Alan M. Voorhees Transportation Center

Pedestrian Lighting in New Jersey:
A Means to Improve Pedestrian Safety

Prepared by:
Ranjit Walia
Senior Research Specialist

Stephanie DiPetrillo
Project Coordinator

Contributing Authors:
Martin Robins
Senior Policy Fellow

Jeffrey Pearlman
Research Assistant

Prepared for:
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RUTGERS
Edward J. Bloustein School of Planning and Public Policy

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EXECUTIVE SUMMARY

Introduction

This paper distinguishes between the concepts of street and roadway lighting and pedestrian lighting. Street or roadway lighting is designed primarily to satisfy the safety and driving comfort of motorists. Street lighting takes into account the illumination of intersections and designated crosswalks; however, the illumination of adjacent walkways, sidewalks, etc. is often a secondary consideration and this lighting might not sufficiently address pedestrian safety issues. Pedestrian lighting relates to how much light is required for the visibility of a pedestrian by a driver, the visibility by pedestrians of other pedestrians and their surroundings, and lighting that gives an overall sense of a comfortable and safe environment. In most cases, lighting for pedestrians is de facto street or roadway lighting. This paper examines approaches to the enhancement of lighting to better protect pedestrians.

This study investigated the current practice of pedestrian lighting design in the state of New Jersey. The study describes the existing requirements and standards for pedestrian lighting at the state, county, and local levels. Interviews with a number of individuals (stakeholders) involved in lighting produced greater understanding of how different participants contribute to the end products – the roadway and pedestrian lighting New Jersey citizens experience on a daily basis.

The study's aim is first to evaluate the current state of planning for the provision of adequate pedestrian lighting. Second, the paper reviews how pedestrian lighting is created in New Jersey, highlighting existing requirements and standards for pedestrian lighting on the local, county, and state levels and the extent to which different levels of government, as well as public agencies and utilities, work together to provide pedestrian lighting. Third, this work examines the technical challenges involved in the provision of pedestrian lighting and the roles that public utilities, professional lighting organizations, and other pertinent groups have in overcoming these challenges. Finally, the paper makes policy recommendations with the goal of identifying steps that New Jersey could take to improve lighting for the safety of its pedestrians.

Statistics

New Jersey encourages its citizens to lead more physically active lifestyles through walking. Safety is an important factor to address in meeting that goal. In 2002, 2.1 pedestrians per 100,000 were killed in New Jersey, a figure greater than the national average of 1.7 per 100,000. This constitutes the eighth highest fatality rate of all states for that year.[1] The risks are even greater for pedestrians at night. Of the 422 pedestrian fatalities that occurred in New Jersey over the 2001 to 2003 time period, 60 percent occurred under conditions of darkness.[2] The most apparent difference between day and night conditions on the road is the visibility of pedestrians. The distance motorists and pedestrians can see at night is significantly reduced when compared to daylight conditions. Roadway and pedestrian lighting is crucial to increase visibility at night. The Illuminating Engineering Society of North America (IESNA) estimates that three times more motor

[1]National Center for Statistics and Analysis (NCSA), *Traffic Safety Facts 2002: Pedestrian,* 2002.

[2] Pam Lebeaux and Meghan Fehlig, Parsons Brinkerhoff, Strategic Assessment: Pedestrian Safety Management: Analysis of NJ Pedestrian Fatality Data for 2001-2003. Memo to Sheree Davis, NJDOT. December 4, 2004.

vehicle accidents occur on unlighted roadways at night than on the same roadway during the day. Providing sufficient lighting is a response to counter limited visibility at night.[3]

Interestingly, NJ pedestrian fatality statistics show that the majority of NJ pedestrian fatalities occur at night with the streetlights on. These fatalities were further categorized according to three lighting conditions: streetlights on (47 percent), no streetlights (10 percent), and streetlights off (3 percent). These statistics indicate not only that pedestrians are at the most risk at night but, surprisingly, in areas which ostensibly have street lighting. Several factors might contribute to this phenomenon. One might be that lighting standards in New Jersey are primarily formulated from the perspective of the driver. "Street lighting," as it is currently implemented, might not meet the needs of pedestrians in New Jersey.

Standards

Roadway lighting for motorists is designed and installed by a variety of governmental entities, from the state government to local municipalities. These agencies can rely on reference manuals and technical documents for guidance when designing roadway lighting.[4] But for pedestrian lighting, there is no specific state manual or design guide, nor are there currently any standards for pedestrian lighting on state highways and roads. Moreover, there is no warrant to determine the need or desirability of pedestrian lighting in state- sponsored projects. As a result, pedestrian lighting in New Jersey is a by-product of lighting on roadways and private properties and is subject to the warrants for those applications. Thus, pedestrian lighting is implicitly governed by lighting manuals and requirements the lighting requirements established for roadways and adjoining land uses.

State, county, and local governments often use the lighting standards promulgated by professional associations in crafting their own lighting guidelines and standards. One such association, IESNA offers a number of lighting standards that affect roadway and pedestrian lighting: roadways (RP-8), bikeways and walkways (DG-5), security (G-1), parking (RP-20), and light trespass/pollution (RP-33).[5] Although there is some guidance on providing lighting for pedestrians in the context of street crossings and motor vehicle traffic, this information is fragmented over numerous documents which make it difficult to assimilate and use.

It should be emphasized that these standards *are not* written for the general public, but rather for lighting engineers, roadway lighting designers, architects and utility engineers. In addition, these standards are designed neither to give advice on construction nor do they provide guidance on the specifics of *when* to provide lighting beyond very general guidelines. Rather, the standards assume a decision has been made to provide lighting and that the standards will be used to help only to determine an appropriate lighting level. It is left to local decision makers to evaluate their needs and conditions to determine when and where lighting improvements should be implemented and what design is appropriate.

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[3] Illuminating Engineering Society of North America (IESNA), *American National Standard Practice for Roadway Lighting, ANSI/IESNA RP-8-00*. (New York: IESNA, 2000).

[4] NJDOT, Roadway Design Manual, 2002, http://www.state.nj.us/transportation/eng/documents/RDME/.

[5] IESNA. *Recommended Lighting for Walkways and Class I Bikeways, ANSI/IESNA DG-5-94*. (New York: IESNA, 1994).; Illuminating Engineering Society of North America (IESNA), American National Standard Practice for Roadway Lighting, ANSI/IESNA RP-8-00. (New York: IESNA, 2000).; IESNA, 2005, http://www.iesna.org.

Responsibilities

Responsibilities for pedestrian lighting are best examined by considering the three major jurisdictional levels: state, county, and municipal. At the state level, the New Jersey Department of Transportation (NJDOT) believes that pedestrian safety on state roadways is a shared responsibility between the state and local governments. NJDOT focuses on lighting for vehicles and streets, including intersections, but generally not sidewalk areas. In this context, NJDOT considers its roadway lighting warrants sufficient to meet the needs of both motorists and pedestrians.

The role of counties in providing lighting seems limited. Anecdotal evidence indicates that counties believe that the primary responsibility for providing lighting lies with the municipalities, although there are limited circumstances under which counties might get involved.

Most lighting is now provided at the municipal level. However, lighting for municipal streets is not regulated statewide and most municipalities have no formally adopted lighting standards. The result is a chaotic landscape of ad hoc lighting practices resulting in projects with varying levels of effectiveness. There is no commonly accepted standard by which the design and the efficacy of the lighting can be judged. The reasons for starting a lighting improvement project can vary amongst municipalities; the goals may differ as well as the end products.

Despite the fact that the utilities can serve the function of offering lighting infrastructure, construction, and maintenance services, the study found that electric utility companies play little role advising municipalities or the state as to pedestrian lighting. In addition, there appears to be little communication between utilities and government on lighting issues, beyond the engineering issues involved with installing fixtures and infrastructure. The electric utility industry represents an untapped resource for the advancement of an improved process for the provision of pedestrian lighting in NJ.

Findings

This report has four major findings.

1. The importance of understanding the distinct lighting needs of pedestrians is not well established among state agencies, county governments, or municipalities throughout New Jersey. Discussions with state, county and municipal officials repeatedly indicated that few officials account for pedestrian lighting issues when implementing roadway improvements. Many officials believe that current roadway lighting addresses the needs of pedestrians.
2. Roadway and pedestrian lighting standards are fragmented across levels of government and published standards. Lighting specifications exist at several levels of government, from the Federal Highway Administration's lighting standards, to the NJDOT Roadway Design Manual, to the multiplicity of local ordinances and downtown improvement district requirements. In addition, lighting designers utilize institutional standards, such as those published by the IESNA. Regarding pedestrian lighting, IESNA guidance is difficult to assemble.
3. Lighting standards published by institutional authorities are often for a professional audience and can seem esoteric to local officials and municipal employees who make lighting decisions and are therefore of limited use to them. In addition, guidance documents dealing with pedestrian lighting are scattered. Under most circumstances, the development of a lighting

design requires specialized knowledge. Most municipal officials and employees are not suitably trained in the specifics of lighting to use the available standards adequately.

4. Most municipalities lack guidance for planning pedestrian lighting. Such guidance would enable them to evaluate their own lighting practices and to assess how their stated goals shape designs. Without this guidance, municipalities have crafted lighting ordinances that are not based off of best practices and may result in poor lighting design. A key player missing in this exercise is the electric utility industry. The utilities possess expertise that could be of considerable value to municipalities, yet they have not been tapped as a resource.

Action in these four areas could improve pedestrian lighting conditions and could contribute to a reduction in pedestrian crashes.

Recommendations

In order to improve pedestrian lighting throughout the state, two separate issues must be addressed.

1. The importance of adequate pedestrian lighting must be made apparent to state, county and municipal leaders, as well as the electric utility industry. The primary goal of roadway lighting is to provide for the safety and comfort of motorists. Good roadway lighting can also provide adequate lighting for pedestrians, but it often does not. If improving pedestrian safety is a goal, then community leaders must understand that changes need to be made to the pedestrian lighting environment.
2. Community leaders must be given the tools necessary to create safe and comfortable pedestrian lighting environments. Lighting design is difficult to conceptualize as well as to execute successfully. Problems arise throughout the process, from the initial setting of goals and assessing existing lighting conditions to understanding lighting processes and designing solutions. Lighting standards must be made available and understandable for all those concerned.

