Post Office Box 566
Closter, New Jersey 07624-0566

Analysis of Steamboat Ski Resort Photometric Layout

Overview –

In response to a reconfiguration of slope and infrastructure topology at Steamboat Ski Resort, a series photometric studies were developed to ensure consistency between original lighting levels and revised plans. It should be noted that photometric studies are distinct from photometric surveys in that studies are always *simulations* derived from computer modeling whereas surveys are actual light meter readings taken in the field: i.e., at the site. There are several light simulation models. Results can vary from one model to another. For consistency, the model used for the original 2013 study and the current layout was/is AGi32. At the time of the original study and subsequent installation, the only technology capable of a hard cut-off at the property line and other slope boundaries was Snow-Bright™ magnetic induction lighting (MIL).

Initial 2013 Photometric Layout –

Ultra-Tech™ Lighting (UTL) representatives attended several meetings with Steamboat Ski Resort personnel and members of the Steamboat City Counsel and Planning Board in 2013 to review proposed Snow-Bright™ lighting for lower mountain slopes. Photometric studies were conducted for proposed areas and slope boundaries were *surveyed* to determine preexisting light levels being projected from south side condominiums toward adjacent slopes. This survey generated data for determining an effectively neutral impact of proposed lighting on and beyond the property line. When there is no increase in lighting levels, the result is effectively “zero:” Effective Zero. UTL produced a 1-page explanation of “Understanding Effective Zero” to provide background for interpreting photometric layouts attached to this report.

The pre-installation survey along the southern property line revealed lighting levels in foot candles (fc) between 0.5 and 0.1fc. This provided a lighting design objective to maintain lighting levels within this range. Further, the full cut-off features of Snow-Bright™ technology was incorporated in the design to make sure lighting levels would not be additive. In the post-installation survey, pictures along the property boundary were taken to substantiate a zero effect along the southern property boundary and other boundaries.

Bear Claw Property Boundary Southeast

The picture demonstrates how light coming from Bear Claw Condominium illuminated the back side of contours that would be more completely shadowed. Lighting levels for current installation are between .05fc and .01fc at the property line. A distinct feature of Snow-Bright™ technology is the hard cut-off of lighting intensity at the edge of the slope boundary; i.e., berm between slope and property boundary.

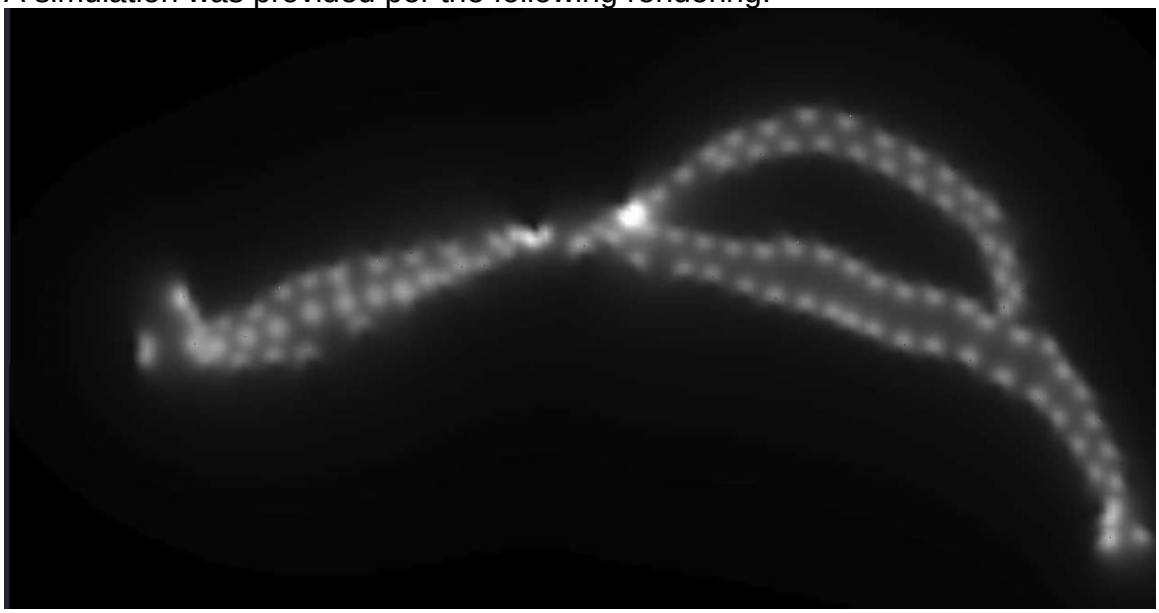
In particular, high intensity light emitting diode (LED) walkway lighting projects from Bear Claw and other condominiums onto slopes. The net effect of combined lighting from both directions is zero, meaning within lighting levels existing in 2013 before the lighting installation.

