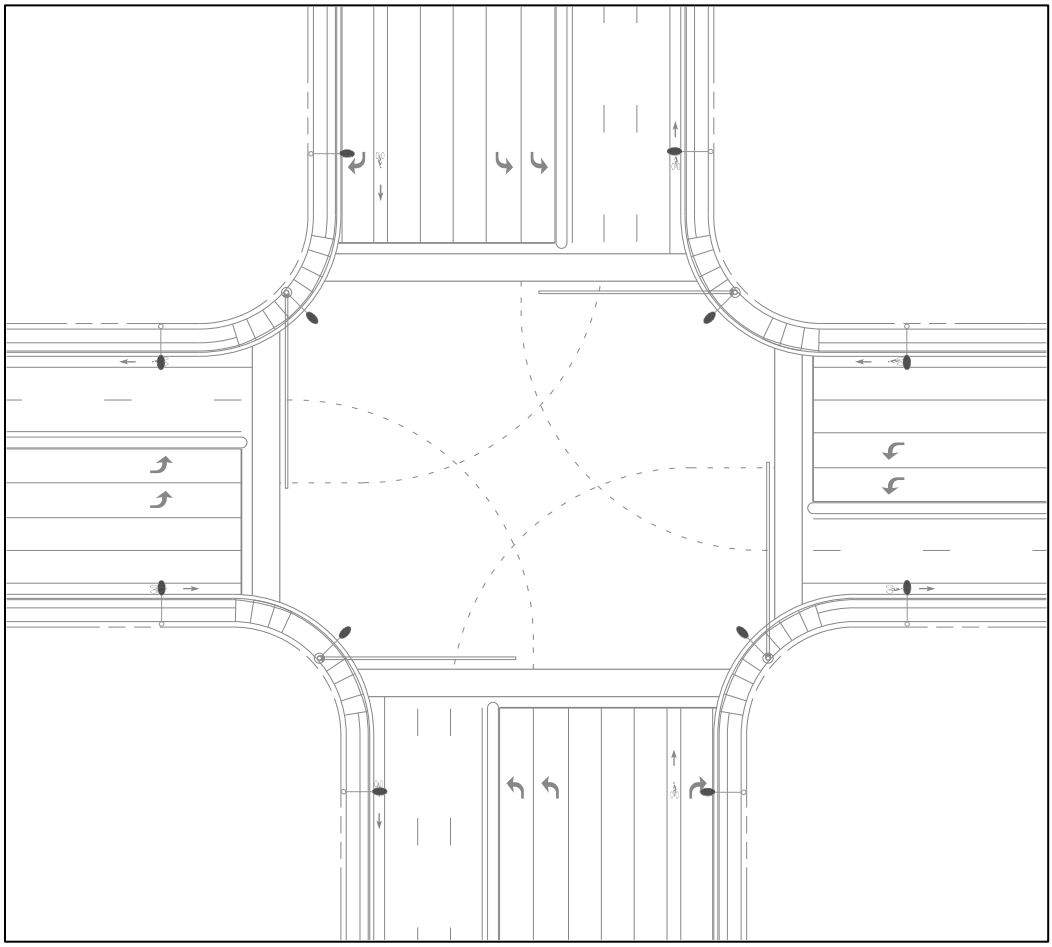


Figure 231.3.4 shows the typical lighting layout for a large intersection. The crosswalk and luminaire locations must be coordinated to optimize the vertical illumination level.

Figure 231.3.4 Typical Lighting Layout for Large Intersection



231.4 Lighting Justification

The Department follows the warrants for lighting established by ***AASHTO***. The warrants are based on benefit-cost ratios determined from the Average Daily Traffic (ADT), the ratio of night to day crashes, initial cost, and maintenance. A benefit-cost ratio of 2.0 or greater is currently the threshold for interchange lighting.

All interchanges on the interstate highway system are to be lighted to assure consistency and to meet driver expectations. A warrant analysis will be required but will not be used as the determining factor for the installation of lighting at these interchanges.

The roadway lighting justification procedure is found in Chapter 14 of the ***MUTS***.

231.5 Existing Lighting During Construction

The maintenance of existing lighting will be the responsibility of the contractor only if the lighting is affected by the construction. The contractor is not expected to replace lamps and pole knockdowns or to repair wiring if these problems are not caused by the construction work.

The plans are to specify the scope of the contractor's responsibility for the maintenance of existing lighting.

231.6 Lighting Coordination

The District Utilities Engineer should be contacted as soon as pole locations are set, and the electrical load has been determined. The designer should coordinate with the utility company providing power on the preferred location for the electrical service.

Coordinate with the Drainage Section to assure that high water tables, stormwater retention areas, or other water bodies will not be a problem with the proposed location of light poles and the light pole pull boxes.

Coordinate locations and attachments of lights and conduits on bridge structures with the bridge structural designer. Include light and conduit locations, and attachment details in the plans. Refer to ***Structures Design Guidelines***, ***Section 1.9*** for details and restrictions related to bridge attachments.

Typically, the District Traffic Operations Engineer in conjunction with the District Utilities Engineer obtains the required maintenance agreements. The designer should coordinate with these offices to ensure that this activity is either underway or scheduled.

Any lighting project, especially high mast, adjacent to or in the vicinity of an airport, may present a potential problem.

Modification for Non-Conventional Projects:

Delete ***FDM 231.6*** and replace with the following:

231.6 Lighting Project Coordination

The Lighting Engineer of Record is responsible for all necessary coordination.

231.7 Lighting Design Analysis Report

Prepare a Lighting Design Analysis Report (LDAR) that provides a photometric analysis for each signalized intersection lighting design, mainline typical section, ramp typical section, interchange, and structure with underdeck lighting. All analyses, including horizontal and vertical illumination analyses, should be shown on separate photometric plan sheets.

Provide voltage drop calculations, load analysis calculations for each branch circuit, and lighting calculations for each lighted sign.

The LDAR should include an evaluation of three lighting design alternatives (e.g., different pole heights, lamp wattage, arms lengths). Provide each alternative with a cost estimate that includes initial cost and the annual maintenance cost.

For all LDAR components, provide sufficient detail in print format (e.g., PDF) so that reviewers do not require compatible design software to check all inputs and results of calculations.