In order to address both of these concerns the following should be considered:

1. Pedestrian lighting considerations should be made a mandatory consideration in the roadway design process at the state, county and local levels. Whenever possible, guidance on pedestrian lighting should be added to state, county and local roadway design guidance documents.
2. Increased funding should be earmarked for public education programs that encourage pedestrian safety as well as for educating municipal officials and engineers in lighting issues. Utilities should be encouraged to assist public agencies in this process.
3. The state, as a funder of local road improvements, should also recognize that the provision of well-designed pedestrian lighting is a vital component of the pedestrian infrastructure. As such, there needs to be increased awareness of the importance of pedestrian lighting. Pedestrian lighting should be considered eligible for funding like other pedestrian infrastructure improvements.
4. Professional lighting associations should be encouraged to consolidate and clarify best practices for pedestrian lighting.
5. Finally, the most significant need is for local officials and decision makers to be able to formulate planning goals for lighting and translate them into appropriate lighting design. A

"Planning for Lighting" guidance document could provide officials with this information. Such a document would stress the importance of pedestrian lighting and include a primer of lighting terminology, a compilation of technical standards, an illustrated listing of lighting hardware, illustrations of lighting installations, and, most importantly, a matrix of factors to be considered in lighting design. Elected and appointed officials, contractors, developers, and interested citizens would then be able to educate themselves using this document and thereby contribute to creating lighting goals for their community.

Next Steps

The following steps should be undertaken to advance the findings of this paper and to improve the understanding of the relationship between pedestrian safety and illumination.

1. The findings and recommendations made in this paper should be verified through focused meetings with a diverse group of lighting practitioners, electric utilities and other stakeholders. Conclusions from the meetings should direct follow-up research and data gathering.
2. A more inclusive workshop should be convened where the key stakeholders in providing lighting in New Jersey can discuss the creation of standards and guidance on pedestrian lighting. Staff of the Board of Public Utilities should be invited to this workshop. Such a discussion should clarify roles, identify gaps, and begin to improve the process by which pedestrian lighting is provided. Strategies should be generated with short and long term goals outlined on how to improve the process.
3. Case studies of best practices, both in New Jersey and nationally, should be researched so as to provide real world examples of policies and processes that have created good lighting.
4. After verification and amplification, this paper should be made available to all relevant New Jersey institutions and stakeholders who are involved in the provision of pedestrian lighting. This should be a first step in a greater campaign for educational opportunities on this topic.

1.0 Introduction

The state of New Jersey encourages its citizens to walk more and to lead more physically active lifestyles. However, the perceived and existing dangers associated with walking have to be addressed – the possibility of being involved in a vehicular accident is one consideration for our state's pedestrians. In 2002, 2.1 pedestrians per 100,000 were killed in New Jersey, a figure greater than the national average of 1.7 per 100,000. This constitutes the eighth highest fatality rate of all states for that year.[6] Along with driver and pedestrian education, and the provision of a complete and interconnected pedestrian network, the implementation and improvement of pedestrian lighting can enhance nighttime pedestrian safety. Making walking more secure and safe at night is a crucial step towards encouraging people to make more trips by foot.

The study's aim is first to evaluate the current state of planning for the provision of adequate pedestrian lighting. Second, the paper will review the way pedestrian lighting is created in New Jersey, highlighting existing requirements and standards for pedestrian lighting on the local, county, and state levels and the extent to which different levels of government as well as public agencies (e.g., energy utilities) work together to provide pedestrian lighting. Third, this work will examine the technical challenges involved in the provision of pedestrian lighting and the roles that public utilities, lighting organizations, and other pertinent groups have in overcoming these challenges. Finally, policy recommendations for New Jersey will be made. The goal is to show what New Jersey could do to improve pedestrian lighting and the safety of its pedestrians.

2.0 Reasons for Study

2.1 Background: Being a Pedestrian at Night is Dangerous

In the United States about 43,000 people are killed in traffic accidents each year. Pedestrians constitute about 11 percent of total traffic fatalities even though the modal share of pedestrian trips for all trips is only about 6 percent.[7] In fact being a pedestrian in the United States is more dangerous than in European countries. The possibility of being killed or injured as a pedestrian in a traffic accident is three to six times higher in the U.S. than in Germany and the Netherlands.[8]

In the year 2002 alone, 4,808 pedestrians were killed and 71,000 were injured in the United States. In other words, a pedestrian is injured every seven minutes and a pedestrian is killed every 109 minutes in a traffic accident in the US. Nearly all pedestrian deaths are caused by a crash involving a motorized vehicle. The vast majority of these pedestrian fatalities occurred in urbanized areas (71 percent) and at night (65 percent).[9] A substantial number of these crashes occurred at intersections. However, most of these crashes (78 percent) were in areas where drivers did not expect and did not see pedestrians entering the roadway, such as somebody entering the roadway from the side or a person appearing suddenly.[10] Hasson and Lutkevich state that in

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[6] National Center for Statistics and Analysis (NCSA), *Traffic Safety Facts 2002: Pedestrian*, 2002.

[7] NCSA, *Traffic Safety Facts 2002*.; John Pucher and Lewis Dijkstra, "Promoting Walking and Cycling to Improve Public Health." *American Journal of Public Health* 93, no. 9 (2003): 1509-1516.

[8] Pucher and Dijkstra, Promoting Walking.

[9] NCSA, *Traffic Safety Facts 2002*.; Patrick Hasson, Paul Lutkevich et al, "Field Test for Lighting to Improve Safety at Pedestrian Crosswalks." Parsons-Brinckerhoff Technical Papers, (2002), http://www.pbworld.com/library/technical_papers/pdf/19_FieldTest.pdf.

[10] Insurance Institute for Highway Safety, Fatality Facts 2003: Pedestrians, http://www.iihs.org/safety_facts/fatality_facts/pedestrians.htm#sec3

1998, 61 percent of all pedestrian fatalities occurred between 6 pm and 6 am.[11] The National Center for Statistics and Analysis found that in 2002, 30 percent of all pedestrian fatalities occurred between 8 pm and 11:59 pm.[12] These figures are surprisingly high. One would expect most pedestrian fatalities to occur during the day, when pedestrian traffic is higher, and not at night. The majority of walking trips are made during the day (e.g., for shopping, to and from work, etc.) whereas pedestrian traffic levels are the lowest at night.

2.2 Pedestrian Lighting and Safety

Pedestrian safety is a key issue in New Jersey that is related to safety and quality of life. Of the 422 pedestrian fatalities that occurred in New Jersey over the 2001 to 2003 time period, 60 percent occurred under conditions of darkness.[13] These fatalities were further categorized according to three lighting conditions: streetlights on, no streetlights, and streetlights off. Note that 47 percent of fatalities occurred with the ***streetlights on***.[14] These statistics indicate that pedestrians are at the most risk at night and, surprisingly, in areas which ostensibly have street lighting.

New Jersey Pedestrian Fatality Crashes by Lighting Condition, 2001-2003 [15]

Lighting Condition	Fatalities	Percent
Street Lights On	*200*	*47%*
Daylight	141	33%
No Street Lights	*43*	*10%*
Dawn or Dusk	20	5%
Street Lights Off	*14*	*3%*
Unknown	4	1%
Total	422	

Several factors might contribute to this phenomenon. One might be that lighting standards in New Jersey are primarily formulated from the perspective of the driver. “Street lighting” might not meet the needs of pedestrians in New Jersey as it is currently implemented. When considering the design of roadways and pedestrian safety, an understanding must be cultivated that street lighting does not equate to pedestrian lighting. Another factor might be that street lighting is placed in areas where there is a great deal of pedestrian activity and, because of this higher level of activity, is associated with a larger number of pedestrian accidents.

[11] Hasson, Lutkevich et al, Field Test for Lighting.
[12] NCSA, *Traffic Safety Facts 2002*.
[13] Pam Lebeaux and Meghan Fehlig, Parsons Brinkerhoff, Strategic Assessment: Pedestrian Safety Management: Analysis of NJ Pedestrian Fatality Data for 2001-2003. Memo to Sheree Davis, NJDOT. December 4, 2004.
[14] Noticably, although a large number of the pedestrian fatalities occurred where lights were on, the data does not specify if there was a sidewalk availble or if the pedestrian was walking in the road.
[15] Lebeaux and Fehlig, Strategic Assessment, p. 22

It is also interesting to note that 74 percent of fatal pedestrian crashes occur at non-intersection locations. Since most fatal pedestrian crashes occur at night and away from intersections where streetlights are on, it is fair to say that the current lighting standards used are either not properly implemented or do not provide sufficient guidance on how to make pedestrians visible at the edge of roadways, particularly mid-block or away from intersections.[16]

New Jersey Pedestrian Fatality Crash Locations, 2001-2003 [17]

Location	Fatalities	Percent
NOT at intersection	*314*	*74%*
At intersection	108	26%
Total	422	

Pedestrian fatality statistics do not give a complete picture of the danger that pedestrians and cyclists face. For the same time period, 2001 to 2003, more than 14,000 vehicle-pedestrian crashes occurred and more than 7,000 vehicle-cyclist crashes occurred. This data were not broken down according to time of day. However, it can be inferred that a similar distribution of daytime/nighttime crashes not resulting in a fatality exists.

New Jersey Motor Vehicle Accidents on Municipal, County, & State Road Systems (Excluding Toll Roads and Interstates), Involving Pedestrians and Cyclists, 2001-2003 [18]

Year	Total Accidents	Pedestrian	Percent	Pedicycle[19]	Percent
2001	245,719	4,909	2%	2,671	1%
2002	249,188	4,890	2%	2,543	1%
2003	250,182	4,856	2%	2,411	1%
Total	745,089	14,655	2%	7,625	1%

2.3 How can Adequate Lighting Help?

The purpose of lighting is to produce

> "*… quick, accurate and comfortable visibility at night. … Visibility may safeguard, facilitate and encourage vehicular and pedestrian traffic*"[20]

[16] Lebeaux and Fehlig, Strategic Assessment, p. 14
[17] Lebeaux and Fehlig, Strategic Assessment, p. 14
[18] State of New Jersey, Department of Transportation (NJDOT), Crash Records, 2005, http://www.state.nj.us/transportation/refdata/accident/.
[19] A pedicycle is a vehicle propelled solely by human-powered pedals.
[20] Illuminating Engineering Society of North America (IESNA), *American National Standard Practice for Roadway Lighting, ANSI/IESNA RP-8-00*. (New York: IESNA, 2000).