Light is also projected from north-facing condominium units toward slopes. These light sources were responsible for ambient lighting levels in excess of levels that are naturally occurring from moonlight that can be as high as 0.05fc during a full moon on a clear night. This was addressed in responses to the June 18, 2013 letter from Bob Keenan, Senior Planner (city) to Doug Allen, VP of Steamboat Ski & Resort Company, attached to this report as Exhibit 1.

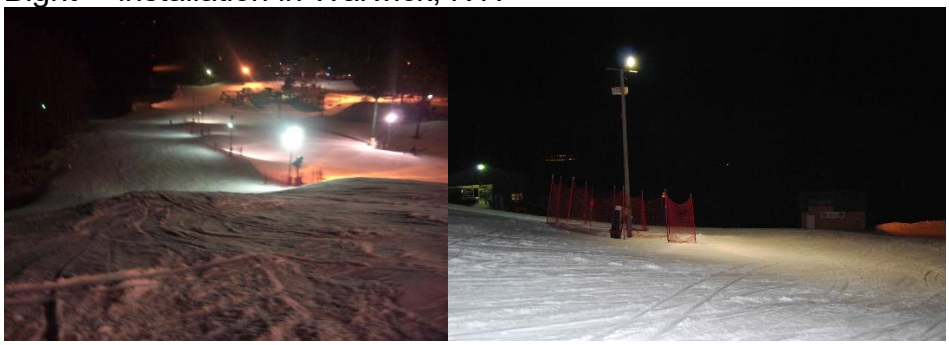
The letter brings up the following pertaining to lighting:

- James Haskins of the Department of Wildlife raised the possibility of wildlife impacts. A paper covering this issue was provided for Mr. Haskins and is attached as Exhibit 2.
- Bob Keenan requested:
    - A photometric study (simulation)
    - Visual examples
    - An explanation of Effective Zero
    - Legend explanation for photometric layout
    - Minimization of light encroachment (explained by Effective Zero)
    - Access lighting plan

A simulation was provided per the following rendering:



Visual examples included before and after pictures of the Mount Peter Snow-Bight™ installation in Warwick, NY.



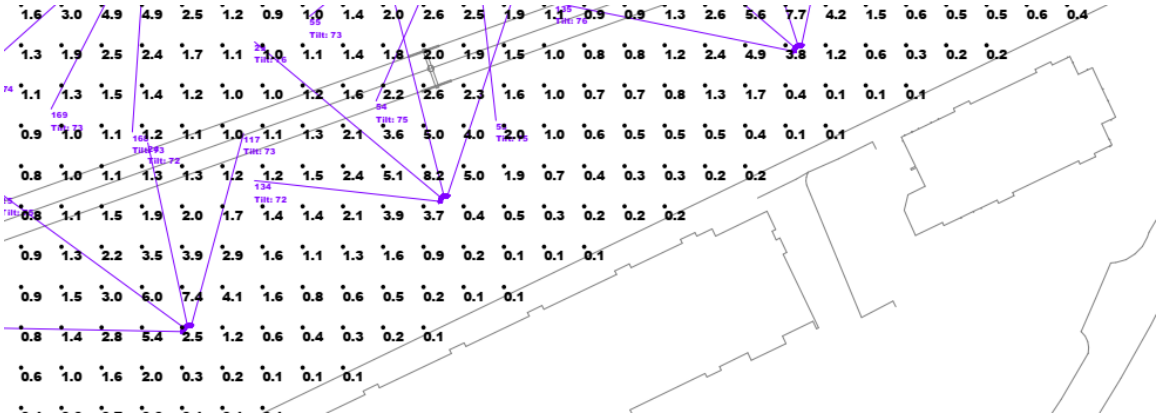
Before After

An Effective Zero explanation was provided and is attached as Exhibit 3.

