VIRGINIA DEPARTMENT OF TRANSPORTATION

TRAFFIC ENGINEERING DIVISION

INSTRUCTIONAL & INFORMATIONAL MEMORANDUM

GENERAL SUBJECT: Roadway Lighting	**NUMBER:** IIM-TE-390
	SUPERSEDES:
SPECIFIC SUBJECT: Light Emitting Diode (LED) Exterior Lighting	**DATE:** May 10, 2019
APPROVAL: /original signed by/ Raymond J. Khoury, P.E. State Traffic Engineer Richmond, VA May 3, 2019	

1.0 PURPOSE AND NEED

This IIM serves to:

- Emphasize that **VDOT's default position is "no lighting", particularly for continuous freeway and street lighting.** Where roadway lighting is to be provided, VDOT's philosophy is **"nodes, not roads"** – meaning that it may be appropriate to provide partial interchange lighting or intersection/crosswalk/roundabout lighting if there is strong safety justification. Lighting is also often necessary in VDOT-maintained parking lots.
- Existing lighting systems shall be reevaluated whenever they are substantially impacted by proposed construction.
- Establish specific policies regarding the various types of exterior lighting on the VDOT system.
- Implement the Chief Engineer's June 2017 statewide LED Lighting Memorandum (Attachment A).
- Establish requirements for lighting design in ways that best benefit roadway safety while minimizing VDOT's potential impact on public health, light pollution, and the environment.

2.0 BACKGROUND

Lighting represents significant installation and ongoing maintenance costs. **Therefore, VDOT's default position is "no lighting", particularly for continuous freeway and street lighting.** However, VDOT-maintained lighting may be appropriate where a safety analysis shows strong justification. If roadway lighting is to be provided, VDOT's philosophy is **"nodes, not roads"** – illumination is best when limited to partial interchange lighting, intersections, midblock crosswalks, and roundabouts. Lighting is also often necessary in VDOT-maintained parking lots.

Additionally, existing roadway lighting systems shall be reevaluated whenever a substantial proportion of the existing roadway lighting luminaires are slated for replacement during proposed reconstruction. For limited access highways, recent studies[1] have indicated that **lighting generally does not provide significant reduction in nighttime crash risk along straight tangent sections of freeway**. Lighting on limited access highways can still sometimes provide significant safety benefit (greatest potential to reduce likelihood of nighttime crashes) at the critical merge/diverge/weave areas.

Lighting of intersections and crosswalks can provide positive safety benefits when appropriately used. Lighting is one of the recommended "tools in the toolbox" of VDOT's 2017-2021 Strategic Highway Safety Plan (specifically the roadway departure, intersection, pedestrian, and bicyclist emphasis areas). Lighting is also a recommendation of the 2018 Pedestrian Safety Action Plan. Lighting can result in approximately 22% reduction in nighttime injury crashes, and an 8%~32% reduction in pedestrian nighttime crashes at intersections.

A useful lighting design resource is FHWA's roadway lighting web-based training.

3.0 LIGHTING JUSTIFICATION OR REMOVAL

3.1 *General*

Similar to traffic signals, lighting needs to be both warranted and justified. Any proposed new VDOT-maintained roadway lighting shall be warranted as per the latest effective revision to the AASHTO *Roadway Lighting Design Guide*, and shall also document the anticipated benefits and costs using Crash Modification Factors (CMFs) from the Highway Safety Manual and the FHWA CMF Clearinghouse. Cost considerations should consider both installation costs and future ongoing maintenance costs.

LEDs have reduced life-cycle costs as compared to traditional HPS fixtures, due to their higher energy efficiency and increased longevity. Historically, lighting still represents significant ongoing maintenance costs, including relamping, electrical service infrastructure maintenance, and replacement of knocked-down or damaged light poles.

3.2 *Limited Access Highways & Interchanges*

The AASHTO *Roadway Lighting Design Guide* defines three basic levels of limited access highway lighting:

- Continuous Freeway Lighting – continuous lighting of all entire interchange areas and the limited access highway segments between successive interchanges
- Complete Interchange Lighting – lighting of the entire interchange area, including the entire length of ramps (from gore area to terminus) and the entire length of the cross road within the limits of the interchange, but not the highway segments between interchanges.
- Partial Interchange Lighting – illumination is limited to acceleration/deceleration/weave areas and ramp terminals.

