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# Lighting Regional Trails

Best practices and recommendations

January 2016

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## EXECUTIVE SUMMARY

This white paper examines current approaches to providing lighting on trails within urban areas that are used for transportation and recreation.[1] In doing so, it explores best practices in and outside of the region, as well as identifies innovations that may be feasible for implementation on the regional trail network. The need for this information was identified during the development of the Regional Active Transportation Plan and will be incorporated into Metro's Regional Trail Design Guidelines which will be developed in 2017-18.

### Key Findings

Through a review of the literature and interviews with local trail providers, the following themes were identified:

- **Trail lighting is not considered a necessity, but instead an amenity**. For example, in the Rails-to-Trails "Trail Building Toolbox" lighting is considered an enhancement along with public art and gardens.
- **Existing standards regarding trail lighting are limited**. Many standards stipulate that lighting should be included at key points like bridges, tunnels and roadway crossings. No standards were found that stipulated that all sections of a trail should be lit. Some standards did suggest that trails with high utilization rates strongly consider lighting.
- **Lighting can increase the utility and perception of safety on a trail**. Trails without lighting can highly discourage use of trails after dark due to personal safety and security concerns, which can negatively impact recreational and commuting abilities.
- **Actual and perceived cost can be prohibitive.** Adding and maintaining lighting can increase a project's overall cost and is a major reason it is not included in more trail projects. However, the cost of lighting is not always fully understood or investigated.
- **Major concerns include light pollution and disruption of circadian rhythms in wildlife, plants and humans.** Light can negatively impact wildlife and habitat, can impact human health, and add to overall light pollution. These are important concerns that must be fully addressed when investigating whether lighting should be included on a trail.[2]
- **Common concerns can be minimized with thoughtful planning and design**. Light design can be done in a manner that minimizes impacts on surrounding uses and cost-savings measures, such as using existing utility poles may be available.

[1] The Portland metropolitan area uses the term "trail" to refer to a broad range of off-street facilities, from the soft-surface hiking trail in natural areas to paved, wide multi-use paths in urban areas. Throughout this paper the term trail is used to refer to trails (or paths) that are within developed areas and are used for both recreation and transportation purposes.

[2] *Reducing Artificial Nighttime Light Pollution and Its Impacts*, Jodi Shi, Office of Air Quality Planning and Standards, Environmental Protection Agency, August 2010.

- **Context is key**. Not every trail will benefit from the addition of lighting. To help better determine which trails should have lighting, a set of decision making guidelines are provided.

### Key Recommendations

The following recommendations were identified through this research:

- **Trails that function as a key commute route should be lit.** These facilities are already likely to have high levels of use. Lighting would ensure that current users are able to safely use the trail and may entice additional users to begin using it.
- **Trails with key connections to transit, school, and employment/activity nodes should be lit.** These routes can be used by many to meet their daily needs and lighting would help ensure that they can be used even after dark.
- **Trails that have safety and/or security concerns should be lit.** While research is inconclusive about the impact of lighting on security, there is evidence that lighting has an effect on an individual's feeling of safety and security. This can lead to an increase in the likelihood of them using the trail; higher numbers of users has also been shown to increase safety and security.
- **Impacts to wildlife and habitat must be carefully considered and weighed against benefits to lighting trails.** Natural resource experts should be consulted early when considering adding lighting to a trail. Low/no impact lighting options should be investigated.
- **When planning trails, lighting should be considered from the outset.** The public engagement phase should include some questions that gauge the desire and need for lighting. Challenges, such as cost, and possible impacts to wildlife and habitat should be investigated early on.
- **Not at all trails or sections of trails need to be or should be lit.** Trails that are located deep in nature, are in rural areas or that are primarily used for recreation generally do not need to be or should not be lit. Carefully considering the context is key to determining when and where to light a trail.
- **When designing trail lighting, best practices in lighting design should be followed.** Best practices include fully shielding light, aiming lamps down, carefully considering spectral output (using warm, not cool LEDs, i.e., selecting LED's rated 3,000 Kelvins or below), and carefully considering the overall lumens so as to not overlight.
- **When trails are constructed or improved a documentation of the cost of the lighting and its impacts would be beneficial.** Further research and the need for better data regarding many aspects of trail lighting, especially costs and impacts is needed

## INTRODUCTION

> "More people would like to walk or bike for transport, but feel unsafe doing so."
>
> -Regional Active Transportation Plan, Metro (2014)

Today, increasing carbon emissions and decreasing levels of physical activity are growing concerns in the United States and many other parts of the world. Rampant increases in carbon emissions are exacerbating the effects of global warming. Decreased levels of physical activity in both adults and children are leading to increased levels of obesity and health implications. Increasing levels of active transportation, getting where you need to go via walking and biking, is part of the solution to both of these growing concerns. In order to increase levels of active transportation, people must feel safe and secure walking, riding a bike and using a wheelchair to get where they need to go.

> Trails are linear facilities for non-motorized users that are at least 75% off-street. Bicyclists, pedestrians, joggers, skaters and other non-motorized travelers use these facilities.

Trails are attractive active transportation facilities because they are separated from motor vehicles. This separation allows for a less stressful experience and increases safety. Separation from traffic can also mean that trails are isolated and do not have street lighting in the same way that sidewalk and bike facilities on the roadway do. This lack of lighting can raise concerns of safety and security on the trail, which can diminish use beyond the daylight hours. The Portland metropolitan region benefits from a great network of regional trails that provide key connections to many destinations. Regional trails traverse both highly urbanized areas and natural corridors. Trails that parallel major highways and transit lines in the region, like the I-205 trail and the Wy'East Way in Gresham,[3] are more likely to be lit than greenway trails like the Springwater Corridor or the Fanno Creek Trail. This white paper examines available information on current approaches to providing lighting on trails. In doing so, it explores best practices in and outside the region, as well as identifies innovations that may be feasible for implementation. The need for this information was identified during the development of the Regional Active Transportation Plan and will be incorporated into Metro's Regional Trail Design Guidelines which will be developed in 2017-18.

[3] Formerly named the MAX Path.

## METHODOLOGY

Research, field tours and interviews with local trail providers were conducted to inform this work. Over the course of the project Metro staff provided updates and received input at two Metro Quarterly Trails Forums in 2015.

### Research

A review of existing literature was conducted to understand the conventional thinking surrounding trail lighting and to identify strong best practice examples. Additionally, national, state, regional, and local plans were reviewed to understand what guidelines for trail lighting are common practice today.

### Expert interviews

To better understand the thoughts regarding trail lighting throughout the region, a series of interviews were conducted with major trails and park providers. These interviews were conducted throughout August and September of 2015 and were each approximately an hour in length. Open ended questions were asked to gauge interest, knowledge, and concerns regarding the lighting of trails. See Appendix 3 for a list of interviewees.

### Field Visits

Through interviews with local trail providers, five trails in the region with lighting were identified. They include the Trolley Trail, Wy'East Way in Gresham, the I-205 Multi-Use Trail, the Eastbank Esplanade/Waterfront Park Loop, and a segment of the Fanno Creek Trail. The trails were visited in early October. These visits were used to better understand the context that the trails exist within and to observe the types of lighting that were used.

## BENEFITS OF LIGHTING TRAILS

Through research and talking with trail providers in the region, a number of benefits of trail lighting were identified.