The 2013 final submission included a legend and details for the layout. This included demarcations for Effective Zero.

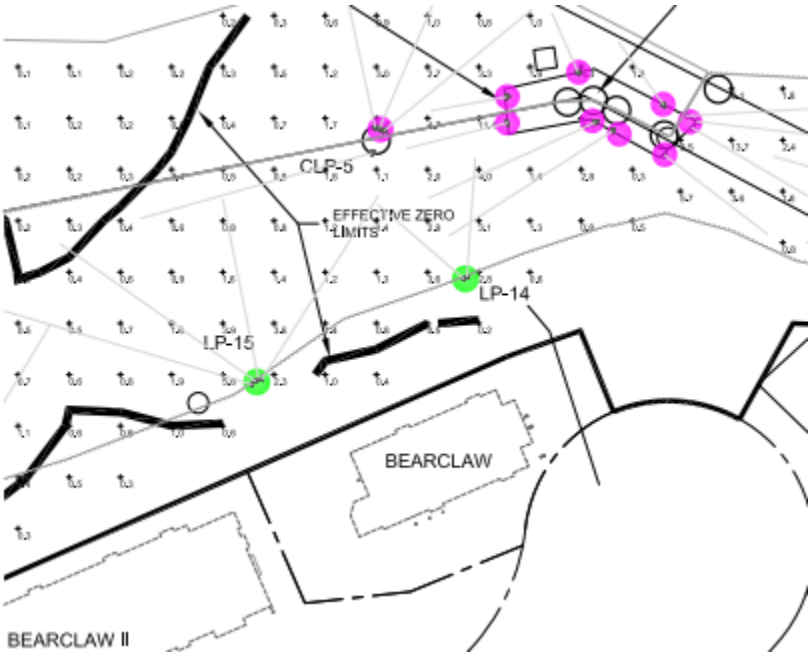
Lighting for access to the slopes appears on the 2013 submission.

Revised 2022 Photometric Layout –



Revised 2022 Lighting Study

The revised 2022 lighting study adheres to the same effective levels of 1) the submitted 2013 filing and 2) the surveyed post-installation levels. Levels range between 0.1fc and 0.04fc.