In general, Partial Interchange Lighting is the best of those three strategies, by targeting lighting only to where it is needed the most – at those key decision-making areas. Partial Interchange

[1] *Evaluation of the Safety Performance of Continuous Mainline Roadway Lighting on Freeway Segments in Washington State; March 2016; van Schalkwyck, Venkataraman, et. al.*

Lighting would also include intersection lighting for ramps that end at unsignalized or signalized intersections; such lighting can reduce risk of wrong-way entry onto the limited access highway.

VDOT's lighting policy for limited access highways shall be as per **Table 1.**

Table 1 – VDOT Policy for Limited Access Highway Lighting

Status of existing hwy	Currently lit	Currently unlit
Slated for major reconstruction/ widening**	If the project will impact a substantial proportion of existing luminaires at a location with Continuous Freeway or Full Interchange Lighting, the District shall consider whether to solely provide Partial Interchange Lighting in the future condition.	The Project Designer may evaluate whether Partial Interchange Lighting is both warranted and justified. Intersection lighting shall be considered at ramp termini with potential for wrong-way entry onto the limited access highway. Neither Full Interchange Lighting nor Continuous Freeway Lighting shall be pursued without Central Office-Traffic Engineering Division (CO-TED) concurrence.
Not slated for major reconstruction/ widening	Districts may prepare an engineering evaluation of whether to decommission or remove existing lighting.	Districts may prepare engineering studies to justify Partial Interchange Lighting installation if there is a demonstrated safety need. Neither Full Interchange Lighting nor Continuous Freeway Lighting shall be pursued without CO-TED concurrence.

**also applies to locations where a substantial proportion of existing light poles must be replaced due to structural issues.

Warrant evaluation shall be as per the latest effective revision to the AASHTO *Roadway Lighting Design Guide*, based on projected opening-day volumes. Justification is based on additional factors such as interchange importance, weaving volumes, and geometry.

When an existing bridge with an underbridge lighting system is being widened/reconstructed, designers shall evaluate whether daytime underbridge lighting is still warranted based on the most recent edition of the AASHTO *Roadway Lighting Design Guide*. If the underpassing road has pedestrian facilities, then the designer should consider the impact on pedestrian safety and security when assessing whether to maintain underbridge lighting when the structure is reconstructed.

Long underpasses (classified as "short tunnels" in IES RP-8) shall be equipped with underbridge lighting systems if daytime lighting is determined to be warranted based on the procedures of the most recent edition of the AASHTO *Roadway Lighting Design Guide*.

3.3 *Intersections and Roundabouts*

Intersection lighting, where properly sited and designed, can provide important safety benefits to motorists, pedestrians, and bicyclists. Lighting is one of the recommended countermeasures for reducing pedestrian crash potential as per VDOT's 2018 Pedestrian Safety Action Plan.

The *AASHTO Roadway Lighting Design Guide* does not provide explicit warrants for intersection lighting. One resource that may be considered is the FHWA *Design Criteria for Adaptive Lighting*'s Design Criteria for Streets (S-Class). This methodology assigns points based on criteria such as speeds, volumes, pedestrians, intersection density, and ambient luminance from adjacent land uses. Intersections calculated as S1 or S2 would likely benefit from intersection lighting.

VDOT's lighting policy for intersections, roundabouts, and crosswalks shall be as per **Table 2.**