### Increase in Security

The perception of security on a facility is likely to impact its level of utilization. Studies have shown that "even when reported data indicate that a facility has experienced no incidents of criminal activity, public perception of crime may lead to avoidance of a facility."[i] Many believe that the addition of lighting on a facility will automatically make it more secure. Some would argue though, that it isn't the level of actual security that is changed, but the perception. Some studies have found that dark areas can increase the fear of crime, and

Safety and security are often used interchangeably. It should be noted that in this report they have distinct differences. Safety is referring one's ability to use the trail without injury from collisions or obstacles on the path. Security is referring to one's ability to use the trail without injury caused by criminal behavior.

conversely, increased lighting has been found to reduce assaults and other criminal activity.[ii]

Crime Prevention through Environmental Design (CPTED) centers on the belief that "proper design and effective use of the built environment can lead to a reduction in fear and incidence of crime."[iii] The major tenants of CPTED include (1) natural surveillance, (2) natural access control, (3) territoriality and (4) maintenance. Within the CPTED model, lighting is considered a component of natural surveillance, which aims to increase the likelihood that people will be able to be seen by others. The conventional wisdom is that crime happens in places with limited visibility areas where witnesses are less likely to be. Strategic placement and design of lighting helps to increase the levels of natural surveillance on a trail, because it illuminates the area helping to enhance the visibility of those on it.

### Increase in Safety

Trails are commonly used by people walking and biking and in certain places also by people on horseback. These competing uses can lead to concerns regarding collisions. Trails are likely to cross roadways introducing the concern of vehicle collisions. Lighting allows people to not only see where they are going, but to be seen by other users potentially limiting the likelihood of collisions. A key finding in the 2012 Regional Transportation Safety Plan was that "serious nighttime pedestrian and bicycle crashes occur disproportionately where street lighting is not present."[iv] Lighting at roadway crossings is the most common recommendation found in scans of existing standards, likely because these crashes can have the most fatal outcomes. Lighting on trails to help prevent collisions with users, however, is not frequently cited as a benefit.

> "Street lights along the path [Springwater Corridor] would make a big difference. It's a key commute route, and oncoming traffic in the dawn and dusk hours can come up fast. I'm surprised there aren't more collisions reported."
>
> –Comment on BikePortland.org blog

Another major safety concern is prompted by not being able to see what is ahead of you on a trail. Without lighting, users may not be able to see debris on the trail or a turn, potentially leading to a crash. Research has indicated that older users are more vulnerable to accidents in poorly lit areas, making their ability to safely use unlit trails in the early morning or evening much more difficult.[v]

### Increase in Trail Use

Trails without lighting often prohibit or highly discourage riding after dark due to risks regarding personal safety and security. This means that facility hours are often dictated by the length of seasonal daylight. In the Portland metropolitan region, the winter months see a limited amount of sunlight, with the shortest day averaging only eight hours and forty minutes of sun exposure. The latest sunrise in the winter happens fairly close to 8:00am and

the earliest sunset happens around 4:30pm. These short days compounded with overcast weather restrict the use of trails that are only open during daylight hours.

Limited daylight hours and the prohibition of nighttime trail use do not easily allow for trails to be used as a commuting facility, because of the short winter days. The traditional workday puts most people commuting outside of the hours between 8:00am and 4:30pm (sunlight period during the winter months) and the unpredictability of hours based on sun exposure may deter some from using trails to commute. These same people may not feel comfortable commuting via bicycle on major thoroughfares, diminishing the likelihood of them using active transportation to get to and from work.

Beyond just the ability to commute, trail lighting or the lack of it, can also impact recreation uses. People that prefer to use trails for recreation purposes will only be able to do so if they work a job with non-traditional hours or on days off. Lighting could help extend a trail's accessibility allowing for more flexibility in times available for recreation during seasons with shortened sun exposure.

### Place Making

Lighting is often thought of in the most utilitarian of forms—its' main purpose being to illuminate the area surrounding it. Lighting, however, can be used in a variety of interesting ways to help enhance the location it is in. Traditional lighting fixtures can be swapped out for those with a more ornamental design to enhance the environment. With greater ornamentation, though, comes a higher cost. Ornamental fixtures are most frequently used in areas steeped in historical significance, like historical downtowns and main streets. The lighting itself can also be morphed through the presence of color or timing. The Indianapolis Cultural Trail in Indianapolis, Indiana has a number of lighting installations along the facility that not only fulfill a need of providing light, but are also considered works of art; these include the Swarm Street tunnel, the Glick Peace Walk and the Prairie Modules.[vi]

**Image 1: The Swarm Street Tunnel in Indianapolis, Indiana combines lighting and public art to create an inviting place.**

## CONCERNS AND BARRIERS TO LIGHTING TRAILS

Through research and interviews with trail providers a number of concerns and barriers were identified. In many cases, concerns and barriers can be addressed through thoughtful planning, design and selection of materials. The best practices presented later in this paper highlight some of the ways that concerns and barriers were addressed.

### Cost

Cost is probably the biggest perceived barrier to the implementation of lighting on trails. Funding for bicycle and pedestrian improvements is limited and funding specifically for trails can be even harder to obtain. Additionally, there is a lack of standardized reporting regarding the cost of lighting systems. Projects that do include lights often don't publicly report project costs at the level of detail necessary. This lack of readily-available information makes it difficult to gauge the cost increase that lighting might have on a project. This leads to the perception that lighting is too expensive.

> After the copper wiring was stolen from the LA River Bike Path's lights, the City replaced the traditional lighting with solar powered LED lights. The solar energy source doesn't use copper wiring, which eliminates the possibility of theft.

Beyond the cost of installation, lighting systems also require maintenance and operating costs. The costs will vary based on the type of lighting and power supply selected. For example, a system that collects and runsoff of its own solar energy will have lower operating costs than a lighting system pulling energy from the grid. LED lights may have higher upfront costs, but will result in lower operating costs due to their longer lifespan. Warm light LEDs (3,000Kelvin and below) are now available at comparable cost and comparable energy efficiency to their higher Kelvin predecessors, and have less negative impacts on the environment. Repairing vandalism is the other cost associated with lighting. Lights can be broken, spray painted and in extreme cases looted for their wiring.[vii] These can be unexpected costs and can range vastly in price depending on the damage.

> The City of Gresham was able to reduce the costs of lighting on the new Wy'East Way, by using existing electrical poles as posts for some of their lighting fixtures.

Carefully determining which types of lighting would be financially feasible and seeking out ways to reduce costs of installation can help make lighting on a project more feasible. For more information on what drives the cost of lighting see Appendix 2 which contains information on various lighting types.

### Residential Light Pollution

Adding lighting to a trail can increase light pollution of nearby residents. A common concern is that lighting on a trail will illuminate personal property that abuts it, potentially

disrupting the privacy and lifestyles of those near it. Another concern is that the presence of lighting will lead to prolonged use of the facility, bringing with it noise and additional disturbances.

### Wildlife and Habitat Impacts

Lighting trails can disrupt sensitive wildlife habitats. Many nocturnal species' navigation patterns are affected by the introduction of light. Artificial light can dim the light from that stars, affecting animals that rely on it for navigation purposes, including migrating songbirds, who rely on the moon and stars to navigate at night. Lighting can also cause disorientation or temporary blindness, making some nocturnal creatures more vulnerable to natural predators and human-caused fatalities like crashes.[viii]

Light pollution can often be reduced by selecting the proper bulbs and lighting accessories. Blue-rich white light produced by LED bulbs over 4,000Kelvins are short wavelength and scatter more readily in the atmosphere than longer wavelength light sources. Selecting warm white LEDs (3,000K and under) helps to minimize the deleterious effects of blue-rich white light, which has been shown to impact circadian rhythms in wildlife, plants and humans, increase stress hormones in fish and birds, and potentially be linked to serious human health issues including breast cancer. Reference International Dark Sky Association, May 4, 2010, *Visibility, Environmental, and Astronomical Issues Associated with Blue-Rich White Outdoor Lighting* and also *Seeing Blue*, IDA synopsis of White Paper, 2010.

Aiming lights down and selecting well shielded light can also help minimize light pollution. Adding shielding to a light fixture can help direct the light onto the trail surface, while avoiding light trespass into unwanted areas. For example, in Dublin, Ireland the Grand Canal Way Trail's lighting system was designed in a manner that didn't interrupt the bat and otter species that call the canal home. [ix] It should be noted that this solution does not completely negate the impacts that lighting can have on nearby wildlife. In the case that there are critically sensitive habitats adjacent to the trail, lighting may be harmful.