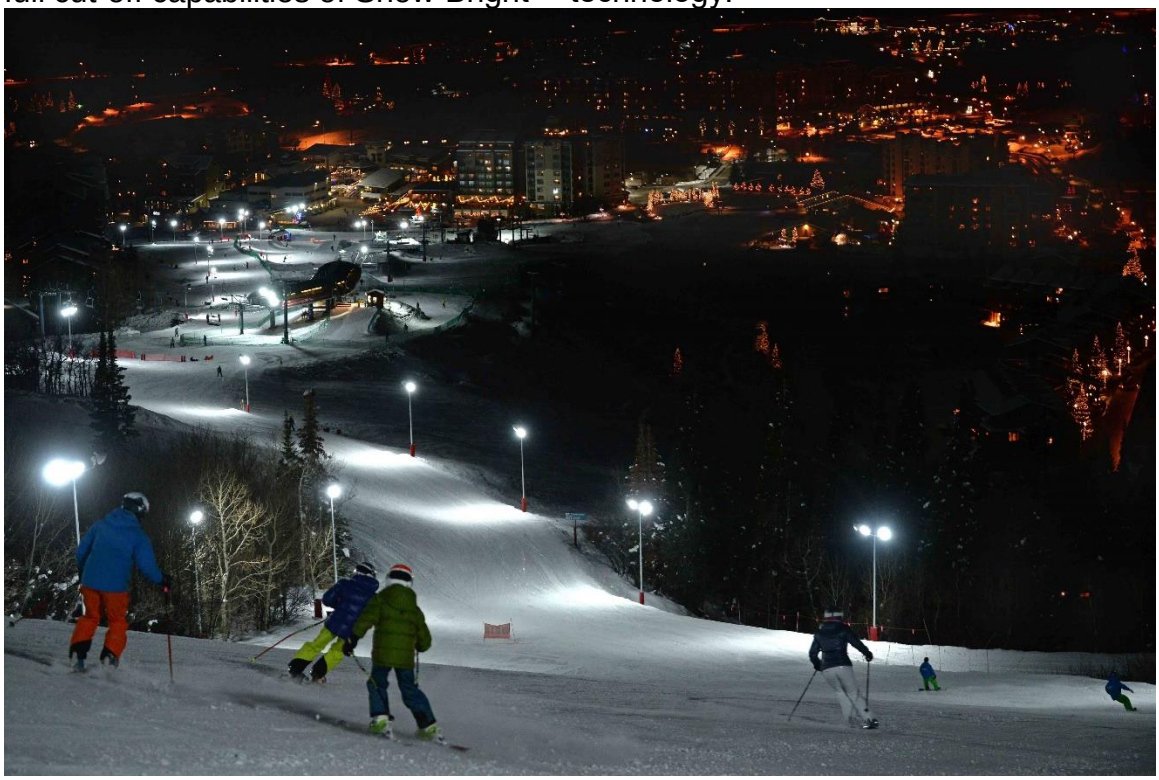
Original 2013 Lighting Study Submittal

The original 2013 lighting study displays levels for the same area from 0.3fc to 0.8fc. The 2013 study includes “Effective Zero” delineations between the slope boundary and property line. Comparisons of the 2013 and 2022 studies show de minimis differences. The two studies are visually indistinguishable. This is based upon studies conducted by MIT and Columbia University that determined a single candle can be seen from far distances and is substantially *more intense* than viewing the star Vega on a clear night. Dispersed light below 0.5fc is not sufficient to read a book. Although moonlight can illuminate a ski slope, it is also not sufficient for reading.

Conclusion –

Keeping in mind that photometric studies are computer simulations and any change in a lighting configuration will affect simulation results, comparisons of the Steamboat Ski Resort slopes and property boundaries will remain visually the same from the 2013 submission and 2022 revision. Any lighting consultant should conclude that levels are insignificantly variable.

The 2022 study conforms to the 2013 levels and in accordance with an Effective Zero boundary between properties. Pictures of the actual installation show the full cut-off capabilities of Snow-Bright™ technology.



Areas behind light show total darkness past the berm drop-off from the top of the illuminated slope to the bottom and along the condominium property boundaries. It should be noted that pole locations to the north of condominiums are not changing. Thus, proposed lighting reconfigurations will not change levels along

property or slope boundaries to the extent of being visually noticeable. Given the removal of fixtures from the south-facing side of the planned lift station relocation, light dispersion in the direction of Bear Claw will be further minimized.

Exhibits are integral to this report.

♦♦♦

www.ultratechlighting.com
(201) 784-1233 NJ Office
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EXHIBIT 1

City of Steamboat Springs

Department of Planning & Community Development

June 18, 2013

Doug Allen
Steamboat Ski & Resort Corp.
2305 Mt. Werner Circle
Steamboat Springs, Colorado 80487

Re: TAC Comments – Steamboat Lower Mountain Lighting DPF-13-01

Dear Doug:

The Technical Advisory Committee (TAC) has reviewed your Development Plan/Final Development Plan for the lower mountain lighting proposal at the Steamboat Ski Area. The following summarizes the comments received from TAC members at this time. Please provide a written response to all of the following comments below and revise plans where necessary.

Please feel free to call me with any questions.

Routt County Building Department – Carl Dunham

Engineered plans and a permit required.