Table 2 – VDOT Policy for Intersection/Roundabout/Crosswalk Lighting

Location type	Recommendation
New or Reconstructed[2] Traffic signals	Traffic signals with pedestrian accommodations: Designers shall consider including intersection lighting. Intersection lighting should be included if the intersection can be properly illuminated using luminaires atop the proposed signal supports without aerial utility or other conflicts. Intersection lighting may be included if adequate lighting would require separate supports. Traffic signals at interchange off-ramp termini: Lighting shall be considered as a way to reduce risk of wrong-way entry onto the limited-access facility. Intersection lighting should be included if the intersection can be properly illuminated using luminaires atop the proposed signal supports without aerial utility or other conflicts. If adequate lighting would require separate supports, then intersection lighting may be provided. Other traffic signals: intersection lighting may be included.
Roundabouts	Lighting is not automatically required at all roundabouts; it should be considered on a case-by-case basis based on expected traffic volumes, roundabout configuration (single-lane or multi-lane), sight distances, and expected levels of pedestrian and bicyclist activity. See "Roundabouts: An Informational Guide" for more guidance.
Unsignalized intersections	Intersection lighting may be considered. Lighting can be an effective safety countermeasure to reduce nighttime crash rates and crash severity at such locations, as summarized in this 2009 FHWA synthesis.
Uncontrolled marked pedestrian crossings	Pedestrian crashes are more likely to happen at night. Crosswalk lighting shall be considered for uncontrolled crossings of higher-speed approaches (≥45 mph) due to the limited sight distance that headlights provide at higher speeds, as well as the greater risk of serious injury or fatality when a pedestrian or bicyclist is struck by a vehicle traveling at higher speeds.
Railroad grade crossings	As per the FHWA Railroad-Highway Grade Crossing Handbook, lighting can be an effective crash countermeasure for some grade crossings.

[2] *Defined, for the purposes of this IIM, as replacement of at least 66% of the mast arms or strain poles.*

3.4 *Sign Lighting*

Refer to the latest effective revision to IIM-TE-380 for policies and guidance on evaluating the need for overhead guide sign lighting.

3.5 *Park & Rides*

Park & Ride lighting shall be included where required as per VDOT's Park & Ride Design Guidelines.

4.0 LIGHTING DESIGN

4.1 *Conventional and High Mast Lighting*

All new VDOT-maintained conventional (Standard LP-1 and LP-2) and high mast (Standard LP-3) lighting shall use LEDs as per the Chief Engineer's June 2017 Memo (Attachment A). This includes:

- Interstates and limited access primaries – mainline and interchanges
- Lighting on non-limited access primaries and secondaries
- Intersection lighting (stand-alone light poles and luminaires attached to signal poles)
- Park & Rides
- Rest Areas/Welcome Centers
- DMV truck weigh stations[3]
- VDOT facility (e.g. District/Residency/Area Headquarters) parking lots

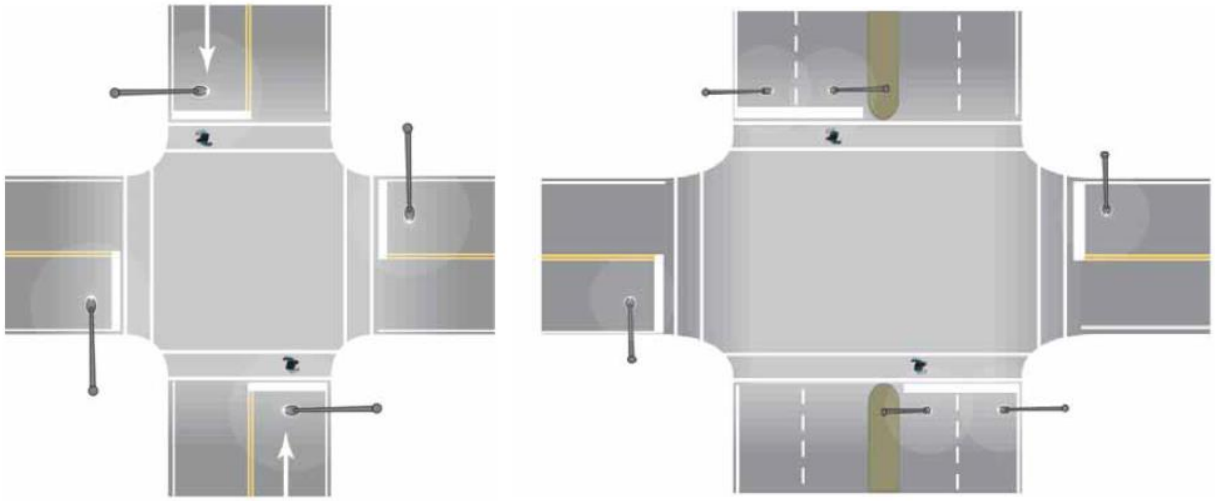
Conversion kits (kits that replace the HPS bulb with an LED within the existing housing) shall only be used with CO-TED approval.