The most apparent difference between day and night conditions on the road is the visibility of pedestrians.[21] The distance drivers and pedestrians can see at night is significantly reduced when compared to the distance drivers and pedestrians can see during daylight. Roadway and pedestrian lighting is crucial to increase visibility at night. The Illuminating Engineering Society of America estimates that three times more accidents occur on unlighted roadways at night than on the same roadway during the day. Providing sufficient street lighting is a response to counter limited visibility at night.[22] Overall traffic engineers propose three main solutions for making walking safer: (1) separating pedestrians from cars, (2) enhancing visibility at night, and (3) reducing motorized speeds.[23]

Lighting standards for increased visibility have to be variable in order to accommodate different visibility requirements. Highways and major roads have different lighting requirements than local roads and pedestrian sidewalks. Urban areas require levels of lighting not needed in rural areas. High-frequency pedestrian land uses call for other lighting measures than would be used in predominantly low-density residential areas. IESNA has put forward several guidelines with recommended standards for lighting according to street categories and levels of pedestrian traffic volume.[24] These categories include freeways, expressways, major highways, collector and local streets as well as sidewalks, pedestrian walkways and bikeways. Additionally IESNA suggests lighting standards for areas with high, medium and low pedestrian traffic intersecting with streets.

This paper distinguishes between the concepts of street lighting and pedestrian lighting as well as between pedestrian lighting and pedestrian-scale lighting. Street or roadway lighting is designed primarily to satisfy the safety and comfort needs of motorists. Street lighting takes into account the illumination of intersections and designated crosswalks; however, the illumination of adjacent walkways, sidewalks, etc. is often a secondary consideration. Pedestrian lighting relates to how much light is required for the visibility of a pedestrian by a driver, the visibility by pedestrians of other pedestrians and their surroundings, and lighting that gives an overall sense of a comfortable and safe environment. In most cases, lighting for pedestrians is de facto street or roadway lighting, though it need not be. Pedestrian-scale lighting refers to the aesthetic qualities of lighting elements and the environment in which they are used. Pedestrian-scale lighting is a design factor that contributes to the "feel" of a place. Pedestrian lighting issues pertain to safety and comfort; pedestrian-scale lighting issues are a design subset pertaining to aesthetics.

2.4 Understanding the Basics of Lighting

Roadway lighting is designed and installed by a variety of governmental entities, from the state government to local municipalities. These agencies reference a few standard manuals and technical documents for lighting guidance when designing roadway lighting. An understanding of lighting terminology is necessary in order to achieve a greater understanding for how lighting

[21] It must be acknowledged that many nighttime traffic accidents are also connected to alcohol use of either the car driver or the pedestrian. Nevertheless it is more difficult for drivers to see a pedestrian entering the roadway from a dark area next to the road at night than it is during the day.
[22] IESNA, *American National Standard Practice*.
[23] Richard A. Retting, Susan A.Ferguson, and Anne T. McCartt. 2003. "A Review of Evidence-Based Traffic Engineering Measures Designed to Reduce Pedestrian—Motor Vehicle Crashes." *American Journal of Public Health* 93 (9):1456.
[24] IESNA, *American National Standard Practice*.

standards are applied. Essentially, **illumination** is the process by which light is used to see objects at a particular location. **Light** is created by the radiant properties of a lamp, be it a 40-watt light bulb or high-powered halogen lamp that is held by a luminaire or fixture. **Luminance** is the density of the light that is emitted by the lamp and is measured in lumens (lm). **Illuminance** is the measure of light that falls on a surface and is measured in foot-candles (fc) or lux (lx). (For a primer of general lighting terms, see Appendix B.)

2.4.1 Pedestrian Lighting Design Issues

A great many local governments seek to improve roadway lighting in order to increase vehicular and pedestrian safety, reduce crime, promote economic development or improve local aesthetics. A number of factors affect the quality of roadway lighting and can determine if the resulting lighting design meets the needs of both motorists and pedestrians. Lighting designers utilize four key lighting factors in their lighting designs.

- Lamp output—lamp type and wattage,
- Luminaire placement—the distance between luminaries,
- Adjusting the mounting or pole height of the luminaire, and
- Increasing the overhang of the luminaire.

Through the manipulation of these factors, lighting designers can achieve improvements in the overall lighting conditions and the safety of pedestrians.

2.4.2 Lighting Limitations

However, merely increasing the output or number of luminaires does not necessarily produce improvements in lighting. Other impacts must be considered when designing a roadway or street lighting scheme. Engineers, planners, and citizens have become increasingly aware of the negative consequences associated with merely increasing the number of lighting fixtures and/or their luminous intensities.

Too much lighting may fail to improve visibility
Photo: http://www.havells.com/streetlighting.htm

Exterior lighting installations that result in excessive luminous intensities create what is now known as light pollution. Simply put, light pollution is light with no "useful" purpose – waste energy.[25] Light pollution takes several different forms. These include:

- **Glare**—an intense and blinding light that causes discomfort and results in a reduction in one's ability to see. Glare is some-

[25] Crawford, 2004. "Bright Days, Dark Nights: Regulating Light." *Zoning Practice*. 21, no. 7 (2004): 2-8.

time referred to as ***veiling luminance***. Glare has the effect of decreased visibility and visual performance and is produced by areas of increased intensity in the visual field.

- **Light Trespass**—light that falls where it is not wanted or needed. Examples include light spilling into a yard or bedroom window from a nearby streetlight, business, or other residence.
- **Visual clutter and confusion**—light pollution caused by light coming either from too many brightly lit signs or from too many lights that result in an individuals' difficulty in differentiating objects, such as directional signs or traffic signal.
- **Artificial sky glow**—the artificial brightening of the night sky due to inefficient lighting fixtures that project light upward.

While the presence of these pollutants create a number of undesirable conditions, the problems associated with light pollution can, and do, have detrimental affects on pedestrian safety. Glare and visual clutter can contribute to the motorists' inability to identify and to prevent pedestrian-vehicle collisions. These conditions are exacerbated during periods of fog, mist, snow, or rain, all of which increase light reflection and reduce contrast. Ironically, improperly designed lighting can potentially reduce safety instead of improving it. Hence, it is important that lighting be designed by knowledgeable professionals.

3.0 Current State of Lighting Planning for Pedestrians in New Jersey

There is no separate manual or design guide specifically for pedestrian lighting in New Jersey. For the most part, pedestrian lighting in New Jersey depends on roadway lighting as well as lighting from private and commercial uses. Pedestrian lighting needs and requirements are therefore influenced by lighting warrants for roads and private uses along these roads. Thus, pedestrian lighting is implicitly dealt with by roadway lighting manuals and the lighting requirements established for land uses. The responsibility for New Jersey's streets is spread over three levels of government: the state of New Jersey maintains state highways, the counties administer county roads, and municipalities act with respect to local roads. Before any claims about pedestrian lighting can be made, the institutional arrangements for providing pedestrian lighting in these jurisdictions should be reviewed.

3.1.0 Lighting on New Jersey State Highways

A majority of pedestrian fatality crashes occurred on state roads and a majority of those occurred under the conditions of darkness. Among those pedestrian fatalities that occurred under dark conditions, 47 percent occurred on roads where streetlights were present and were on.[26] Therefore, improving the visibility of pedestrians may reduce the number of pedestrian fatalities on New Jersey's roads. While there is a guide to street lighting, there are currently no mandatory standards for pedestrian lighting on state highways and roads beyond the lighting called for at all signalized intersections. Moreover, there is no requirement to determine the potential need for pedestrian lighting in state sponsored projects. However, it should be noted that NJDOT intends on including a requirement to included pedestrian lighting at crosswalks at roundabouts when the new Roadway Design Manual is published.

3.1.1 Pedestrian Lighting and the NJDOT Roadway Design Manual (RDM)

Warrants for lighting on state highways in New Jersey are specified in Section 11 of the Roadway Design Manual published by the New Jersey Department of Transportation.[27] The standards are designed as a "guide in the design and planning of a highway lighting system" and the criteria specified should be followed as "closely as possible" to achieve its main goal: uniform lighting levels for roadways. The Roadway Manual incorporates lighting recommendations from the American Association of State Highway and Transportation Officials (AASHTO), the Federal Highway Administration (FHWA), and the Illuminating Engineering Society of North America (IESNA).

Pedestrian lighting is not explicitly mentioned in the Roadway Design Manual. However, one major conflict area between pedestrians and vehicles, the intersection, is touched on by the RDM in relation to illumination. The design guide states that signalized intersections must be illuminated. All non-signalized intersections must be illuminated if they meet any of the following conditions: (1) if one of the intersecting roads is a 4 lane highway, (2) if any right turn movement greater than 75 vehicles per hour, (3) if any left turn movement greater than 25 vehicles per hour per leg or (4) if through movement of 50 vehicles per hour in either leg.[28] Factors that relate to pedestrian travel and pedestrian needs such as the frequency of pedestrian traffic, land use factors, and the context of the area are not specifically mentioned as variables to be considered when determining the lighting warrant. However, NJDOT will conduct evaluations of pedestrian activity at intersections as needed.

At signalized intersections the standards for illumination for a potential crosswalk are .6 to .8 average maintained footcandles minimum. The area of illumination includes handicap ramps directly adjacent to the roadway. This minimum is the same illuminance level that is recommended for signalized intersections without marked crosswalks. Essentially, the same illumination level is required at intersections regardless of the presence or absence of marked crosswalks. The extent of illumination differs, however. For intersections with marked crosswalks, the lighting design area is required to provide illumination at all of the crosswalks at the intersection. The street lighting units that are used for roadways are the same ones that are used to illuminate crosswalks. The RDM does provide some flexibility as to the treatment of non-signalized crosswalks and

[26] Lebeaux & Fehlig, Strategic Assessment, p. 22
[27] NJDOT, Roadway Design Manual, 2002, http://www.state.nj.us/transportation/eng/documents/RDME/.
[28] NJDOT, Roadway Design Manual.

mid-block crosswalks on state highways. The RDM allows for variations in the lighting levels according to "specific conditions" in these areas. These conditions are to be evaluated on a case by case basis.