Colorado Department of Wildlife – James Haskins

Local CPW staff has looked at the potential for wildlife impacts from the proposed activity. At this time we do not believe there are significant issues. We would point out however that there are a small number of elk and moose that winter adjacent to the ski trails on Mount Werner each year…

City Engineer – Danny Paul

Comments that are required to be addressed prior to Public Hearings:

1. Comments made for a specific plan sheet or report may necessitate changes in other locations of the submittal.
2. Revisions to current submittal may result in additional comments or requests by Public Works.
3. Show the existing 78" Burgess Creek culvert and provide a minimum of 10 ft offset from outer edge of culvert to light poles (LP-1 and LP-2)

Comments for informational purposes:

4. A Grade & Fill permit shall be required with this project if needing to create access roads to facilitate the installation of the light poles.
5. A Colorado Department of Public Health & Environment Construction Stormwater permit may be required for this project if total disturbance associated with the project exceeds one acre (including access roads).
6. Coordinate light placement with all underground utilities and infrastructure installed as part of the Base Area Promenade & Burgess Creek Daylighting improvements.

Fire Prevention Services – Jay Muhme

No comments.

Planning Services – Bob Keenan

Planning and Public works staff would like to meet with you to go over some of these comments. Please give me a call and we can setup a meeting at your convenience.

1. Surrounding Property Owner Notice – It appears that there is still some work that needs to be done on the map and identified owners to meet the CDC noticing standards. The Code requires that all parcels within 300' of the subject property be notified. Looking at the map, it appears there are some properties missing. Also, the Code requires that all property owners be notified or the board of directors.

   Staff strongly suggests that all property owners be notified. Identifying the board of directors of all the multi-family projects along the base can be very difficult and notification of just these individuals can be problematic as they may not get the word out to their homeowners.

   There was also some previous discussion about having Ski Corps. conduct an open house prior to public hearings. Is this something you are interested in?

2. Use- Skiing is classified as a Recreation Outdoor and that is a Conditional Use in the OR zone district. Staff finds that this is an expansion of your existing use and needs to be approved as such through this process.
3. What are your proposed hours of operation and dates of operation?
4. Please provide a photo simulation or computer modeling for both day and nighttime that visualizes the changes that are to be made to accommodate the proposal. Please provide an illustration/specification of the fixtures to be used for both pole and building mounted lighting.
5. Please provide other visual examples of the proposed lighting similar to what is proposed in the Snow-Bright brochure.
6. Please help us understand what is meant by "effective zero"
7. Please provide a legend on the photometric plans. What does the brown line mean? Are these values foot-candles or lumens?

8. Based upon the photometric plans, it appears that there is a small amount of light trespass on adjacent properties along the south side of the lower base area. Can this be eliminated?
9. Please depict pedestrian circulation and lighting that will be used to accommodate your customers for night skiing.
10. Please indicate where parking will occur.
11. How will the lighting be installed?

Please contact me at (970) 879-8260 if you have any questions or concerns.

Sincerely,

Bob Keenan, CFM
Senior Planner

CC: #DPF-13-01
Danny Paul, Public Works Engineer

EXHIBIT 2

Environmental Impact Upon Wildlife

CONFIDENTIAL AND PROPRIETARY

This document contains confidential and proprietary information regarding the spectral tuning of Snow-Bright™ lighting technology. It is not intended for general distribution. Materials contained in this document are solely for the purpose of evaluating Snow-Bright™ technology as it may impact nocturnal wildlife. This document is subject to updates and changes as new information and research becomes available.