4.2 *Lighting Design at Intersections and Pedestrian Crossings*

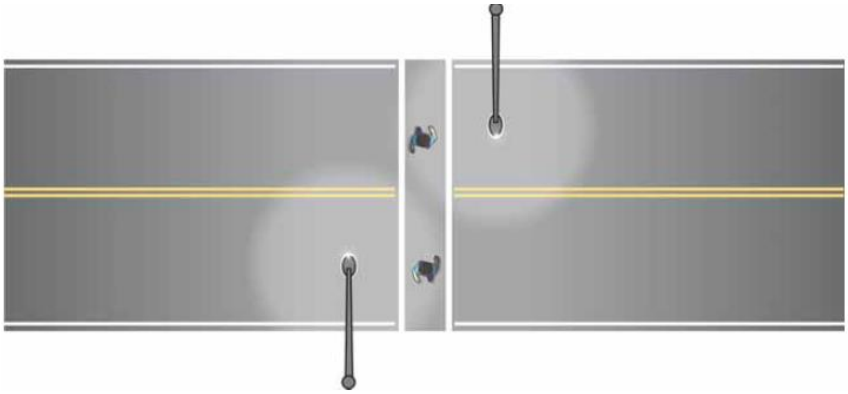
The below graphics, taken from the FHWA Informational Report on Lighting Design for Midblock Crosswalks, indicate recommended lighting placement for intersections and midblock crossings. These light positions are designed to maximize uniformity of illumination, and provide lighting on the approach side of the pedestrian rather than behind the pedestrian. Refer to Section 5.3 (crosswalks) of the Illumination Engineering Society (IES) Recommended Practice RP-8 (version 2018 or later editions) for more guidance.

Wherever possible, intersection lighting should use combination poles (luminaires mounted atop traffic signal poles) to minimize the number of fixed objects and ancillary structures in each quadrant.

[3] Although truck weigh station infrastructure is operated and maintained by the Department of Motor Vehicles (DMV), their operation is funded by VDOT, and VDOT often maintains the light poles located along the entry and exit ramps to the weigh station.



Recommended luminaire placement at intersections (from FHWA Informational Report)



Recommended luminaire placement at midblock crossings (from FHWA Informational Report)

4.3 *Sign Lighting*

Sign lighting design shall be as per the latest effective revision to IIM-TE-380 and the *Traffic Engineering Design Manual*.

All new sign lighting shall be LED luminaires.

4.4 *Underbridge and Short Tunnel Lighting*

Underbridge lights illuminate underpasses and short tunnels (including VDOT structures that cross locally-maintained streets). This category does not include major tunnels such as HRBT, MMMBT, and the two I-77 tunnels.

All new VDOT-maintained underbridge/short tunnel lights installed via construction contract shall be LED luminaires.

Typically, LEDs must be installed in locations differing from the existing HPS “wallpack” locations and the existing conduits and NEMA junction box enclosures must also be replaced. When

designing underbridge lighting replacement, designers should evaluate whether the existing number of luminaires can be reduced while still providing appropriate illumination.

All underbridge lighting systems shall be coordinated with District Structure & Bridge. Where possible, luminaires should be attached to pier caps rather than girders (to the side rather than over the travel lanes) to facilitate future maintenance.

4.5 *Other Exterior Lighting*

Other types of VDOT-maintained exterior lighting includes:

- Major tunnels
- VDOT-maintained pedestrian overpasses and underpasses
- pedestrian-scale lights (sometimes referred to as "decorative post-tops", and rarely maintained by VDOT)
- marine navigation lights for VDOT structures over navigable rivers
- aviation hazard lights for VDOT structures near airports and hospitals
- toll plaza canopy lights

LED technology should be used for these other lighting types unless another technology is judged to be more prudent based on engineering judgment.

4.6 Light Loss Factor (LLF) shall be considered in all lighting design calculations. Typically a LLF of 0.86 is appropriate for LED luminaires.