The warrants and lighting standards listed in the RDM are specific and are closely followed for intersections. NJDOT does have the flexibility to allow deviations from the set warrants established in the RDM. If a design has elements that are different from the standards in the RDM the proposed changes have to be "*detailed in writing*" by the designer and submitted to the DOT for review. Lighting designers must send in the warrants to justify their lighting project. They must also submit calculations and the spacing of luminaries. The electrical engineers of the Traffic Signal and Safety Engineering section of NJDOT review proposals, provide approval, or require the proposal to be resubmitted pending changes. Most roadway lighting plans submitted on the behalf of local governments are sent back for changes.

A common situation where this sort of review takes place is for roadway lighting that is defined by the Roadway Design Manual as "*non-functional historic replica lighting*" (section 11.09) and "*functional historical lighting*" (section 11.10). "Non-functional historic replica lighting" is typically used for aesthetic purposes, not for pedestrian safety. In historic or some downtown areas, a municipality may desire replica lighting for aesthetic reasons, which simulates the glow of a "gas lantern". For areas with security issues where higher lighting levels need to be met, "functional historical replica lighting" may be used. "Functional historical replica lighting" is also used for aesthetic purposes in historic and downtown areas.

Functional historical lighting on State Street, Chicago, IL
Photo: http://www.holophane.com/Case/Images/Statest1.jpg

Currently, standards for poles, arms, or luminaries for either functional or non-functional historic lighting, are not madated by the RDM. The RDM does not provide design guidance regarding these lighting types but does state that any lighting of this nature should avoid any potential glare, distraction, contrast, and visibility problem to both pedestrian and vehicular traffic.[29] In addition, the manual specifies that, "*This lighting shall be placed as far off the edge of the highway as possible, behind the sidewalk as a minimum. (…) The level of luminance on the highway shall not exceed 2.15 lux.*"

[29] John Nizolek, interview by Ranjit Walia and Jeffrey Perlman, February 2, 2005.

3.1.2 Conditions under which the NJDOT become involved in pedestrian lighting

NJDOT acts as the lead department for the design and repair of state highways and roads. As such, it addresses roadway lighting through its projects and controls state funding for lighting projects along state roadways. The department reviews pedestrian fatality statistics and evaluates the need for lighting. Though counties and municipalities may initiate pedestrian lighting projects along state roadways, and, thus, necessitate NJDOT involvement, local governments must adhere to NJDOT lighting guidelines or seek approval on a design that is not covered by the RDM. In addition, the department responds to requests by residents and investigates the need for additional roadway lighting.[30]

Generally, NJDOT does not involve itself in pedestrian lighting projects for pedestrian or bicycle activities that occur along a roadway. The department is primarily concerned with lighting roadway intersections where pedestrian traffic is likely and multiple conflict points exist. Exceptions do exist, however. The Route 18 multiuse path, part of the planned Route 18 widening in New Brunswick, is one such example.[31] In this case, the designers identified a need and NJDOT paid for the installation utilizing participating federal funds. For large projects such as the Route 18 improvements, the department usually contracts out lighting design and engineering to consultants while smaller projects are designed and engineered in-house.

According to sentiments derived through interviews, the NJDOT's prevailing philosophy is that pedestrian safety is a shared responsibility of both the state and local government with respect to a state roadway. NJDOT focuses on lighting the vehicle and street, typically regarding sidewalk areas to be municipal responsibilities. However, NJDOT does take responsibility for pedestrian lighting at signalized intersections. Although specific warrants for lighting are only called out for signalized intersections, NJDOT will provide on a case-by-case basis pedestrian lighting at overhead pedestrian bridges, mid-block crosswalks, and considers areas which may need attention where there is heavy pedestrian traffic. If pedestrian lighting is desired on a state roadway away from the intersection, it is likely that the locality making the request would have to fund these improvements. In this context, NJDOT considers its roadway lighting warrants sufficient to meet the needs of both motorists and pedestrians. In regards to pedestrian safety, NJDOT believes that pedestrian education is a critical component to reducing pedestrian fatalities on state roadways.

3.2 Lighting County Roadways

The management and improvement of county roadways rests with the department of public works and/or engineering in each of New Jersey's twenty-one counties. These departments initiate roadway and intersection design, develop plans for the improvement and signalization of county intersections, and maintain county roadways. Anecdotal evidence indicates that county departments consider improvements for pedestrians to be the responsibility of municipalities.[33] When specifically asked about lighting along county roadways, several county engineers re-

[30] Nizolek, interview.
[31] Nizolek, interview.
[33] Bergen, Hunterdon, and Middlesex counties were consulted.

sponded that pedestrian lighting has not been a consideration and that they had no warrant to provide lighting along county roadways or at intersections. In a few cases, lighting has been considered but only in the form of street lighting. County engineers indicated a willingness to work with a municipality should a request be made to improve lighting along county roadways. However, county officials could not recall any such request. A municipality would need to request the use of the county right-of-way and coordinate with the county to provide pedestrian lighting.

A statewide survey of New Jersey counties should be completed to determine what, if any, pedestrian lighting projects have been initiated by counties.

3.3 Municipal Level – Pedestrian Lighting

Generally, municipalities do not have formally adopted lighting standards. If it is determined that lighting is desirable, the project is investigated and tailored on a case-by-case basis. Lighting for municipal streets is not regulated statewide. The result is a chaotic landscape of ad hoc lighting practices resulting in projects with varying levels of effectiveness. There is no commonly accepted standard by which the design and the efficacy of the lighting can be judged. The reasons for starting a lighting improvement project can vary amongst municipalities; the goals may differ, as might the end products. The issues surrounding the identification and implementation of roadway and pedestrian lighting are described below.

3.3.1 Municipal Planning for Better Pedestrian Lighting

Municipalities have the power to choose how much light will be on their streets and the method by which that light will be provided. There are several ways in which municipalities can affect the provision of lighting in their locality. Planning and zoning boards are typically the municipal bodies that have an impact on lighting on local streets. These boards accomplish this through subdivision ordinances and site plan review.

In addition, a muncipality might include lighting goals in its comprehensive master plan. Municipalities that include circulation, roadway, or utility elements in their master plans might make reference to where street lighting is desirable and can recommend appropriate lighting schemes for identified areas. Circulation elements, however, are one of several discretionary components in master plans and are often not developed by communities in New Jersey. Since the master plan is a guiding document for a community and can be used to set goals and assess community needs, lighting goals set forth in the master plan can have a great impact on the provision of lighting in a municipality.[34]

Another tool that municipalities use to set lighting standards is the municipal ordinance. Lighting ordinance defines where lighting is required and how bright the light can be but does not address *how* to provide the mandated lighting. In typical municipal ordinance, pedestrian lighting is not explicitly required. Rather, lighting is addressed through street and commercial lighting requirements in ordinances related to storefronts and parking lots.[35]

[34] Carl Peters, interview by Ranjit Walia and Jeffrey Perlman, March 10, 2005.
[35] Peters, interview.

In many instances, lighting ordinances do not come into play except when applied to a major subdivision. This is because major subdivisions tend to have utility upgrades, where lighting standards might be included. Minor subdivisions are less likely to require utility upgrades, and therefore, lighting requirements. It is interesting to note that standards for major subdivisions are guided by Residential Site Improvement Standards (RSIS) for New Jersey municipalities.[36] When these standards are consulted for lighting requirements (5.21-4.11 Street and Site Lighting) the RSIS says "RESERVED". When "RESERVED" appears in this context it means that the RSIS does not provide guidance and that local ordinance will govern on the issue until an "authoritative" source is adopted and the RSIS standards are revised. Essentially, municipal ordinance currently governs lighting requirements in relation to major subdivisions. Since pedestrian lighting is typically not addressed directly by municipal ordinance, pedestrian lighting is usually not considered. The RSIS only applies to residential development. The RSIS would not govern in roadway and pedestrian lighting improvements that might be desirable in non-residential projects.

Another means by which a municipality might provide pedestrian lighting is through capital improvements. For instance, the Borough of Princeton has used infrastructure improvements, such as replacing curbs and repairing sidewalks, as an opportunity to address street lighting issues.[37]

Lighting can be, and often is, addressed outside of ordinances. Lighting can be integrated into development and redevelopment plans. Typically, lighting can be found as a component in downtown improvements. Lighting is often found to be desirable for aesthetic reasons or deemed necessary due to anticipated pedestrian volumes in commercial areas. Municipalities most often pursue lighting improvements for their downtowns as a way to enhance economic activity and vitality of their downtowns. When lighting is provided in this fashion, it is often limited to the scope of the improvement plan and is not part of a broader policy on pedestrian lighting. Some communities in New Jersey provide dedicated pedestrian lighting beyond downtown and commercial areas, but this is the exception rather than the rule. The Borough of Princeton is one such example as it has extended its pedestrian lighting improvements beyond the main commercial district into some adjacent residential neighborhoods.

Municipalities that engage in a roadway or pedestrian lighting project may do so with various goals and objectives in mind. These goals may include improving the aesthetic quality of their downtown, providing better security to pedestrians, or reducing the number of collisions between motorists and pedestrians. For example, the Borough of South Bound Brook sought to increase economic development opportunities in their downtown through physical improvements and published a visioning document for enhancing their downtown. Among the infrastructure enhancements planned were streetscape improvements that included street lighting. South Bound Brook's motivation towards street lighting design was to increase the quality of nighttime environment and to guide pedestrians and motorists through the borough's center.[38] The borough also utilized aesthetic lighting design to enhance building facades and civic structures.

Other municipalities, such as the Borough of Princeton, specifically considered pedestrian lighting requirements in their street lighting efforts. In particular, the borough focused upon pedes-

[36] State of New Jersey, Department of Community Affairs, Residential Site Improvement Standards, 2005, http://www.nj.gov/dca/codes/nj-rsis/sc1.shtml.
[37] Peters, interview.
[38] LDR International, A Vision Plan for Canal Road and Main Street: South Bound Brook, March 28, 2001.

trian security, the cost of electricity, and light trespass issues.[39] Residents raised concerns that sidewalks were dark along certain borough streets. The borough strove to enhance pedestrian lighting through its lighting improvements on Witherspoon, Nassau, and Chambers streets. Their goal was to better illuminate the sidewalk and improve pedestrian safety.[40]

When a community engages in a lighting project, the responsibility to generate the lighting design or plan rests with the municipality. Typically, municipalities lack the technical experience to establish the criteria needed to develop satisfactory lighting designs. They are therefore unable to effectively evaluate their needs or to formulate and express their goals. Depending on the goal, the approach to the lighting scheme and the final product will vary. Without a goal in mind, there is no measure by which the product can be compared.