### Perceived Invitation for Criminal Activity

There is concern that lighting a facility could lead to an increase in crime and loitering, because people feel comfortable being there. Planners in Gresham reported that before installation of lighting on the Wy'East Way the area was prone to illegal dumping and graffiti. This is still present today, but hasn't increased which suggests that lighting has not been a deterrent to these types of acts, but also hasn't invited it.

## EXISTING STANDARDS

Standards from AASHTO, various state departments of transportation and trail providers in the region were reviewed. Where trail lighting standards exist, they were often limited. AASHTO and many state departments of transportation require that lighting exist at trail heads, bridge and overpasses, and in tunnels and underpasses. Beyond that, guidance is fairly vague. Within the region, trail lighting is sometimes considered an amenity, similar to

benches and trash cans, along the trail. For a more in depth look at each standard reviewed, see Appendix 1.

## COSTS

Costs associated with including lighting on a trail are dependent upon a variety of factors including the fixture type, spacing, height, and service agreement with local utility, as well as whether the lighting was installed during construction or added later as a retrofit. In general, light fixtures are spaced every 100 to 150 feet and at trail heads, at underpasses and bridges and street crossings.[x] However, there are examples of trails that have lights spaced as far apart as 300 feet and as close together as 75 feet. A typical 2-mile trail might have approximately 70-75 light fixtures.

- Lighting a **trail underpass** can range from $350 to $3,400 each.
- Lighting a **trail street crossing/crosswalk** can range from $10,750 to $42,000 per crosswalk.
- **Light fixtures** can range from median cost of $2,500-$3,600 (or $1,000 if installed on an existing utility pole), to an average cost of $4,880-$10,000, to a maximum cost of $13,900 per light fixture. Pole height, type of fixture, and design add to the range in cost.
- Including planning, engineering and installation **lighting a trail** can range between $90,000 and $250,000 per mile (based on an average spacing of a light every 150 feet).
- Based on an average of 5 hours of lighting per day for 365 days/year, **light fixture bulbs** can last between 10 and 50 years. Refer to Appendix 2 for lighting types and average lifespan.

## DECISION MAKING GUIDELINES

The decision to add lighting to a trail should be based on the context that the trail exists within. For example, highly trafficked urban trails will have different needs when compared to trails within a removed natural area. Ideally, lighting should be considered at the earliest stages of planning. We found that, in the region, lighting is sometimes added to a trail only after the community asks for it. A more proactive approach is desired as it better serve the community and help achieve the benefits associated with lighting trails.

If lighting cannot be provided on the entirety of a trail or on major segments, there are some areas of the trail that should at a minimum be lit, according to AASHTO guidelines. These include:

- Street crossings
- Trailheads
- Blind corners
- On bridges and overpasses

- In underpasses and tunnels

These areas were most commonly identified in the scan of existing standards and are cited as necessities in AASHTO guidelines. Lighting these areas will help to ensure that users are able to safely traverse a trail.

The City of Seattle in a recent Pedestrian Lighting Citywide Plan applied a data driven approach to prioritizing where pedestrian lighting should be added in the city. Using land use, the city determined the pedestrian demand of an area based on surrounding attractors and generators. They also analyzed a variety of social and economic data to help prioritize traditionally under-served populations. Lastly, the city considered how the streets they are evaluating are intended to be used in the street network. Taking these three factors into account, the city was able to prioritize projects that would receive limited funding.[xi]

The following are a series of statements to help determine if lighting should be included on a trail. **If a majority of your answers are "yes," lighting should be considered.** These criteria can also be used to determine which trails should be prioritized for the addition of lighting.

**1. There is a public desire for lighting.**

Everyday people use the regional trail system and are able to identify improvements that may not have been considered in the planning process. If the public is coming forward with lighting as an identified need and desire, it should be considered.

Beyond just waiting for citizen requests, outreach should also be considered. In the planning phase of a trail, citizens should be asked if they would prefer lighting. Many might not know that lighting is something they can ask for or even consider.

**2. The surrounding land use patterns result in a high density of housing or jobs.**

Trail counts are the most commonly used metric to determine trail utilization. Counts, however, fail to capture the future population that may use the facility, or the potential latent demand. Looking to land use patterns can provide insight to the concentrations of people in the area that may take advantage of a nearby amenity if additional features, like lighting, are added. Trails that are located in high density areas and have high trail counts should be considered strong contenders for the addition of lighting as they will not only benefit the current population using it, but also have the potential to attract new users.

**3. The trail provides connections to transit, schools, employment/amenity nodes, bicycle routes or neighborhoods.**

If the trail provides direct connections to transit, schools or employment/amenity nodes, lighting should be prioritized. Trails with direct connections are usually more likely to be

used to meet one's daily needs. Lighting would illuminate these connections ensuring that things community members need to meet their daily needs are accessible even in the dark.

**4. The trail is in an underserved or low-income community.**

Data has shown that low-income communities are more reliant on active transportation as a means of getting to work and carrying out daily activities than those with higher incomes. Making these facilities more useable is likely to benefit the population most reliant on walking and bicycling to meet their daily needs.

**5. The level of use on the trail or a particular segment of the trail is high.**

Trail count data can be used to better understand current utilization of trails. Survey data compiled by Alta Planning and Metro in the "Intertwine trail use snapshot: An analysis of National Bicycle and Pedestrian Documentation Project data from 2008 to 2012" provides documentation on how both walkers and those riding bicycles use trails across the region.[xii] Counts give information on the raw number of people using the trail and the survey data can give insight into how the trail is used. This data can be useful when trying to prioritize trails that might benefit from the addition of lighting.

It should also be noted that a trail in its entirety may not be suitable for lighting, but there may be some sections that would benefit from it. It is okay to identify and light those certain segments.

**6. The trail is used by commuters.**

While both commuting and recreational users can benefit from the presence of lighting, commuters often have less flexibility in the times of day that they can use a facility. During the winter months in the region, much shorter days leave those that work during a traditional work day commuting in the dark.

The "Intertwine trail use snapshot: An analysis of National Bicycle and Pedestrian Documentation Project data from 2008 to 2012" summarizes data from counts and intercept surveys on many of the region's trails. This information gauges how the trail is used and who is using it and could be a good starting point for understanding how trails have been used.

**7. There are current security concerns.**

If there are issues regarding the security of users on the trail, lighting would be a good addition. The lack of lighting in public spaces can often lead to the assumption that a place is unsafe. While research on whether or not lighting reduces actual crime rates, lowering the perception could attract more users to the facility where there may be a safety in numbers.

**8. The trail is far enough from private residences that lighting would not be a disturbance.**

Light trespass onto private property can be a major concern. If a trail is set far enough back from property lines this shouldn't become an issue. However, if that is not the case this still shouldn't deter you from including lighting as shielding installed on the light fixtures can reduce this impact.

### 9. There are no sensitive habitats that could be disrupted by lighting

Disruption to ecological habitats due to the introduction of artificial light is often a major concern when adding lighting to a trail that runs through a natural area. Lighting can disrupt migratory patterns, predator prey relationships, nesting and reproductive activity, and foraging activity. In these types of environments, lighting may not be appropriate. However, if a number of the above criteria are met and you think the lighting should be added, it is critical to design lighting according to best practices. There are also a number of examples of lighting that has been designed to mitigate the impact on both diurnal and nocturnal species.