Overview –

The most paramount design criteria for Ultra-Tech™ Lighting, LLC are environmental impacts. Along these lines, every major issue is carefully measured and addressed to provide the ultimate environmentally friendly lighting solutions for specific applications. Objectives include:

- Energy conservation
- Reduced carbon footprint
- Non-toxic and environmentally safe components
- Minimal light pollution
- Animal friendly spectral output
- Low heat profile
- Silent operation
- Instant on/off (no warm-up or cool-down)
- No flicker or harmonics
- Feature-friendly aesthetics

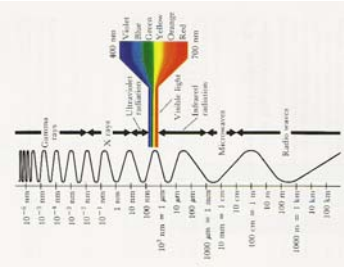
Since most ski areas are located in and around forest and park areas, particular attention was given to the spectral output of Snow-Bright™ lighting. Extensive research was conducted to determine what aspects of lighting intensity, color temperature, and spectral output might affect wildlife. Even the influence of sound that might be generated by the drivers (ballasts) was taken into consideration. Research was compiled into various design characteristics to strike a balance between lighting objectives and effectiveness and environmental impacts.

Vision Characteristics of Nocturnal Wildlife –

A wide range of wildlife considerations exist when designing lighting for snow recreation areas. Nocturnal wildlife includes mammals and birds. Although there are nocturnal reptiles, they generally do not make their habitat mountains and snowy regions. Exceptions include the Tiger Salamander (Ambystoma Tigrinum), Boreal Toad (Bufo Boreas), Boreal Chorus Frog (Pseudacris Maculata), Wood Frog (Rana Slyvatica), Western Terrestrial Garter Snake (Thamnophis Elegans) and the Snapping Turtle (Chelydra Serpentina). Since nocturnal reptiles generally avoid artificially lit areas, Snow-Bright™ lighting has negligible impact upon these species.

Common to most nocturnal mammals are retinas dominated by rod photoreceptor cells which detect shape and light intensity, but do not resolve color. Rod dominance is better in low light and is a feature shared by canines (dogs) and felines (cats). Many nocturnal animals have a reflective layer behind the retina called the *taptum lucidum* that acts to reflect light back onto the retina to intensify image resolution in low light. This exists among foxes, bobcats, cougars, wolves, deer and moose. This layer makes eyes appear to glow in the dark.

Bears are not specifically nocturnal; however, they have active lives during the day and night.



Bears have keen night vision, but share similar retinal characteristics with humans. Bears have both rods and cones and can resolve color in the human visual range from approximately 480nm to 720nm. The expression, “Sees like a bear,” is attributed to the sharp eyesight believed to be inherent in the American Black Bear.

Owls make up the majority of nocturnal birds and have very unique vision. The owl’s eyes are fixed forward in the head and are also rod dominant. The eyes are exceptionally large relative to the brain and capable of processing motion, and shadows. Owls do not resolve color well. They have extraordinary peripheral vision, but must move their heads to change their field of view. Most owls are disturbed by intense singular light sources. They are amenable to full moonlight.

Snow-Bright™ Interaction –

All nocturnal wildlife can be disturbed by artificial light at night. Bright light can be a distraction and may disrupt natural circadian rhythms. The first objective in designing night lighting for areas within wildlife habitats is to balance intensity and utility. This means producing the *minimal* amount of light necessary to accomplish the *necessary* illumination. Snow-Bright™ technology takes a unique and *new approach* by concentrating light within the visually effective range of the human eye while emphasizing spectral frequencies that most effectively reflect off the crystal construct of snow.

Crystals have the capacity to slow down and refract light. The “brilliant” characteristics of a diamond are attributed to the internal refraction within the gem. Water crystals have similar properties. By

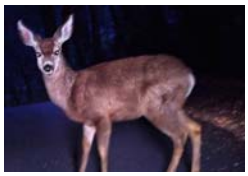
focusing the specialized Snow-Bright™ spectral output at the proper angle to the snow surface, the technology actually transmits light laterally much the same way as a fiber optic cable, but with refractory release along the way. This carefully designed feature reduces glare from the snow and creates an exceptional *glowing effect* that enhances visual acuity *from the snow surface.*

Wildlife presumably sees Snow-Bright™ as a modestly higher intensity than full moonlight on a clear evening. In sharp contrast to conventional lighting that uses high pressure sodium or metal halide bulbs, Snow-Bright™ fixtures can be directly viewed without significant discomfort. This is *impossible* with other modern lighting technologies like light emitting diodes (LEDs) or light emitting plasma (LEP) which will actually damage the retina if directly viewed.