4.7 Interior Lighting (lighting inside VDOT buildings) is outside the scope of this IIM.

5.0 MINIMIZING LIGHTING IMPACTS TO RESIDENTS

5.1 *General*

Lighting design shall be as per:

- The VDOT L&D Division Traffic Engineering Design Manual
- The latest effective RP-8 design requirements (currently version RP-8-18) of the Illumination Engineering Society (IES), as required by Virginia Code §2.2-1111
- The latest effective revision to the AASHTO *Roadway Lighting Design Guide*
- VDOT's current approved LED Special Provisions/Specifications

5.2 *Correlated Color Temperature*

Correlated Color Temperature (CCT) is a measure of the color appearance of the light ("warm" or "cool") as measured in degrees Kelvin (K). Most LED manufacturers provide luminaires with 2700K, 3000K, 4000K, or 5000K CCT options.

Lighting design plans shall indicate the CCT in the plan sheets or the plan notes.

In June 2016, the American Medical Association issued a report recommending that agencies limit all exterior lighting LEDs to 3000K, due to the AMA's concerns that LEDs with higher CCT will adversely affect melatonin production in humans.

In response to this report, VDOT has undertaken extensive research into impacts of CCT, and the effects of CCT on roadway safety, public health, skyglow/light pollution, and the environment.

CCT shall be as per Table 3, which was developed based on that research. This policy may be revisited after ongoing US Department of Energy research into this topic is completed.

Table 3 – VDOT Lighting CCT Policy

Location type	CCT	Notes
Designated environmentally sensitive areas	2700K	This applies to locations where there is a documented concern with the impact of 4000K CCT lighting on flora or fauna
Designated historic areas/landmarks	2700K lighting may be used where requested by the locality or historic area/landmark owner	
Interstates and limited access highways	• Interchange lighting = 4000K • Freeway mainline lighting = 3000K	Interchange lighting includes luminaires that illuminate ramps, gore areas, the first 500 feet of acceleration/deceleration lanes, and short weaving areas (1000 feet or less)
Primaries, Secondaries, and City Streets	• Speed limit ≤ 30 mph = 3000K • Speed limit ≥ 35 mph = 4000K • Decorative post-top luminaires = 3000K	Intersection and roundabout lighting CCT shall be based on the posted/statutory speed limit for the highest-speed approach
Park & Rides	3000K	• 4000K may be used if requested by the locality • Intersection lighting at the Park & Ride entrance shall be as described above • If the Park & Ride has an entrance or exit directly onto an Interstate/Limited Access Highway, then lighting of the ramp entrance/exit shall be as described above
Rest Areas/ Welcome Centers	4000K	
Overhead Sign Lighting	3000K	
Toll Facilities	• Traditional (staffed) toll plazas = 4000K • All-electronic toll facilities = case by case basis	• At traditional toll plazas, there are varying speeds of drivers approaching and exiting the toll plaza, as well as the potential presence of toll plaza employees crossing from lane to lane • At all-electronic toll facilities, a CCT should be selected that will best facilitate accurate toll collection
Weigh Stations	4000K	Note that pedestrians (weigh station personnel, police, and truck drivers) are often present at weigh stations

Location type	CCT	Notes
Tunnels	4000K or higher	• tunnel lights do not contribute to outside light pollution • vehicular tunnel lights play a critical role in tunnel operations and emergency evacuation needs • pedestrian tunnel lights play a critical role in pedestrian comfort and security
Aerial/marine navigation lights	As recommended by regulatory agency	Aerial and marine lights are regulated by the FAA and Coast Guard respectively

Existing LED lights can remain until the end of their useful service life regardless of CCT, however when replaced those lights shall be brought into conformance with this policy.

It is important to note that this guidance has been developed in consideration of typical VDOT lighting types. Localities who maintain neighborhood street lighting may sometimes consider additional factors, such as aesthetic considerations and input from local police.

5.3 *Reducing Light Pollution/Skyglow*

Luminaires with a zero uplight rating (a Backlight-Uplight-Glare BUG rating of U0) shall be used wherever possible.

Additionally, all conventional pole fixtures shall be oriented parallel to the road.