The Institute for Public Administration at the University of Delaware convened a stakeholder workshop which brought together community, private-sector, government and nonprofit representatives from around the state of Delaware to discuss the issue of pedestrian lighting. This stakeholder workshop brainstormed a number of criteria that should be used to determine if there is a need for lighting. It should be noted that while this was for all variations of pedestrian lighting and not specifically trail lighting, the themes are consistent with what research on trail lighting has brought forth. Criteria identified included:

- Areas with key roadway safety issues
- Population density
- Compliance with ADA standards. (In low-light areas, where public entities have provided accommodations for walking, ADA laws may require lighting)
- Perceived or actual security concerns
- Connectivity (Does the area under consideration connect areas of residential populations to essential services or transit.)
- What does the actual pedestrian want

## CASE STUDIES: REGIONAL TRAILS WITH LIGHTING

There are a number of trails within the Portland region that have lighting installed along them. These trails are in varying places and contexts, use different lighting technologies, and have different management structures. In some cases, very little was known about the lighting on particular facilities. A commonality held among all of the local trails with lighting was their function as a key connector. All of these trails provide direct connections to transit and/or major community hubs. Additionally information about trail usage was pulled to highlight who is using the trails and for what purposes.

### Eastbank Esplanade/Waterfront Park

Together, the Eastbank Esplanade and the Tom McCall Waterfront Park create a 4-mile loop around Portland's waterfront. This loop is accessible to both people walking and riding a bicycle. The Waterfront Park was completed in 1978 when it replaced Harbor Drive, an expressway that ran parallel to the river. The Eastbank Esplanade was completed in 2001 and skirts the east bank of the river. Previously, access to this side of the river was cut off to the public by a freeway and rail road lines. This facility is well lit. Tom McCall Waterfront Park has many historic acorn style lights that are not well designed to minimize light scatter into the adjacent river and contribute to overall light pollution. As shown in this picture, the lights illuminate the path and increases user safety, but should be better shielded to reduce impacts to the riparian corridor, the river, and overall sky glow. Detailed information on the lighting of this trail was unavailable.

**User Snapshot**

**Users:**
*Waterfront:* 13,170 (daily), 400,000 (monthly)
*Eastbank:* 11,290 (daily), 343,000 (monthly)
**Mode Split:**
*Waterfront*: Walk 53%; Bike 47%
*Eastbank:* Bike 32%; Bike 68%
**Gender Split:**
Waterfront: Women 41% Men 59%
Eastbank: Women 35%; Men 65%
**Why bikers using trail:**
*Eastbank:* Commute 82%; Pleasure/Exercise-13%
**Why walkers using trail:**
*Waterfront:* Pleasure/Exercise: 100%
*Eastbank:* Commute 16%; Pleasure/Exercise-84%
**Safety considered good or excellent:**
*Waterfront*: 100%
*Eastbank:* 85%

**Image 2: Lighting at night on the Eastbank Esplanade.**

## Fanno Creek Trail

When completed, the Fanno Creek Trail will span 18 miles, linking Tualatin, Tigard, Beaverton, unincorporated areas in Washington County, and Portland. Oversight of the trail is done predominantly through Tualatin Hills Parks and Recreation District (THPRD). The trail serves as an active transportation corridor and a key wildlife corridor.

**Image 3: A man walks through the portion of the Fanno Creel Trail that has lights.**

A majority of the trail is not lit; the trail traverses sensitive wildlife habitat and adding lighting would need to ensure that the habitat was not negatively impacted. There is, however, a section in Beaverton near SW Bel Aire Lane and SW Hall Boulevard that has lighting. This segment is approximately 0.25 miles long and connects a residential area to a major thoroughfare and park with easier access than existing street conditions provide. Contacts at THPRD were uncertain about when the lighting was installed, what prompted it and costs associated. The lighting is pedestrian scaled and well-maintained.

## User Snapshot

**Users:** 1,260 (daily), 38,000 (monthly)
**Mode Split:** Walk 63%; Bike 35%; Other 2%
**Gender Split:** Women 37%; Men 63% Men
**Why bikers using trail:** Commute 50%; Pleasure/Exercise-43%
**Why walkers using trail:** Pleasure/Exercise: 94%
**Safety considered good or excellent:** 90%

While out walking the Fanno Creek Trail, we talked to a young man named Kadin who was riding his bike. He uses the trail frequently to commute between his job at the local Target and home.

He expressed a desire for lighting on the trail, because it can be hard to see debris and upcoming turns. Kadin also wondered how users with limited visibility or mobility fare on the trail at night without lighting. He mentioned that some lighting from the building abutting the trail reaches the trail, but that it isn't enough.

**Image 4: Kadin frequently rides the Fanno Creek Trail and appreciates the lights in this small section.**

### Trolley Trail

The Trolley Trail is a 6-mile trail that runs along historic streetcar right of way, connecting Milwaukie to Gladstone. The trail was planned in 1970 and came to fruition in the early 2000s when North Clackamas Parks and Recreation District partnered with Metro to pass a bond measure that allowed the right of way to be acquired. With the construction of TriMet's Orange Line to Milwaukie some of the Trolley Trail needed to be shifted over a few feet to make way for the train. In this reconstruction phase, lighting and new public art were added to a half mile stretch of the trail. [xiii,xiv] Information regarding costs was unavailable.

**Image 5: Two people bike along the newly reconstructed portion of the Trolley Trail, which includes lighting.**

## User Snapshot

**Users:** 400 (daily), 12,000 (monthly)
**Mode Split:** Walk 54%; Bike 40%; Other 6%
**Gender Split:** Women 54%; Men 46%
**Why bikers using trail:**
Commute- 38%; Pleasure/Exercise- 50%
**Why walkers using trail***:*
Pleasure/Exercise: 90%; Commute-5%
**Safety considered good or excellent:** 50%


**Image 6: The Trolley Trail provides a direct connection to the recently opened MAX Orange Line.**

## Wy'East Way, Gresham[4]

Gresham's newest multi-use path runs parallel to the MAX Blue Line from the Cleveland Station in Downtown Gresham to the Ruby Junction Station in Rockwood. The path also provides key connections to the Springwater Corridor and Gresham-Fairview trail.

The path was completed in 2015 and includes 37-LED lights, which were installed to ensure increased visibility. The Kelvin rating on the lights was not available so it is not clear if this follows best practices. The style of the lighting fixtures along the path differ due to design standards that exist in the Civic Neighborhood. Ten decorative posts with lights were installed and 27 Cobra head lights were installed. In some spots along the trail, the project team was able to take advantage of existing power poles lowering project costs. Lighting is set to the levels equivalent to lighting on a neighborhood street.

Lighting for the project totaled approximately $180,000. The decorative lighting systems carried a higher cost of approximately $7,500 per unit, while the cobra head systems were only $2,500 each ($1,000 each if installing on an existing utility pole). Approximately $60,000 in lighting costs was allocated to engineering and construction designs and the extension of the power lines.

**User Snapshot**[5]

**Users***:* 270 (daily), 8,000 (monthly)
**Mode Split:** Walk 44%; Bike 56%
**Gender Split:** Women 33% ; Men 67%
**Why bikers using trail:** Commute 100%
**Why walkers using trail:** Pleasure/Exercise:100%
**Safety considered good or excellent:** 100%

**Image 7: Wy'East Way in Gresham has decorative lighting through one segment to match city design guidelines.**

[4] Formerly the MAX Path.
[5] Stats for the nearby Gresham-Fairview Trail are presented here, because data does not exist for Wy'East Way yet; it is assumed that user stats will be similar.

**I-205 Multi-Use Trail**

Constructed in the 1980s, the I-205 multi-use path is a 16-mile path that runs from Marine Drive in Portland to SE 82nd Avenue in Gladstone. The alignment of the path follows I-205 and the MAX Green Line. The entire length of path has lighting on it. In the early 2000s, the Oregon Department of Transportation, which has oversight over the path, partnered with TriMet to secure $4 million in federal stimulus funds that would be used to install lighting on the path. This funding allowed for lighting on the segments from Lents to Gladstone, which at the time was the remaining section unlit.