When implementing a project, the municipality may choose to rely on its own engineering department, typically for smaller lighting design projects or contract with professionals for larger streetscape projects. When working with a professional lighting designer, the borough sets the scope of work and determines the goals of the lighting design. The municipal governing body is responsible for awarding the design contract. In addition, it has final design approval, but may delegate that responsibility to its engineer. Lighting plans for the Boroughs of South Bound Brook and Princeton were created through contracts with professional lighting engineers and consultants.

Once the municipality has a lighting design, it can approach the utilities for implementation. The utilities' role is to inform the municipality about the types of lighting infrastructure available and to construct infrastructure according to submitted designs. If a municipality wishes to use lampposts, fixtures, etc., that the utility does not offer, it can work with independent vendors for the provision and construction of the lighting. The utility will then provide metered power.

3.4 Institutional Standards and Guidance

Roadway lighting standards are determined by a number of institutional authorities. These authorities include Illuminating Engineering Society of North America (IESNA), American Association of State Highway and Transportation Officials (AASHTO), and the Lighting Research Center (LRC). State, county, and local governments often use the lighting standards promulgated by these authorities in crafting their own lighting guidelines and standards.

3.4.1 Illuminating Engineering Society of North America (IESNA)

IESNA is an internationally recognized technical authority on illumination. The mission of IESNA is to advance the knowledge, dissemination, and education of people for the advancement of the lighted environment to the benefit of society.[41] It does so through the contribution of its diverse membership including engineers, architects, designers, educators, students, contractors, distributors, utility personnel, manufacturers, and scientists. Through its technical committees, IESNA correlates research, investigations, and discussions to guide lighting experts and

[39] Light trepass is a form of light pollution in which light falls where it is not wanted or needed. See page 5 for a discussion of light pollution.
[40] Peters, interview.
[41] Rita Harrold, interview by Ranjit Walia and Jeffrey Perlman, March 3, 2005.

laypersons via consensus based lighting recommendations. The society publishes a variety of publications including recommended practices for applications, design guides, technical memoranda, and publications on energy management and lighting measurement. The society works cooperatively with related organizations on a variety of programs and in the production of jointly published documents and standards. While it responds to requests for information from other agencies, IESNA is a technical organization and not a professional society. IESNA does not deal with professional issues, such as the creation of lighting designs or providing case specific advice or plans.

IESNA is a member of the American National Standards Institute (ANSI), and thus authorized to publish lighting documents and standards.[42] This is conducted through establishing committees, composed of a diverse and balanced membership including users, producers, utilities, and laypeople. A rigorous process is conducted in establishing lighting standards. Content for lighting documents are derived from deliberation among its members. Other institutional authorities and government agencies participate in these expert committees such as AASHTO and FHWA. The aim is to promote cross-pollination of ideas between the various institutions. Field studies are sometimes conducted as well as specific studies for establishing lighting standards. Lighting standards are iterative, and build upon the earlier publications. If IESNA lighting standards are not changed, then the current standards are re-affirmed.

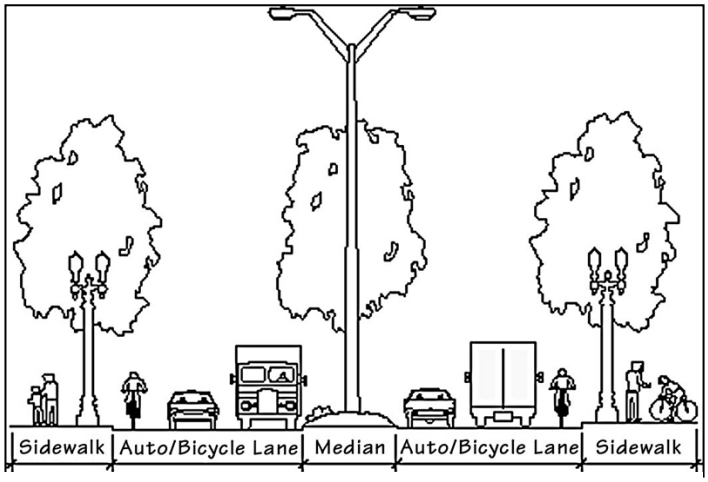
IESNA covers a wide array of lighting concerns – indoor and outdoor, from residences to airports. A variety of lighting standards exist. Lighting standards that affect roadway and pedestrian lighting exist for roadways (RP-8), bikeways and walkways (DG-5), security (G-1), parking (RP-20), and light trespass/pollution (RP-33). It should be emphasized that these standards *are not* written for the general public, but written to be used by lighting engineers and roadway lighting designers as well as architects and utility engineers. *In addition, these standards are not designed to give advice on construction, nor do they provide advice on when to provide lighting beyond very general guidelines*. Rather, the standards assume a decision has been made to provide lighting and that the standards will be used to help determine an appropriate lighting level. Local decision makers or their agents are responsible for decisions that lighting is to be provided by evaluating local needs and conditions to determine when and where lighting improvements should be implemented.

3.4.2 IESNA recommendations for roadway lighting

Published in 2000, the RP-8-00 for Roadway Lighting serves as a guide for the design of fixed lighting for roadways, adjacent bikeways, and pedestrian ways and is the most commonly referenced IESNA publication. This revision, the first in 17 years, represents an attempt by the IESNA to incorporate pedestrian lighting needs into its roadway lighting recommendations.[43] Previous versions of the RP-8 focused only on the roadway surface and a driver's ability to see obstructions and hazards. In this latest version, the entire right of way is examined, including pe-

[42] The American National Standards Institute (ANSI) is a private, non-profit organization (501(c)3) that administers and coordinates the U.S. voluntary standardization and conformity assessment system. ANSI facilitates the development of these standards by accrediting the procedures of member organizations.

[43] Paul Lutkevich. "It's Time to Look Beyond the Roadway: New Lighting Standards." *PB Network* issue no. 49, vol. 15, no. 1 (March 2001): 35-36. http://www.pbworld.com/news_events/publications/network/issue_49/49_15_LutkevichP_TimeLookBeyond.asp March 2001.



Pubic Right-of-Way between Property Lines
Figure: IESNA, *American National Standard Practice*

destrian zones. IESNA's new lighting standards attempt to integrate pedestrian needs into roadway lighting by recommending standards that allow the motorist to view objects such as parked cars and pedestrians. These standards are also intended to provide pedestrian and security lighting as well as overall aesthetic improvements.[44]

In order to provide for pedestrian needs, IESNA specifies three distinct criteria (or methods) for determining roadway lighting: illuminance, luminance, and small target visibility. The Roadway Lighting guide provides an additional set of design criteria for the lighting of streets with pedestrian sidewalks and/or bikeways. Separate lighting specifications are provided for pedestrian bridges, underpasses, and mid-block crosswalks as well as for intersections. To correctly apply each of these methods, the designer must be knowledgeable about roadway, pedestrian walkway, and bikeway classifications as well as pedestrian conflict area and pavement classifications. Lighting designers need to be well versed in all of these methods and to know when a particular method is to be applied. IESNA *does not specify* which of these methods is to be applied or what criteria a designer might use to choose amongst the methodologies.[45]

These new standards are remarkable given that previous IESNA roadway lighting standards did not address adjacent sidewalks and bikeways. In an earlier publication, DG-5-94, IESNA promulgated lighting standards for separate walkways and Class I Bikeways but offered none specifically for walkways adjacent to roadways. In that document, IESNA stated "spillover light … may not produce the proper quality or quantity of light for comfort and safety of the pedestrians or cyclists."[46] Lighting designers were supposed to reference and reconcile the specifications of both the Roadway Lighting (RP-8) and the Walkways and Class I Bikeways (DG-5) documents.

The more recent IESNA roadway lighting standards attempt to incorporate the standards for adjacent walkways directly into the document. This effort illustrates a growing recognition that pedestrian needs are an important consideration when recommending lighting standards. Still this document does not address all the light-

[44] IESNA, *American National Standard Practice*.
[45] IESNA, *American National Standard Practice*.
[46] Illuminating Engineering Society of North America (IESNA), *Recommended Lighting for Walkways and Class I Bikeways, ANSI/IESNA DG-5-94*, (New York: IESNA, 1994.)

ing needs of pedestrians and cyclists. It is primarily interested in the pedestrians and cyclists that enter into the roadway. Other standards besides RP-8-00 deal with pedestrian needs along sidewalks. For example, vertical lighting, which is important for establishing adequate pedestrian lighting, is covered in G-1 lighting standards, not in RP-8-00 or in DG-5. Even with these additional lighting standards, IESNA does not tell lighting designers ***how*** to provide adequate pedestrian lighting. This requires the technical expertise and experience of the lighting designer to adequately integrate the multiple standards into a lighting design.

3.5.1 Utilities and Street Lighting

Primarily, utilities provide power, electricity and gas, to communities. In addition, they provide lighting infrastructure and are responsible for the construction and maintenance of that infrastructure. Given this, municipalities often turn to utilities for assistance with making lighting improvements.

The role of utilities is limited. When asked by a community, utilities such as Public Service Electric and Gas (PSE&G), can measure existing light levels. However, utilities will not define the desired light levels for a municipality and, as such, do not specify how roadway and pedestrian lighting should be provided. Moreover, utilities do not have their own set of pedestrian lighting guidelines, neither for pedestrian visibility by motorists nor for pedestrians to see their surroundings.[47] In general, municipalities through their ordinances define the outdoor light levels desired. Those levels vary; some communities want a lot of light, others want their streets to be more dimly lit.

A mix of pedestrian lighting and street fixtures in South Bound Brook, NJ
Photo: VTC

In general, utilities provide poles and lamps, charging a flat rate per light to the community, the county, or the state for these un-metered applications. Utilities, normally, will specify cobra-head style lamps. However, they also offer other poles and lamps, each with different characteristics concerning energy efficiency, aesthetics, and costs. Utilities supply and maintain the lamps and posts provided. Many municipalities and developers choose these or other architecturally appropriate lighting, particularly in areas with heavy foot traffic. When municipalities install their own lighting infrastructure, utilities serve only as power suppliers. These are metered applications and municipalities pay according to the amount of electricity used.