5.4 *Reducing Light Trespass*

During the design process, designers shall analyze the impact of the recommended lighting design on the adjacent ROW, and shall ensure that light levels at the ROW line do not exceed the Maximum Initial Vertical Illuminance spill light established in the table below (adapted from Table 4-1 and 4-2 of RP-8-18).

Lighting Zone (LZ) determination is to be made based on existing land use at the time of the lighting design. Where appropriate, the designer may take into account changes in adjacent land use that have been approved by the locality and anticipated to be implemented by the time of start of construction.

LZ	Where Used	Max. Initial Vertical Illum-inance Spill Light (f-c)
0	Wilderness areas, parks and preserves	0.05
1	Single-family residential, undeveloped areas, agricultural fields, office parks	0.1
2	Small neighborhood businesses, apartment/condo complexes, schools, churches, hospitals, light industrial facilities, small neighborhood recreational centers	0.3

3	Commercial corridors, fast-food/fast-casual restaurants, car dealers, gas stations, high-use recreational ball fields, industrial facilities with significant nighttime usage	0.7
4	Downtown central business districts and heavy industrial districts	1.4

Designers should use the lowest possible Glare (the "G" in BUG) rating that is practical for sufficient illumination of the road.

High mast luminaires should use asymmetric illumination patterns wherever possible, and the design plans should indicate required house side/street side orientation of the rotatable optics.

5.5 *Lighting Controls Systems (LCS) and Dimming*

Lighting Controls Systems (LCS) allow lighting owners to remotely access, monitor and adjust luminaire illumination using wireless communications and a web-based user interface. Advantages include:

- Energy savings – LCS allows owners to achieve 15%~30% additional energy savings beyond those achieved purely by switching to LEDs. These savings are achieved by (a) automatically adjusting for constant light output, and (b) "trimming" the lumens output (gradually ramping up and down the illumination) to avoid instant turn-on and turn-off at dusk and dawn.
- Energy metering – provide highly accurate (utility grade) measurements of actual energy usage.
- Asset management/maintenance benefits – GPS capabilities allow users to keep track of assets and receive automatic notification of outages.
- Dimming – allows for dimming or curfewing of luminaires based on time-of-day schedules. Dimming schedules can be remotely implemented/adjusted/disabled for individual luminaires or groups of luminaires. Dimming periods could vary based on day of week or month of year.
    - LED luminaires without LCS can be manually dimmed.
- Other – Other agencies are experimenting with using LCS for vehicle/parking occupancy detection, Connected/Autonomous Vehicles applications, doubling as Wi-Fi hotspots, or other "smart city" applications.

Any experimentation with LCS must be coordinated with TED.

Dimming may be considered under the following conditions:

- Roadway lighting – corridor-wide or interchange lighting levels may be reduced below "normal" 100% illumination during late-night periods when volumes drop below certain thresholds. Any late-night dimming shall use the procedures of FHWA's *Design Criteria for Adaptive Highway Lighting* publication, using the best available time-of-day volume information for that road, and shall be approved by TED.
- Parking lot lighting – dimming of parking lot lights is allowed as per IES RP-20-14 *Lighting for Parking Facilities*. Rest area/welcome center dimming is not recommended due to their 24/7 nature, however dimming of park & ride lots and VDOT facility parking lots may be appropriate during late-night periods where there is nominal activity within those lots. Curfews are not recommended to minimize influence on real or perceived criminal activity.

- Individual luminaires may be dimmed if the immediately-adjacent property owner has complained about perceived light impacts, and it is not feasible to shield, re-orient, or replace the luminaire in such a way as to reduce the property impacts.

Dimming offers several potential advantages:

- Dimming is consistent with VDOT's commitment to minimize its impact on the environment, including light pollution.
- Dimming offers an opportunity for VDOT to substantially reduce its electric bills.
- During late-night periods:
    - traffic volumes are typically low enough that roadway lighting falls below the volume thresholds of the AASHTO *Roadway Lighting Design Guide*.
    - Pedestrian activity is typically nominal outside of college campuses, major transit stations, central business districts, and other unique area types.
    - Most parking lots (except rest areas/welcome centers) see only sporadic activity.