**Image 8: The I-205 multi-use trail provides direct connections to transit.**

Lighting on the path is most commonly 30 foot poles with "shoe box" fixture lights as suggested in ODOT's "Traffic Lighting Design Manual."[xv] Fixtures of this size are not typically considered pedestrian scale lighting, but are used by ODOT because they are less prone to vandalism and allow lights to be spaced further apart.

It is estimated that the type of lights used on this facility cost between $10,000 and $15,000 per light. (This includes the light fixture, pole, installation, etc.)

**User Snapshot**

**Users***:* 1,180 (daily), 36,000 (monthly)
**Mode Split***:* Walk 11%; Bike 88%; Other 1%
**Gender Split:** Women 36%; Men 74%
**Why bikers using trail:**
Commute- 29%; Pleasure/Exercise-64%; Other-7%
**Why walkers using trail:**
Commute- 14%; Pleasure/Exercise: 72%; Other- 14%
**Safety considered good or excellent:** 85%

## CASE STUDIES: BEST PRACTICES FROM AROUND THE WORLD

Trails from around the world were identified and highlighted in this section. Each of these trails were able to use a creative design approach or technology to solve some of the major concerns that have been identified as barriers to lighting. In all of these cases, lighting has had a positive impact on trail users, while mitigating concerns.

### Haxton Way Trail-Lummi Nation-Whatcom County, Washington[xvi,xvii]

*Combination of innovative technologies to increase safety while minimizing impacts on the environment.*

**Image 9: The Haxton Way Trail is a popular walking path and key connection to jobs. Lighting has helped increase the level of safety on the trail.**

Prior to this project, Haxton Way had the highest fatality rate in both the Lummi Nation reservation and Whatcom County. Despite its role as a major connection between jobs and essential services and housing, the roadway lacked pedestrian and bicycle facilities. A separated pedestrian and bike trail was created with funding from the County and Lummi Nation as well as grant funding from Washington State DOT, the American Recovery and Reinvestment Act and the FHWA's Federal Lands Highway Coordinated Technology Implementation Program. Total project costs for the 2-mile trail totaled $1.7 million dollars. The path was completed in 2010.Reporting done in 2012 had found that no injuries, deaths or accidents had happened on Haxton Way since the installation of the bike and pedestrian path. The community has also seen an increase in people choosing to walk or ride a bicycle for transportation and recreation needs.

Early engagement with the community identified three desired outcomes for the path. It needed to be wide enough to allow people to walk in groups and converse. It also needed to be illuminated to promote safety and allow for continued use beyond daylight hours. Lastly, it was important to the community that the installation of the path and lighting have as minimal an effect as possible on the surrounding wildlife environment.

**Image 10: The Haxton Way Trail uses motion-sensored lighting to illuminate the path.**

Seventy solar powered, LED lights equipped with smart motion sensor technology were installed on the trail. The decision to go with solar powered lights was driven by costs and lessened environmental impacts. Solar powered lighting didn't require trenching to bury the lighting, which reduced the impacts imposed on the surrounding wetlands and negated the need to allocate funding towards mitigating these potential impacts. The use of LED lights helped make solar a feasible option because it uses less electricity to produce the same amount of light than other types of lights. Finally, the lighting in place is equipped with smart technology. Sensors tell the lights when to turn on and off and adjust the brightness of the light based on time of day and weather conditions. At night, the lights are set to 25% brightness. When a sensor detects a person the level of illumination increases to 100% brightness. The lights communicate with one another in order to know when to brighten and dim, helping to save on energy and minimize the disruptions to the surrounding ecosystem.

### Grand Canal Way- Dublin, Ireland[xviii]

*Lighting designed in a manner to not disrupt the wildlife habitats around it.*

**Image 11: Lighting on Grand Canal Way was designed to ensure that lighting doesn't spill into the canal or surrounding vegetation.**

The Grand Canal in Dublin had been used from the 1750s to 1960s to move both passengers and goods throughout Dublin and the surrounding region. When boats stopped using the canal, it fell into a state of disrepair. In 2008, the South Dublin County Council, Dublin City Council, Waterways Ireland and ESB networks partnered to restore the canal and provide public access to the water way via a 5-mile pedestrian and bicycle path. It was important that the path be accessible 24 hours a day to encourage its use. Lighting, therefore, became an essential component.

The waters of the canal and surrounding shrubbery were home to a number of species, mainly bats and otters, whose sleep and food gathering patterns could be disturbed with the introduction of artificial light during the nighttime. Three-hundred lights were added to the Grand Canal Way path. They were outfitted with customized shielding to ensure that the lighting only illuminated the path and not the surrounding waterway or shrubbery. The brightness of the lighting was also set to be no-brighter than the light of a full moon. The lighting on this trail was also the first in Europe to dim lighting through remote monitoring and control. Follow up studies suggest that the presence of lighting has not affected the creatures in the habitats surrounding it.

**The High Line in New York**[xix]

*Lighting designed to minimize light pollution on surrounding neighbors.*

**Image 12: The High Line uses positions all the lighting no higher than waist level to avoid light pollution.**

The High Line in New York City, which is a linear park and pedestrian trail on a decommissioned elevated rail line. Due to its elevated nature, The High Line is at the same level as many windows on the upper floors of buildings. This required that the lighting design be very thoughtful.

All lighting on the High Line is placed no higher than waist level. The lack of overhead lighting helps to reduce the amount of light that trespasses into those nearby developments. Lighting is cleverly tucked under benches and railings, which illuminates the path and helps to increase the sense of safety. With this design, the effect of the light is highlighted without making its source the focus. The lighting design also has a benefit in terms of aesthetics. The lack of overhead lighting reduces glare, which allows path users to see and appreciate the views of the cityscape at night.

The lighting design for the High Line was the jury winner of the Architizer A+ Award in the category Architecture + Light.

**Connswater Community Greenway- East Belfast, Ireland[xx,xxi]**

*Lighting to enhance safety included in the engagement phase of the planning process.*

**Image 13: Residents were consulted early in the process and stressed that the presence of lighting would help increase their personal feelings of safety.**

The Connswater Community Greenway is a 5.5 mile linear park and multi-use path running along the Connswater, Knock and Loops Rivers in East Belfast. Phase 1 of construction was recently completed and Phase 2 is expected to be completed by Mid-2016. The £40 million project aims to revitalize the areas around the river and unite a community that has been historically fragmented because of political unrest. Operating within this context, it was important that safety be emphasized as an end result and that the community be involved in the creation of this new amenity.

Residents and stakeholders were surveyed in the pre-design phase of the work. Lighting was highly favored by both groups and was identified as a determining factor regarding usage of the path.

- 85% of residents and 88% of stakeholders supported the trail being open and lit 24 hours a day.
- 85% of residents and 82% of stakeholders felt that their sense of personal safety would be increased by the presence of lighting.
- 65% of residents and 68% of stakeholders would be more likely to use the greenway if it was lit 24 hours a day.

The path is considered to be safe by design. It has implemented many of the commonly held CPTED principles. The trail has improved site lines, so while the greenway may jog, it is very easy to see what is in the distance ahead of you. Lighting is planned for the entire length of the greenway. Additionally, there are Greenway Wardens, Closed Circuit Television (CCTV) cameras, and defensive plantings in place to discourage criminal behavior. It is also expected that because the community has been so involved in the development and implementation of the project they will have a common interest in making sure it is successfully stewarded into the future. Because the path isn't complete, data on utilization and safety levels are not yet available.

## NON-TRADITIONAL LIGHTING OPTIONS

If traditional lighting is not feasible, there may be other options to illuminating a path.

### Glow-In-The-Dark Path Application[xxii,xxiii]

*Good fit for areas where you would like people to see where the trail goes, but not necessarily invite them to linger.*

**Image 14: StarPath illuminates the path itself allowing people to see where the trail goes.**

Pro-Teq, a company based in the United Kingdom that specializes in spray-applied elastomeric coating material used on pathways, has recently created a glow-in-the-dark path application. The spray-on application is comprised of a polyurethane base, layer of light absorbing chemicals and a waterproof sealant. Paths with this treatment look like an ordinary surface during the day, but glow in the evening guiding the way. The light absorbing chemicals absorb UV rays during the day, and release them in the form of a glow at night. The level of illumination is also responsive to the brightness of the sky surrounding it. While it won't provide light that enhances the visibility of all things within its vicinity, this application is effective in showing where a path goes.