When seeking additional luminaires, a municipality can request that the utility conduct a survey of an area to determine if supplementary lighting is needed to meet local demands. On occasion municipalities have requested that additional luminaires be added to utility poles. Likewise, municipalities can ask utilities to remove fixtures from intersections if they are to be replaced by different lighting.[48] In general, no additional lighting devices may be added to existing utility

[47] Jim Shipman, interview by Ranjit Walia, August 12, 2004
[48] Shipman, interview.

poles without municipal request and utility approval. However, municipalities are free to install their own poles for pedestrian lighting, which would then be metered. In new residential developments, homeowner associations may install their own poles and lamps. The utility would only serve as a power provider in those cases.

Typical cobra-head street fixture
Photo: http://vernon.ca/services/public_works/images/street_lighting.jpg

3.5.2 Lighting Manufacturers

Municipalities generally contract with consulting companies or major lighting manufacturers for design assistance with their lighting system. For example, General Electric (GE) offers consulting services for lighting design and lamp fixture selection. GE engages in consulting service opportunities through their regional sales representatives, whose clients may be either municipalities or contractors. Sometimes, municipalities will ask utilities for assistance and these utilities will make use of GE's services. GE will also design complete lighting projects for businesses, parking lot designs, for example.

Luminaire added to existing utility pole
Photo: http://www.parkdaleliberty.com/frames/projects/liberty_improvment_project.html

The lighting design process, as explained by a GE representative, is not typically a collaborative process. Municipalities state their goals and GE lighting designers apply a number of different software packages to develop a lighting design. GE is responsible only for the design, not for the determination of goals. They do not aid municipalities in understanding the community issues associated with a street lighting design. Often, municipalities desire lighting systems that minimize spill lighting (light pollution), but which do not meet IESNA standards.[49] While municipalities often have a specific lighting goal in mind, they may not know of other issues that conflict with this goal. For example, a municipality interested in aesthetic street lighting may request a lighting design that would result in increased glare

[49] Richard Owens, interview by Ranjit Walia and Jeffrey Perlman, March 16, 2005.

to the motorist. It is often the case that the goals are not very specific but more along the lines of a general directive. For instance, “we want downtown lighting.”

During the design process, a sale representative may discuss specific lighting issues with a municipality. In many cases, however, preexisting municipal lighting ordinances are poorly constructed and can result in poor roadway lighting. In these cases, GE will design a lighting scheme according to the municipality’s ordinances, but will inform the municipality that its lighting ordinances are poorly constructed and should be re-examined. Some municipal ordinances specify mounting heights and lamp wattages. These specifications limit the options available to a lighting designer. If no lighting ordinance exists, then the lighting designer adheres to IESNA standards. For example, GE will often use RP-8-00, RP-20, and RP-33 IESNA standards in completing a lighting design. GE does not have its own lighting standards.

At times there are issues not taken into account in the lighting design. For example, installation issues are often not discussed when establishing a lighting design. Underground utilities are rarely acknowledged when deciding luminaire placement. Moreover, lighting designs do not consider light from commercial buildings or light blocked by street trees. Therefore, a lighting design may produce more or less light than requested by a municipality. Ambient light is not considered in design, unless municipalities specifically provide information about current lighting conditions. GE does not conduct a current site assessment prior to beginning a lighting design.

Although municipalities increasingly review the costs associated with street lighting as they attempt to keep electricity costs down, an evaluation of maintenance requirements is not considered part of the design process. Lighting designers do not conduct economic analyses of lighting designs. Rather, it is the function of sales representatives to draft maintenance plans associated with lighting designs.

4.0 Findings and Recommendations

This report has four major findings.

1. The importance of understanding the distinct lighting needs of pedestrians is not well established among state agencies, county governments, or municipalities throughout the state. Discussions with state, county and municipal officials have indicated that few, if any, officials even account for pedestrian lighting issues when implementing roadway improvements. Many officials believe that current roadway lighting addresses the needs of pedestrians.
2. Roadway and pedestrian lighting standards are fragmented across levels of government and published standards. Lighting specifications exist across several levels of government, from the Federal Highway Administration’s lighting standards, to the NJDOT Roadway Design Manual, to the multiplicity across New Jersey of local ordinances and downtown improvement district requirements. In addition, lighting designers utilize institutional standards, such as those published by the IESNA. Regarding pedestrian lighting, IESNA guidance can be found in a variety of their documents. This makes it difficult to easily access and reference relevant guidance. It also makes it more challenging to understand the links and tradeoffs between different purposes for pedestrian lighting and

how to provide it. For example, security vs. aesthetics, lighting for off-road facilities vs. on-road facilities, etc.

3. Lighting standards published by institutional authorities are intended for a professional audience and can seem esoteric to local officials and employees who make lighting decisions and are therefore of limited use to them. In addition, guidance documents dealing with pedestrian lighting are scattered. Under most circumstances, the development of a lighting design requires specialized knowledge. Most municipal officials and employees are not suitably trained in the specifics of lighting to use the available standards adequately.
4. Most municipalities lack guidance for planning pedestrian lighting. Such guidance would enable them to evaluate their own lighting practices and to assess how their stated goals shape designs. Without this guidance, municipalities have crafted lighting ordinances that are not based on best practices and may result in poor lighting design. A key player missing in this exercise is the electric utility industry. The utilities possess expertise that could be of considerable value to municipalities, yet they have not been tapped as a resource.

Action in these four areas could improve pedestrian lighting conditions and could contribute to a reduction in pedestrian crashes.

In order to improve pedestrian lighting throughout the state, two separate issues must be addressed.

1. The importance of adequate pedestrian lighting must be made apparent to state, county and municipal leaders, as well as the electric utility industry. The primary goal of roadway lighting is to provide for the safety and comfort of motorists. Good roadway lighting can also provide adequate lighting for pedestrians, but it often does not. If improving pedestrian safety is a goal, then community leaders must understand that changes need to be made to the pedestrian lighting environment.
2. Community leaders must be given the tools necessary to create safe and comfortable pedestrian lighting environments. Lighting design is difficult to conceptualize as well as to execute successfully. Problems arise throughout the process, from the initial setting of goals and assessing existing lighting conditions to understanding lighting processes and designing solutions. Lighting standards must be made available and understandable for all those concerned.

In order to address both of these concerns the following should be considered:

1. Pedestrian lighting considerations should be made a mandatory part of consideration in the roadway design process at the state, county and local level. Whenever possible, guidance on pedestrian lighting should be added to state, county and local roadway design guidance documents.
2. Increased funding should be earmarked for educational programs that encourage pedestrian safety as well as for educating municipal officials and engineers in lighting issues. Utilities should be encouraged to assist public agencies in this process.

3. The state, as funder of local road improvements, should also recognize that the provision of well designed pedestrian lighting should be seen as a vital component of the pedestrian infrastructure. As such, there needs to be increased awareness of the importance of pedestrian lighting. Pedestrian lighting should be considered eligible for funding like other pedestrian infrastructure improvements.
4. Professional lighting associations should be encouraged to consolidate and clarify best practices for pedestrian lighting.
5. Finally, the most significant need is for local officials and decision makers to be able to translate planning goals for lighting into appropriate lighting design. A "Planning for Lighting" guidance document could provide officials with this information. Such a document would stress the importance of pedestrian lighting and include a primer of lighting terminology, a compilation of technical standards, an illustrated listing of lighting hardware, illustrations of lighting installations, and, most importantly, a matrix of factors to be considered in lighting design. Elected and appointed officials, contractors, developers, and interested citizens would then be able to educate themselves using this document and thereby contribute to creating lighting goals for their community.

4.1 Importance of Pedestrian Lighting

Discussions with state, county, and municipal officials have indicated that few officials consider pedestrian lighting issues when implementing roadway improvements. Most officials interviewed believe that current roadway lighting provides adequate lighting for pedestrians. State DOT officials and the NJDOT Road Design Manual (RDM) indicate that pedestrian lighting is not explicitly required, except at intersections and crosswalks. Intersections and crosswalks are lighted so that motorists can see pedestrians as they enter the vehicular zone. These locations are not, however, the only places where pedestrian fatalities have occurred. A large number of pedestrian deaths occur away from intersections, in locations that have not been addressed by recent roadway lighting practices.

Slowly the lighting needs of pedestrians are being recognized. The most recent edition of the IESNA's roadway lighting standards acknowledges that lighting designers should consider the needs of pedestrians in the entire right of way, not only intersections and crosswalks.[50] The RDM is currently undergoing revisions. Lighting recommendations from AASHTO, IESNA, and FHWA are to be incorporated.[51] This message needs to be reinforced. State, county, and municipal officials need to be made aware of the lighting needs of pedestrians.

4.2 Fragmented lighting standards

This study did not evaluate any one municipality in terms of its roadway and pedestrian lighting designs or how these designs might affect pedestrian safety. However, there is a general agreement that improvements in lighting could enhance the safety and comfort of pedestrians in our

[50] IESNA, *American National Standard Practice.*
[51] Nizolek, interview.

state. Lighting specifications exist across several levels of government, from the Federal Highway Administration's lighting standards, to the NJDOT Roadway Design Manual, to the multitude of lighting ordinances and downtown improvement districts' lighting provisions that exist in many municipalities across the state. In addition, lighting designers utilize institutional standards, such as several published by the IESNA.

Given this assortment of lighting recommendations, municipalities are often at loss as to which standards apply to their situation. Many municipal officials do not have the technical background to choose amongst the numerous and, at times, contradictory lighting standards. They lack a clear guide as how to evaluate their lighting needs and thus how to determine their goals. Without straightforward guidance, the likelihood of municipal officials making improvements to local pedestrian lighting or to implement appropriate pedestrian lighting ordinances for their communities is diminished.

4.3 Lack of Technical Proficiency

According to an IESNA representative, poor lighting is often a product of ill-considered design. Government entities, such as municipalities, rely upon professionals they already have established relationships with rather than seek out those with training in lighting design. Under most circumstances, the development of a lighting design requires specialized knowledge. Most municipal engineers are not suitably trained in the specifics of lighting to use the available standards adequately. Rather, municipalities should consider hiring a consulting engineer, trained in lighting issues, to apply the various lighting guidelines.[52] Municipal engineers interviewed for this study also made this recommendation.