Virginia Code §2.2-1111 does not prohibit late-night dimming.

6.0 LIGHTING MAINTENANCE

6.1 *Maintenance Responsibilities*

Lighting installation, operation and maintenance responsibilities shall be as per §24VAC30-530-10 and §24VAC30-151-420 of the Virginia Administrative Code.

Typically, VDOT does not maintain corridor street lighting on non-limited access primaries and secondaries, with the following exceptions:

- Intersection/roundabout lighting
- Underbridge lighting where VDOT-owned structures carry limited access highways over VDOT- or locality-maintained primaries/secondaries/city streets

VDOT shall not maintain any new lighting on locality-maintained roads, nor shall VDOT maintain new decorative "post-top" lighting. For existing VDOT-maintained lighting on locality-maintained roads or existing VDOT-maintained pedestrian-scale lighting, Districts should work with the locality to transfer maintenance responsibility to the locality or other appropriate entity.

For lighting that is being installed by VDOT construction project but is required to be maintained by a permittee (typically the locality), the District shall secure a Permit agreement with the permittee prior to construction. If lighting is justified from a safety standpoint but the locality wants decorative lighting for aesthetic purposes, then the locality should be responsible for costs above and beyond what would be required for "normal" lighting.

All non-VDOT-maintained lighting in VDOT ROW, shall not exceed the maximum CCT, skyglow, and light trespass thresholds established in this IIM.

6.2 *Replacement of Existing VDOT-Maintained HPS Luminaires*

When replacing luminaires on existing poles, designers should select LED luminaire replacements that best meet IES requirements for uniformity of lighting, given existing pole spacing and height constraints.

When replacing lights through attrition, it is acceptable to replace strings of lights with LED (have whitish LED strings followed by yellowish HPS strings) as long as there is consistency in light output (lumens) when transitioning between LED and HPS zones. Isolated replacement of single lights may result in driver complaints about inconsistency in lighting appearance, and would lead to more lighting replacement Maintenance of Traffic (MOT) operations.

When existing tilted luminaires are replaced, the replacement luminaires shall be parallel to the road. An acceptable method of doing this is to place an 8-inch (approximate) long adaptor bracket atop the existing LP-2 light pole for attachment of an LED "cobrahead" luminaire. Tilted luminaires will be allowed if there is documentation that there is no other feasible way to replace existing HPS luminaires without creating a potential safety concern due to nonuniformity of illumination. Tilted luminaires shall not be used when new lighting is installed or an existing lighting system undergoes full replacement due to major widening/reconstruction.

6.3 *Vibration Concerns*

Districts should immediately contact S&B and TED Divisions if a vibration issue is observed post-conversion, and evaluate the potential to attach external vibration-dampening devices that are designed to mitigate both first-mode and second-mode vibrations.

Dampeners on new luminaire poles shall be as per the Road & Bridge Specifications.

6.4 *Disposal of Existing Luminaires*

Existing HPS luminaires are classified as Universal Waste and must be properly disposed of as per Environmental Division guidance.

7.0 EFFECTIVE DATE

Requirements for use of LEDs (as opposed to HPS or other traditional light technologies) shall be as per the Chief Engineer's June 2017 LED Lighting Memorandum.

This IIM shall be effective for all projects for which detailed lighting plan design has not yet begun, and should be applied to the extent feasible and practical for all projects in the design process.

8.0 REFERENCES

- 2017-2021 Virginia Strategic Highway Safety Plan
- 2018 VDOT Pedestrian Safety Action Plan
- VDOT Traffic Engineering Design Manual
- FHWA Lighting Handbook
- FHWA Design Criteria For Adaptive Roadway Lighting

- FHWA Informational Report on Lighting Design for Midblock Crosswalks
- AASHTO Roadway Lighting Design Guide
- Illumination Engineering Society (IES) RP-8-18, *Recommended Practice for Design and Maintenance of Roadway and Parking Facility Lighting*
- IIM-TE-380, Overhead Guide Sign Lighting
- VA Code §2.2-1111
- Virginia Administrative Code §24VAC30-530-10 and §24VAC30-151-420
- FHWA lighting web-based training