This product requires no construction to install, which minimizes costs, time, and disruptions to habitat and citizen commute patterns. It also doesn't require a connection to electricity or the ongoing cost of electricity to power the lighting. This product was conceived of at a time when many local governments in the United Kingdom were turning off park and pathway lighting at night as a cost saving measure. While the illumination level isn't high enough to remove street lighting, it was determined sufficient enough to show where a path goes and to see what is ahead.

Pro-Teq's StarPath was piloted in Christ's Pieces open space in Cambridge, UK. This material was applied to approximately 1,600 square feet of path within the park at approximately $10.50 per square foot. It took approximately four hours from start to finish to apply the application on the path and allow for drying. It was reopened to the public that day. This particular application was installed in an urban setting. It is most likely not appropriate in areas with sensitive wildlife habitat.

### Solar Powered Studded Path Lights

Similar to StarPath, this solution will not light the areas around the path, but can help to provide direction on where the path goes. Saris, a company that makes these lights, suggests that they can "help enhance the bicyclist [or pedestrian] experience by providing supplementary markings and visual cues to lead the bicyclists along an unlit path…"[xxiv]

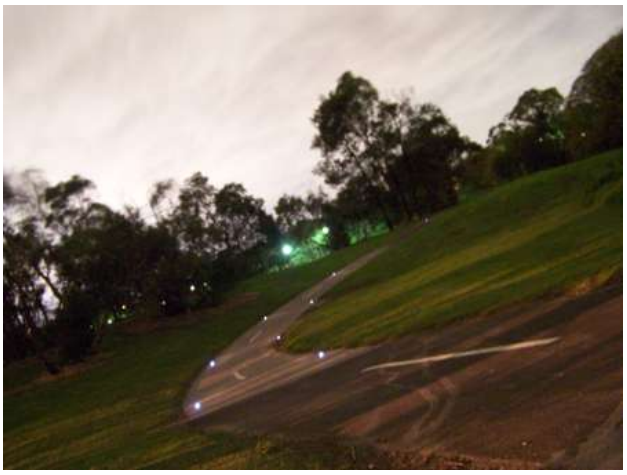

**Image 15: These path lights help show where the path leads, but don't illuminate the surrounding areas.**

At approximately seven millimeters tall, these guide lights are designed to lay flush within the ground of a path or road. Solar cells embedded in the tops of these studs charge battery packs, which later supply energy to the lights. The lights have sensors which allow them to turn on and off based on the sunlight patterns of the day. The batteries within the devices are estimated to last between five and ten years. The devices have been designed to withstand the impact of snow plows and other maintenance vehicles. The plastic on the tops of these studs are textured to ensure that they are non-slip. The lights and the epoxy necessary to install them cost approximately $140 each.

These lights were piloted in both Portland (on SE Couch near the Burnside Bridge approach), Chicago and on a trail in Fitchburg, Wisconsin.[xxv,xxvi] Similar lighting can also be found on the Gardiner Trail in Ashburton Australia.

**Image 16: On a winding section of the path, these studs highlight the edges.**

## CONCLUSIONS

Lighting trails can help create a space where people feel safe and secure, which can significantly increase a trail's potential. As congestion, greenhouse gas emissions and health problems continue to soar in communities; well designed trails can entice people to choose active transportation as a means of travel. Lighting on trails should be considered as part of a well designed trail.

Adding lighting to trails does pose challenges and concerns that should be carefully weighed and addressed. The cost of adding and operating lighting systems is one concern, and the overall cost of the trail and its use should be a guide. Lighting trails can impact wildlife habitat and must carefully be addressed. The illumination of private property and the potential invitation of loiterers are additional concerns that must be addressed; design treatments can be effective to block unwanted light and minimize dark shadows, for example. With careful planning and selection of lighting these concerns may be minimized and the benefits, including higher levels of utilization, can be realized.

A review of existing standards and literature found that there is a lack of information on this topic. Standards tend to highlight where, at a minimum, lighting should be included in trail projects or they consider it an amenity that might make a nice addition. These documents fail to provide information on what factors might make trail lighting a wise investment.

Lighting on trails provides benefits to trails users and should be considered as an important element when trails are being built or improved. During the planning phase, the public should also be consulted to understand how the addition of lighting might impact their use of the facility. Context is important; not all trails in the region would benefit from lighting. Trails that play a major role in commuting or that connect neighborhoods to activity nodes should be lit. Trails that are used to provide a direct connection to transit should also be lit. Trails that run through more natural and scenic areas, might not necessitate lighting because they are likely used in a less utilitarian manner.

## APPENDIX 1- TRAIL LIGHTING EXISTING STANDARDS

The following standards were reviewed to get a better understanding about how trail lighting is regarded in the region and across the country. This is in no way a comprehensive scan of all possible standards present across the nation, but a sample. Those agencies with standards in place tend to suggest that lighting be in places where user volumes necessitate it and at key places along a trail including trail heads, on bridge and in tunnels.

### National/State Level

#### AASHTO's "A Policy on Geometric Design of Highways and Streets"[xxvii]

This particular guide does not provide guidance on trail lighting. There is mention to lighting in the pedestrian zone, which could be considered fairly similar. The standard was:

> "Provide lighting and eliminate glares sources at locations that demand multiple information gathering processing."

#### AASHTO's "Guide for the Development of Bicycle Facilities"[xxviii]

This AASHTO guide lacks direct guidance in regards to trail lighting, but includes information about pedestrian-scale lighting. Areas identified as key locations for lighting include intersections where roads and pathways intersect, in tunnels and through underpasses. It also suggests that reflective edge lines be used in areas that are not lit. AASHTO highlights that trails with lighting do not need to be lit at all times, and can instead be used to facilitate travel and recreation during certain hours.

The guide also provides some guidance on the types of lighting that should be considered. For example, lighting should be placed on poles that are an average of 15 feet in height and should be spaced close together to avoid dark spots. Because "white light" helps to facilitate better user recognition, AASHTO recommends metal halide light bulbs over high pressure sodium vapor bulbs. AASHTO also suggests that solar energy is an acceptable power source, but it should be carefully evaluated ensure that the area has adequate sun exposure throughout the year.

#### WisDOT's "Wisconsin Bicycle Facility Design Handbook"[xxix]

The Wisconsin Department of Transportation's standards state that:

> "Lighting for shared use paths is important and should be particularly considered where night use is expected, such as on urban and suburban paths serving college students or commuters, especially those consistently serving both pedestrians and cyclists. Even where lighting is not used for the path itself, lighting of intersections at trails and roadways should be considered. Lighting should also be considered through underpasses or tunnels, overpasses or bridges, and when nighttime security could be an issue."

WisDOT also highlights the importance of uniformed illumination to avoid hot spots of light that can temporarily compromise night visions and to avoid deep shadows, which provides spaces for unsafe activities to occur. They also prefer that lighting be shielded in order to avoid spilling light onto areas not on the path. Similar to AASHTO, WisDOT standards call for pedestrian-scaled lighting approximately 15 feet in height.

It is useful to note that WisDOT has a state trail pass program that created revenue to fund and maintain trails. These passes must be purchased for $20 a year by individuals wanting to ride a bicycle or ski on certain trails. It is likely that some of this funding is used to provide and maintain lighting.

### MassDOT's "Chapter 11- Shared Use Paths and Greenways"[xxx]

The Massachusetts' Department of Transportation's advice on lighting is fairly limited and is a combination of AASHTO and WisDOT standards. The following guidance was provided:

> "Lighting for shared use paths is important and should be considered where night use is expected, such as paths serving college students or commuters, and at highway intersections. Lighting should also be considered through underpasses or tunnels and when nighttime security could be an issue."