In most cases, the problem does not appear to be a lack of awareness that IESNA standards exist, but a lack of technical proficiency. This lack of technical proficiency often results in the ineffective application of IESNA standards. According to an IESNA representative, the design of roadway lighting, which incorporates pedestrian, energy, and light trespass issues, requires the integration of more than one lighting design document. For a downtown lighting project, a municipality must consult DG-5 (lighting standards for bikeways and walkways), RP-8-00 (roadway lighting), G-1 (security lighting), RP-20 (for parking), and RP-33 (light trespass/ pollution). Moreover, these different lighting standards are not in complete agreement with each other.[53] There are variations among the recommendations and, at times, contradictions. For example, specific lighting standards exist for "moving" merchandise – i.e., gas stations. The lighting standards for this application are different than ones designed to minimize light trespass. Implementing a good lighting design requires the professional lighting engineer to choose amongst the lighting standards in these documents to best meet the needs of the client. This requires more than the simple application of a standard or calculation to determine a high quality lighting design.

[52] Harrold, interview.
[53] Harrold, interview.

4.4 Planning Guidance for Lighting

Municipal officials choose to improve lighting for a number of reasons: pedestrian safety and comfort, downtown improvement, aesthetic goals, etc. Their fundamental objective may be clear— additional lighting in a downtown or along roadways well used by pedestrians—but translating these objectives into reality is difficult. They are not lighting experts—nor should they be. Improvements in pedestrian lighting will only occur when lighting information is presented in a form that is understandable to these officials and a wider audience.

While IESNA standards are comprehensive and do acknowledge pedestrian needs, these standards are written for lighting professionals who possess a high degree of technical proficiency. Lighting professionals apply these standards capably and produce high quality lighting designs. However, these designs will inevitably reflect the lighting goals set by the community. Communities and their leaders there must understand the myriad factors involved in setting lighting goals.

The standards published by IESNA as well as those included in the Roadway Design Manual do not provide the information necessary for determining lighting goals. Communities need assistance with the formation of these goals just as they do with the formation of designs that satisfy those planning goals. While, municipal officials and engineers, as well as those on the county level, need access to lighting design concepts, they also need ways of understanding how planning for lighting will affect lighting design and ultimately the illuminated environment. A comprehensive planning guide for pedestrians lighting requirements could satisfy many of these needs.

5.0 Recommendations

In order to improve pedestrian lighting throughout the state, two separate issues must be addressed.

1. The importance of adequate pedestrian lighting must be made apparent to state, county, and municipal leaders. The primary goal of roadway lighting is to provide for the safety and comfort of motorists. Good roadway lighting can also provide adequate lighting for pedestrians, but it often does not. If improving pedestrian safety is a goal, then community leaders must understand that changes need to be made to the pedestrian lighting environment.
2. Community leaders must be given the tools necessary to create safe and comfortable pedestrian lighting environments. Lighting design is difficult to conceptualize as well as to execute successfully. Problems arise throughout the process, from the initial setting of goals and assessing existing lighting conditions to understanding lighting processes and designing solutions. Lighting standards must be made accessible for all those concerned.

In order to address both of these concerns, the following recommendations are offered. Improvements to pedestrian lighting can be achieved through a combination of changes in policy, educational efforts, and design guidance. This study makes the following recommendations:

5.1 Pedestrian Lighting and Roadway Design

Pedestrian lighting considerations should be made a mandatory part of the roadway design process. The importance of pedestrian lighting issues must be promoted. This study is part of a larger effort to draw attention to the importance of adequate lighting in making safer environments for pedestrians.

The newest revision of the Roadway Design Manual (RDM) should explicitly include pedestrian lighting standards and design guidance. These pedestrian lighting standards should draw upon IESNA standards, incorporating recommendations from all applicable publications.

5.2 Education

Increase funding for educational programs that encourage pedestrian safety. Pedestrians should be encouraged to walk in lighted areas and to cross at established crosswalks when possible.

Increase educational opportunities for municipal officials and engineers. This could be provided through state sponsored training programs or through financial assistance to defray the costs of privately provided training. Major lighting manufacturers, such as General Electric, currently provide "on-site lighting design training" for large clients to educate engineers about lighting designs principles, the use of lighting software, and to perform simple calculations.[54]

A planning document should be published that educates counties and municipalities about the need for pedestrian lighting. The document should establish a clear set of standards and recommend ways to achieve good pedestrian lighting design.

5.3.1 Lighting as a Pedestrian Safety Measure

Lighting should be viewed as a key pedestrian safety measure, not just a secondary enhancement. Typically physical improvements for increased pedestrian safety have been limited to sidewalks, barrier curbing, bulb-outs, median pedestrian refuges, etc. Lighting should be considered an equally important pedestrian safety measure. Clearly, statistics show that pedestrians are at greatest risk under conditions of darkness. An understanding of pedestrian lighting, as well as how and when to provide it, would be a considerable advance in transportation planning. Encouraging the construction of well-designed pedestrian lighting would be a great benefit to pedestrian safety.

Transportation agencies that provide funding for pedestrian improvements should consider including pedestrian lighting on the menu of options they are willing to fund when making such improvements. It is important that both communities and transportation agencies in New Jersey recognize the importance of lighting as a key safety measure, and not simply an aesthetic improvement. Education on this concept is necessary and its importance to pedestrian planning and safety must be emphasized.

[54] Owens, interview.

5.4 Planning for Lighting

The most significant need amongst local officials is an ability to translate planning goals into appropriate lighting design. In order to do this, they need assistance with a whole range of lighting issues. To provide this assistance, a "Planning for Lighting" guidance document should be researched, published, and disseminated. Elected and appointed officials, contractors, developers, and interested citizens should be able to educate themselves using this document and thereby contribute to creating lighting goals for their community. Elements of the document might include:

- An introduction to pedestrian lighting, educating readers as to the importance of lighting for pedestrian needs;
- A technical primer or "ABC's of Lighting";
- A compilation of technical standards drawn from IESNA's diverse documents. This should include descriptions and applications of each standard;
- An illustrated compilation of lighting hardware explaining purpose, appropriate use, and criteria for selection;
- Illustrations of lighting installations. These examples should document lighting goals, design intentions, and final products. It is essential to include nighttime photos that graphically illustrate the effect of different light levels on visibility.
- A schematic list or matrix of factors to be considered in lighting design and the importance of each one.

Professionals surveyed for this study support the development of such a document. The IESNA representative interviewed agreed that a planning document should be created that can help communities identify lighting issues and how those issues affect design. IESNA publishes a similar document concerning all aspects of lighting, including indoor and outdoor lighting, *The IESNA Lighting Handbook*.[55] "The Lighting Design Guide," a section of the book, contains a matrix of lighting applications and lists all the factors that might be considered, the importance of each, and how each factor works with or conflicts with another. The section also includes some outdoor tasks with appropriate design factors that should be considered along with the recommended illuminance level.

6.0 Next Steps

The following steps should be undertaken to advance the findings of this paper and to improve the understanding of the relationship between pedestrian safety and illumination.

1. The findings and recommendations made in this paper should be verified through focused meetings with a diverse group of lighting practitioners and stakeholders. Conclusions from the meetings should direct follow-up research and data gathering.
2. A more inclusive workshop should be convened where the key stakeholders in providing lighting in New Jersey can discuss the creation of standards and guidance on pedestrian light-

[55] IESNA, *The IESNA Lighting Handbook, HB-9-00.* (New York: IESNA, 2000).

ing. Staff of the Board of Public Utilities should be invited to this workshop. Such a discussion should clarify roles, identify gaps, and begin to improve the process by which pedestrian lighting is provided. Strategies should be generated with short and long term goals outlined on how to improve the process.

3. Case studies of best practices, both in New Jersey and nationally, should be researched so as to provide real world examples of policies and processes that have created good lighting.
4. After verification and amplification, this paper should be made available to all relevant New Jersey institutions and stakeholders who are involved in the provision of pedestrian lighting. This should be a first step in a greater campaign for educational opportunities on this topic.

Appendix A

RELEVANT ORGANIZATIONS REFERENCED

American National Standards Institute (ANSI)
American Association of State Highway and Transportation Officials (AASHTO)
General Electric (GE)
Illuminating Engineering Society of North America (IESNA)
International Dark Skies Association (IDA)
Institute of Transportation Engineers (ITE)
Jersey Central Power & Light (JCP&L)
Lighting Research Center (LRC)
National Center for Statistics and Analysis (NCSA)
National Highway Traffic Safety Administration (NHTSA)
New Jersey Department of Community Affairs (NJDCA)
New Jersey Department of Transportation (NJDOT)
Public Service Electric and Gas (PSE&G)

Appendix B

LIGHTING TERMS[56]

Cutoff angle The angle of light distribution from a luminaire, measured upward from nadir, between the vertical axis and the first line at which the bare source (lamp) is not visible.

Cutoff classification The classification system of the Illuminating Engineering Society of North America (IESNA) that describes the light distribution of an outdoor luminiare. Cutoff classifications define the luminous intensity limits in two illumination zones that occur within the range of 80° to 180° above nadir.

Disability glare A type of glare that causes a loss of visibility from stray light being scattered within the eye.

Discomfort glare The sensation of annoyance or even pain induced by overly bright sources.

Footcandle (fc) The amount of light in a defined task area; a measure of illuminance in lumens per square foot (1 fc = 1 lumen/sq. ft.). One footcandle equals 10.76 lux, although for convenience 10 lux commonly is used as the equivalent.

Fixture A complete lighting unit consisting of lamp or lamps and the parts designed to distribute the light, position and protect the lamp(s), and connect the lamp(s) to the power supply. (Also referred to as luminaire.)

Glare The sensation produced by luminances within the visual field that are sufficiently greater than the luminance to which the eyes are adapted, which causes annoyance, discomfort, or loss in visual performance and visibility.

Horizontal illuminance A measurement of illumination on a horizontal object such as a roadway; or the average density of luminous flux incident on a horizontal surface, measured in footcandles (fc) or lux (lx).

Illuminance The amount of light (luminous flux) incident on a surface area. It is the converse of luminance and describes the intensity of light that falls on a surface, rather than the intensity of light leaving a surface. Illuminance is measured in footcandles (lumens/square foot) or lux (lumens/square meter).

Illumination The process of using light to see objects at a particular location.

Intensity (luminous intensity) Total luminous flux within a given solid angle, in units of candelas, or lumens per steradian.

Lamp A radiant light source.

Light trespass A undesirable condition in which spill light is cast where it is not wanted.