### Hawaii DOT's "Toolbox Section 7: Shared Use Paths" [xxxi]

Hawaii DOT takes a context sensitive approach to the lighting of trails. They suggest that paths that are frequently used during the nighttime hours strongly be considered for lighting, but caution against lighting trails in more remote areas due to issues regarding personal security. Hawaii also stresses that lighting should be designed in a way that minimizes impact on surrounding neighborhoods and that it is in accordance with dark sky ordinances.

Their standards call for pedestrian scaled lighting 12 to 15 feet in height or bollards. Lastly the standards cite the use of a 4 to 6 inch wide white edge line on the trails as a useful addition to better define a path's edge.

### Iowa DOT's "Statewide Urban Design and Specifications Design Manual"[xxxii]

The Iowa DOT was the first standard found that acknowledges the role that lighting can play in avoiding collisions between users and obstacles along a trail. It suggests that trails that expect high nighttime use, typically trails frequented by commuters and college students, be lit. At a minimum, the standards suggest that lighting be used in underpasses and tunnels and in areas where nighttime security is an issue.

## Oregon State/Regional

### ODOT's "Bicycle and Pedestrian Design Guide"[xxxiii]

ODOT suggests a context sensitive approach to lighting trails and shared-use paths. They suggest that the need to illuminate be based on the location of the path, the purpose for lighting and the light pollution that could be created. If a trail runs parallel to a well lit road there may be less of a need to light it when compared to those in isolated areas. If the trail or path has a history of unsecure behavior happening on it, ODOT recommends consistent lighting throughout the entire facility. If there is more of a concern over user safety, ODOT defaults to AASHTO standards of lighting at key intersections and access points.

They also acknowledge that there may be competing needs and desires in regards to lighting a trail. The standards discuss lighting for safety and security reasons, but balancing that with fear of light pollution and compliance with Dark Sky Ordinances. They suggest that the solution "to satisfy these often competing needs is to illuminate the path only in the evening with a sign telling users when the lighting will be turned off."

### ODOT's "Traffic Lighting Design Manual"[xxxiv]

ODOT's Traffic Lighting Design Manual provides guidance on bikeway and pedestrian path lighting. Their standards call for a "shoebox" styled fixture with high pressure sodium lamps. Their standards stipulate that lights should be mounted at 30 feet, as anything lower is prone to vandalism. Lights mounted within tunnels and overpasses should also be carefully selected to ensure that they are vandal resistant.

### Oregon Parks and Recreation Department's Oregon Statewide Comprehensive Outdoor Recreation Plan[xxxv, xxxvi]

The last two plans (2008-2012 and 2013-2017) made no direct recommendations on whether or not trail lighting should be considered. The 2008-2012 plan recommended that a pilot program be carried out to see if the addition of lighting on high-trafficked trails "would significantly increase trail use during evening and early morning hours and among women." It is unclear if this work has been carried out.

The 2013-2017 plan considers lighting a trail amenity. It suggests that trails may "include amenities such as directional and control signage, gates, benches, overlooks, drinking fountains, lighting, trailhead kiosks and interpretive signs."

### Metro's 2014 Regional Active Transportation Plan[xxxvii]

The Regional Active Transportation Plan suggests that trails that serve as a major transportation corridor be lit to improve safety and increase use. It acknowledges that cost and issues of light pollution may pose a challenge.

> "Lighting of trails and paths that serve as transportation corridors is desirable. Most trails in the region are not lit. However, those that are seeing more and more travel for transportation purposes may be lit to improve safety and continue to increase use. Lighting increases and expands the use. Low impact lighting should be used as necessary to avoid impacts on neighbors and wildlife. Lighting paths can be

expensive, but can make a path more accessible and useful for transportation purposes."

### City of Wilsonville's Department of Public Works Standards[xxxviii]

While the City of Wilsonville's standards do not stipulate if and when trail lighting should be included in a project, it does articulate a number standards in regards to lighting levels and design. In regards to luminance and uniformity values, the standards default to American National Standard Practice for Roadway Lighting (RP-8-00) prepared by the Illuminating Engineering Society (IES). Lighting on the trails should be pedestrian scale, with lights mounted no more or less than 10 feet from the ground and pedestrian level lighting, such as bollards are prohibited. Additionally, the luminaries and lighting picked must be in conformance with city-adopted Dark Sky policies.

Unlike most standards in place, the City of Wilsonville makes a specific provision for trails that run through designated natural resource and wildlife areas. In these areas, the City Engineer can authorize a reduction in the prescribed lighting standard or not require lighting of the shared-use path if determined it would be detrimental to the ecological habitats.

### City of Beaverton's Engineering Design Manual and Standard Drawings[xxxix]

The City of Beaverton's Engineering Design Manual articulates why and under what conditions lighting is appropriate and the standard levels of illumination necessary. They acknowledge that lights can help reduce conflicts on shared-use paths and allow users to more safely see surface conditions and obstacles. Lighting should be seriously considered on trails that serve commuters, provide direct access to transit and that intersection with highways. The manual also calls for lighting at underpasses and in tunnels and along locations that present a security concern.

Similar to the City of Wilsonville, Beaverton acknowledges the inherent conflict between lighting and wildlife habitats. In these areas, the City and natural resource agencies must work together to determine whether or not lighting along the path would be appropriate.

Guidance on technical specifications are also included in the manual:

> "Depending on the location, average maintained horizontal illumination levels of 0.5 foot-candle (5 lux) to 2 foot-candles (22 lux) shall be considered. Where special security problems exist, higher illumination levels may be considered. Light standards (poles) shall meet the required horizontal and vertical clearances. Luminaires and standards shall be at a scale appropriate for a shared-use path."

### Council Creek Regional Trail Master Plan[xl]

The Council Creek Regional Trail Master Plan considers lighting an amenity that may be added to the facility. Also listed as an amenity are bridges, boardwalks, signage and trail furniture.

### TriMet's Design Criteria[xli]

While TriMet does not build trails, it has a number of standards regarding pedestrian scaled lighting in the public right of way. The standards acknowledge that lighting is not a one size fits all approach, but instead the design and selection of lighting systems must be considered in their individual context. Mid-level (10-14 feet) lighting is required at all pedestrian access points to stations and station facilities. Lighting is also required at trackway intersections and where pedestrian activity is high adjacent to the tracks and where crossing are not well defined. Of particular concern to TriMet is the glare from lights that can affect their operators' visibility.

### Additional Plans

The following plans were reviewed and did not have a specific mention to trail lighting:

- THPRD's Trail Plan for the Tualatin Hills Parks and Recreation District
- Portland Parks and Recreation's Trail Design Guidelines for Portland's Park System
- North Clackamas County Parks and Recreation District's 2014 Master Plan
- City of Hillsboro's Trail System Master Plan
- City of Gresham's Parks and Recreation, Trails and Natural Areas Master Plan
- SMART's Transit Master Plan

# APPENDIX 2- LIGHTING OPTIONS

**Things to consider when selecting lighting:**

Once the decision to install lighting on a path is made, there are still a number of decisions that need to be made in regards to lighting. These include the type of lighting you will use, the source of the light's power, types of fixtures, etc.

## Types of Bulbs

There are four main bulbs that can be used for street and pedestrian scaled lighting available for purchase on the market today. Each has its own advantages and drawbacks. They differ in costs, illumination levels, lifetime expectancy, etc. Many communities have a preference in the types of lights that are used in public spaces today.

*High Pressure Sodium*

**Lighting Statistics:**
Color Rendering Index: 20-30
Lumen/Watt: 80-140
Bulb Life: 24,000 hours

High pressure sodium light bulbs are the most common bulb used in street lighting today. This bulb was developed and brought on to the market in the 1960s, making it well tested. Their adoption is most common because they are perceived as low-risk. HPS bulbs have a lower initial cost than other bulbs, but may have a shorter life span. This type of lighting uses a combination of sodium, mercury and xenon, which when combined with a spark of energy create the light. This combination of chemicals makes disposing of these bulbs after their useful life extremely difficult.

HPS bulbs have better color rendering and bulb life than its predecessor, the low pressure sodium bulb. It is also smaller allowing it to fit into a greater variety of fixture. Other lighting sources like LEDs are considered more efficient and have even better color rendering than HPS bulbs.

*Metal Halide*

**Lighting Statistics:**
Color Rendering Index: 90
Lumen/Watt: 65-115
Bulb Life: 10,000-20,000 hours

Metal Halide lighting is most commonly used in buildings with high ceilings (warehouses, big box retail, etc.) and in street and stadium lighting. This lighting scores very high on the color rendering index coming close to being able to simulate daylight lighting conditions (only spotlights and search lights are brighter). While this provides a well-illuminated area, it also prompts concerns regarding light pollution and the disruption of nocturnal species. A high cost per bulb has made the wide-spread adoption of these lights challenging.

Similar to HPS lighting, this type of bulb contains a mixture of chemicals (most commonly argon, mercury and metal halide salts) that when introduced to a high voltage of energy produce light. The use of mercury makes this type of bulb very difficult to dispose of once it is no longer useful.

*Light Emitting Diodes (LED)*

**Lighting Statistics:**
Color Rendering Index: 70
Lumen/Watt: 28-150
Bulb Life: 25,000-100,000 hours

While LED lighting has been around since the 1960s, it has most commonly been used as indicator lights in electronics. In the 1990s, the ability to create white illumination through LED made it more feasible for lighting purposes. This technology is still evolving and is getting more efficient and reliable. This rapid pace of advancements in the technology, however, makes some apprehensive to adopt it as future advancements may render the lighting obsolete rather quickly. They also have a higher up-front purchasing cost than other lighting source options, but require less electricity to run and have a much longer lifespan.

LEDs work when voltage is applied to a semi-conducting element. This voltage causes electrons (with a negative charge) to move towards positively charged "holes." As these two components move across the semi-conductor, they combine in the middle releasing energy in the form of light. This light is funneled through a single point source creating a bright, concentrated light. This focused nature helps reduce the possibility and effects of light pollution. Because LEDs do not need a bulb to house the lighting components, LEDs are thought to be more durable and shock proof.

*Induction Lighting*

**Lighting Statistics:**
Color Rendering Index: 80
Lumen/Watt: 65-87
Bulb Life: 85,000-100,000 hours

Induction lighting is a type of fluorescent lighting. Similar to LED lighting, this type technology has been around since the 1960s, but was introduced in a wider context in the 1990s. Unreliability in supporting technologies and a high cost per bulb have stagnated the widespread adoption of these lights. The ballasts, which regulate the lights' current and provide the necessary start up voltage, were designed over 20 years ago and are prone to failure. This usually means that the lights' supporting technology will fail before the bulb itself. If the ballasts had a more useful lifespan, the induction bulb would have the longest span out of the four commonly used bulbs.

Induction lighting uses an electromagnetic field to excite mercury particles that are infused in an inert gas. (Unlike HPS and metal halide lights, this mercury is in an amalgam form making it stable.) This creates a UV light, which is filtered through a phosphor located in the bulb to create the visible light. The use of an electromagnetic field to create the lighting emits a noise on the radio frequency, limiting where it can be installed.

## Lighting Power Source

*Wired*

Wired lighting is the most common power sources used today. This requires connecting the lighting fixtures to the electric grid, which can be quite expensive. Electrical wires must be extended from their current location to and throughout the lighting system. Most commonly the wires are buried underground, which require trenching the area. This can be costly, time intensive and disruptive to the surrounding habitat. Overhead wiring is possible, but has a much higher potential for damage. Wired lighting does ensure the most reliable source of power as it pulls from the grid, but that reliability carries with it an energy cost that the city or trail provider must cover.

*Battery*

Battery operated lights have the lowest installation costs, because they require less technology than solar and don't need to buried like wired lighting. Battery operated lights are, however, likely to cost more over the life span of the lights, because the batteries would need to be replace at a much greater interval than maintenance on a wired or solar system might necessitate. Battery powered lighting also raises a sustainability concern regarding the disposal of batteries after their useful life. Battery operated lights aren't recommended on trails with low volumes of utilization, because it can be difficult to gauge when a battery may run out. In low-volume areas, this could go unnoticed for some time, resulting in a drop in security or safety.

*Solar*

Solar powered lighting requires the installation of solar panels, which gather energy from the sun during the day and store it in a rechargeable battery. At night, the lights pull the energy from the battery to power the lights. Most solar powered systems are capable of storing enough energy for multiple days. While more costly to install than battery-powered lights, these systems have a lower continual operating cost and less of an impact on the environment. In areas with dense tree canopy or regions with limited sun exposure during the winter months, these systems may not be feasible.

## Other things to consider

*Motion Activated*

Motion activated lights use sensors and communication technology to sense when people are passing through and adjust the level of lighting accordingly. Many system set their lighting to low levels of illumination (approximately 20%) when no one is passing through and brighten to higher levels of illumination (approximately 80%) when a person is detected. These systems reduce the impacts of light pollution and can save energy.

Motion activated lighting was installed on the County Kerry Recreational Path in Tralee, Ireland, as a way to lower levels of carbon dioxide emissions and levels of light pollution. The municipality reported a 60% decrease in energy utilization after the system was installed.

*Mesh Network/Smart Technology*

Smart technology allows lights to communicate with an off-site lighting dashboard or vice versa. Communication from the dashboard can allow operators to remotely adjust the level of lighting emitted from each light. Communication from the lights themselves can provide real-time information on outages, allowing issues to be fixed in a timelier manner.

For more information on lighting types and their potential tradeoffs, the following resource is recommended: *Life Cycle Assessment of Streetlight Technologies* by the Mascaro Center for Sustainable Innovation.[xlii]

Appendix 3-Correspondence

We talked with the following people throughout August and September of 2015:

- Robert Spurlock, Parks Planner at Metro
- Lori Hennings, Senior Natural Resource Scientist at Metro
- Steve Gulgren, Superintendent of Design and Development at Tualatin Hills Parks and Recreation District
- Michael Janin, Superintendent of Design and Development at Tualatin Hills Parks and Recreation District
- Katie Dunham, Senior Planner at North Clackamas Parks and Recreation District
- Kelly Clarke, Senior Transportation Planner at the City of Gresham
- David Daly, Civil Engineer at the City of Gresham
- Jordon Orsor, Region 1 Signal and Illumination Engineer at Oregon Department of Transportation.

Additionally, email correspondence about trail lighting design guidelines and standards were exchanged with:

- Jeffrey Owen, Active Transportation Planner at TriMet
- Jen Massa Smith, Program Manager at the City of Wilsonville's SMART Transit
- Chris Neantzu, AICP, Planning Director at the City of Wilsonville

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**Image 1**: http://www.indianapolismonthly.com/news-opinion/introducing-the-light-fantastic/

**Image 2**: Lake McTighe

**Image 3**: Lake McTighe

**Image 4**: Lake McTighe

**Image 5:** Lake McTighe

**Image 6**: Lake McTighe

**Image 7**: Lake McTighe

**Image 8**: Lake McTighe

**Image 9:** https://www.environment.fhwa.dot.gov/strmlng/newsletters/sep13nl.asp

**Image 10**: http://lightingcontrolsassociation.org/page/47/

**Image 11**: http://www.schreder.com/en-aes/Projects/Pages/Grand-Canal-Dublin.aspx

**Image 12:** http://livinthehighline.com/wp-content/uploads/2011/05/Lights2.jpg

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