Lumen (lm): luminous intensity or the quantity of the energy of light emitted by a light source; total amount of light emitted in all directions from the point source. Ratings of initial light output provided by manufacturers express the total light output after 100 hours of operation.

[56] Except where noted, these terms have been adapted from those found in the Lighting Research Center's glossary. See http://www.lrc.rpi.edu/programs/NLPIP/glossary.asp for addition lighting terminology.

Luminaire A complete lighting unit consisting of a lamp or lamps and the parts designed to distribute the light, position, and protect the lamp(s), and to connect the lamp(s) to the power supply. (Also referred to as fixture.)

Luminance: the density of light emitted per square meter of a lighting surface or the quantity of light emitted toward an observer.[57]

Lux (lx) The amount of light in a defined task area; a measure of illuminance in lumens per square meter. One lux equals 0.093 footcandle.

Nadir In the lighting discipline, nadir is the angle pointing directly downward from the luminaire, or 0°. Nadir is opposite the zenith.

Sky glow Brightening of the sky caused by outdoor lighting and natural atmospheric and celestial factors.

Spill light Light that falls outside of the area intended to be lighted.

Vertical illuminance A measurement of illumination on a vertical object such as a pedestrian; or the average density of luminous flux incident on a horizontal surface, measured in footcandles (fc) or lux (lx).

Zenith In the lighting discipline, zenith is the angle pointing directly upward from the luminaire, or 180°. Zenith is opposite nadir. In astronomical usage, zenith is the highest point in the sky, directly above the observation point.

[57] Wulfingdoff, D.R., *Energy Efficiency Manual: Measuring Light Intensity*, 1999, http://www.energybooks.com/pdf/D1150.pdf.; IESNA, *Lighting for Exterior Environments: an IESNA Recommended Practice, ANSI/IESNA RP-33-99.* (New York: IESNA, 1999).

Appendix C

LUMINAIRE CLASSIFICATIONS

Luminaires are classified in a number of ways. Fixtures can be selected according to: 1) mounting type, 2) distribution intensity, and 3) cutoff characteristics.

Luminaire Mounting Types

Fixtures come in four distinct mounting types: pole-mounted, surface-mounted, bollard, and floodlight luminaries.[58]

Pole-Mounted luminaires are commonly used for roadway and parking lot lighting and produce wide light intensity distributions. Pole mounting allows for extended spacing and fewer fixtures. When using pole-mounted fixtures, designers must control for minimum and uniform horizontal illuminance.

Surface-Mounted luminaires are mounted on walls or ceilings of parking structures and are designed to distribute light onto road surfaces. These fixtures can provide too much light and reduce visibility due to veiling luminance.

Bollard luminaires are contained within short posts, used typically to light walkways or other pedestrian areas.

Floodlight luminaires are designed to light building façades, as sports lighting, or used in other special applications. These have a wide range of intensity distributions to satisfy specific needs, from narrow to very broad. These fixtures should have glare shielding to prevent light trespass.

Luminaire Distribution Types

Luminaire configurations are divided according to light distribution patterns. The standard forwarded by the IESNA, only describe these patterns according to intended setback with Type I being closest to the roadway and each subsequent type being greater than the one preceding it. As these classifications are general, lighting manufacturers and suppliers have tried to provide additional guidance to distinguish amongst fixtures. The following list includes the IESNA classification according to type as well as descriptions offered by PSE&G (in italics).[59]

Type I: Closest setback from roadway (or mounted over roadway.) Primarily used for narrow walkways and bike paths.

Type II: Greater setback than Type I, less than Type II. Typically used for wider walkways, entrance roadways, bike paths, and other long and narrow lighting applications. Lighting is intended to be located near the side of the roadway.

Type III: Greater the Type II, less than Type IV. Most often used for roadways, general parking, and other area lighting applications.

Type IV: Greatest setback from roadway. This distribution is suited for wall mounting applications and for lighting the perimeter of parking lots.

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[58] IESNA, *Lighting for Exterior Environments*.

[59] IESNA, *Lighting for Exterior Environments*.; PSE&G, http://www.pseg.com/customer/business/small/outdoorlighting/terms.jsp.

Type V: Axially symmetric; produces a circular illuminance pattern. This distribution is best suited for general parking and area applications. Should be located at or near the center of an intersection or large area as it produces a circular distribution.

Luminaire Cutoff Classifications

The IESNA classifies outdoor roadway lighting according to their cutoff characteristics or the degree to which a luminaire emits light upward into the sky. This characteristic is defined by a fixture's cutoff angle or the angle of light distribution along the vertical axis from directly below the fixture (nadir) to the point where light is no longer visible.

Full cutoff luminaires emit no light upward, at or above 90° above nadir, and where no more than 10% of the luminaire's intensity is emitted at 80° above nadir.

Cutoff luminaries emit no more than 2.5% its intensity upward and where no more than 10% is emitted at 80° above nadir.

Semicutoff luminaries emit no more than 5% of its light intensity upward and no more than 20% is emitted 80° above nadir.

Noncutoff luminaries are fixtures that have no limit on the intensity of light emitted upwards.

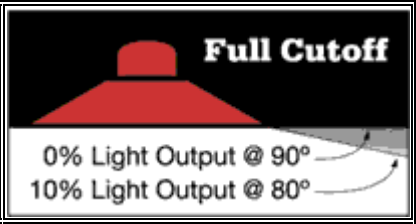
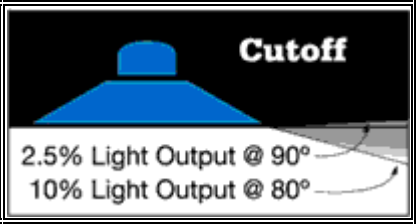
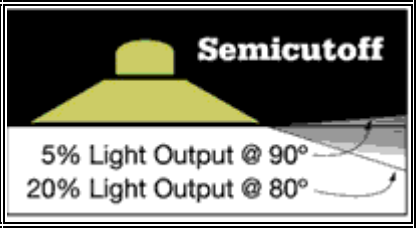
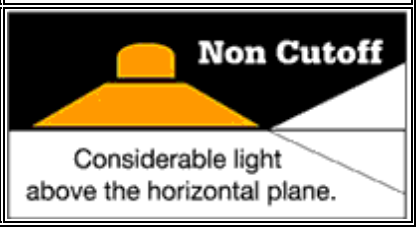
FC Full Cutoff No light directed at or above the horizontal plane; little or no light at angles typically associated with glare.	
C Cutoff Negligible light directed at horizontal plane; less than 2.5% of lamp lumens directed above horizontal plane.	
SC Semi Cutoff Slightly more light permitted at horizontal plane than in cutoff distribution; less than 5% of lamp lumens directed above horizontal plane.	
NC Non Cutoff Considerable light above the horizontal plane.	

Figure: http://www.pseg.com/customer/business/small/outdoorlighting/pollution.jsp

Appendix D

LOCAL LIGHTING IMPROVEMENT PROJECTS: A Comparison of South Bound Brook and Princeton Boroughs

Typically, municipalities and their governing bodies initiate and develop local lighting projects. However, these projects frequently occur not along local roadways but along the county and state roads situated in the municipality. Although these roadways fall under state or county jurisdiction, the state and county are not always involved in a roadway lighting project initiated by a municipality. At times, these projects are completed with little input from the state or county. In other instances, the state or county works cooperatively with the municipality to achieve improved roadway lighting. Recently both Princeton and South Bound Brook Boroughs undertook roadway lighting improvement projects. In the first instance, Princeton Borough's project proceeded with little input from the state. South Bound Brook, on the other hand, had some cooperation from Somerset County with their efforts to achieve improved pedestrian lighting.

Princeton Borough has only 100ft of county road and only two state roads – Rte 206 and Rte 27. The borough initiated and paid for the roadway lighting project completed along Rte 27 (Nassau Street). While the state did not provide input into the lighting design, a permit to install lighting fixtures was required by the state. The borough's aim was to incorporate lighting improvements into a larger infrastructure project. Other upgrades included changes to curbs and sidewalks. In projects such as these, a municipality must apply for a "highway opening permit" prior to completing the infrastructure improvements.

The project in South Bound Brook resulted from an arrangement between the borough and the county. The borough undertook streetscape improvements that included street lighting. Somerset County then hired a consultant to work with the borough during installation of the project.[60] To achieve its goals, the borough engaged in a visioning process to develop a downtown revitalization plan. Part of this plan was to improve the Main Street streetscape, through traffic-calming measures, improved street lighting and other measures.

Pedestrian lighting improvement in South Bound Brook, NJ
Photo: VTC

According to the borough's engineer, South Bound Brook currently does not have any standards for sidewalk lighting. The borough's only lighting requirements are specified in subdivision or-

[60] Tom Herits (Engineer, Borough of South Bound Brook, New Jersey), telephone interview, October 22, 2004.

dinances for parking lots as well as for housing and commercial buildings.[61] Guidelines for the downtown improvements referenced IESNA standards. Specifically, IESNA standards were to be followed with respect to recommended footcandle levels. The borough specified street illumination using pedestrian-scale lighting with a pole height of twelve feet and a controlled light distribution pattern. In addition, light sources should emit a white light. These requirements seek to both promote safety and minimize excess illumination of adjacent properties. Moreover, the borough set lighting design guidelines in pedestrian plaza, pedestrian connections, and sitting areas.

Princeton Borough utilized a different method for determining desired pedestrian light levels. The borough does not rely exclusively upon IESNA standards. Rather, the borough relies upon an empirical approach, using light meters to evaluate street lighting design and to determine preferred illumination. The borough has light ordinances, but the engineering department indicated that they are not heavily utilized.[62] Instead, they use their own experience to determine what degree of illumination is needed as they find that lighting designers tend to make the streets too bright.

Princeton Borough contracted with landscape architects and engineers for the design of the lighting project on Nassau Street, as well as that on Witherspoon Street. The borough installed the pedestrian-scale fixtures in the late 1980s as a metered system with power provided by PSE&G. Aesthetic concerns largely determined the type of lamp used. The borough preferred the white light of metal halide lamps to the yellow glow of high-pressure sodium (HPS) lamps.[63]

[61] Herits, interview.
[62] Carl Peters (Engineer, Borough of Princeton), in-person interview, March 10, 2005.
[63] A lighting project on the adjacent Princeton University campus utilized HPS lamps provided by PSE&G. In that location the primary concern was safety, not aesthetics.

Appendix E

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