Concerns that Snow-Bright™ lighting might attract wildlife because it does not produce the same "fear factor" as more intense conventional lighting are unfounded. Although animals and birds are less disturbed by gentle Snow-Bright™ lighting, they are sufficiently apprehensive about entering a lighted and active area to keep a safe distance. The important element is to prevent light *over stimulation* and avoid intensity that could be damaging to wildlife vision. Further, Snow-Bright™ fixtures are *full cut-off* which means they do not bleed or spread light beyond their intended focus area.

Specifically, the lower intensity of Snow-Bright™ lighting interacts in a far more healthful manner for animals with tapetum lucidium; the reflective membrane behind the retina. Since the purpose of this membrane is to reflect light back within the eye, the lower the lumen intensity, the *less disturbing and damaging* the light will be. Encounters with animals like the red fox, deer, and moose prove the point. In the case of the red fox, conventional lighting can attract, and then stun. This is demonstrated by a simple experiment where the light is directed at 90 degrees to the fox's path and then turned to face the animal. Snow-Bright™ lights do not have the same effect. The fox is undisturbed by the light intensity *even when directly focused*.

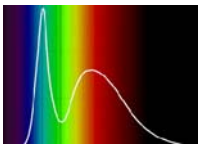
Intense light has a similar impact upon moose and caribou. The tendency is to attract first and then stun; hence, the expression, "A deer in the headlights." Typically, a 1,000W metal halide or 1,200W high pressure sodium light will be replaced with a 300W or 400W Snow-Bright™ fixture. The direct intensity may be reduced by as much as 60%, however, the "visually effective lumens" that can be detected by the *human eye* can be the same *or greater*. This is a major Snow-Bright™ difference. Skiers, snowboarders, and tubers can use the light most effectively while rod dominant species are minimally influenced.



Equally important, conventional lighting is characterized by a small concentrated light source (the bulb) that is dispersed from a mirrored reflector. This concentration is what tends to be damaging to the eye and most disturbing to animals that may become fixated by such intense light. In contrast, Snow-Bright™ light is produced by elongated circular or rectangular tubes that cover a wide area. For example, the diameter of a 300W Snow-Bright™ round magnetic induction bulb is 20 inches. The highly specialized dual-stage reflector uses a nano-

material that is exactly matched to the spectral output of the bulb and produces high dispersion and diffusion. This *softens* the appearance of the lamp for direct viewing and tends to be innocuous to nocturnal wildlife while, at the same time, producing the maximum visual experience for skiers and riders.

LEDs have become very popular, but are *not appropriate* for lighting snow. LEDs tend to have



a high blue and UV bias that can be dangerous for humans and many animals. The LED spectrum is generally concentrated in the lower region with *insufficient light* within the most visually acute areas for human vision. Even filtered LEDs are usually deficient in the transition into green and yellow which are the most reactive wavelengths for the human eye. The effect is called "Green Droop," and is inherent in all III-N LEDs. Although highly efficient, LED light for ski areas tends to be *overly intense* to compensate for a deficient spectral output.

Snow-Bright™ employs a full spectrum light with a color temperature of 6,500K. This is similar to overcast daylight. Certain proprietary tuning is used to create maximum contrast that brings out features like bumps, indentations, slope, distance, and contours. The specialized properties of spectral output, diffusion, focus, and luminance allow photometric designers to lower lighting intensity without sacrificing human visual perception. The principle when accommodating nocturnal wildlife is, "*Less is more!*" By way of example, a Snow-Bright™ 120W rectangular flood can replace a 400W high pressure sodium rectangular flood with less glare and more visual perception, saving more than 70% of the energy with an associated reduction in carbon footprint.

Sound emissions are also an important consideration. Many ballasts for conventional lighting produce a low pitch hum and/or high frequency noise. Of concern is sound pollution in the range of 20,000 to 120,000 hertz which is the frequency range used by bats. Snow-Bright™ drivers (ballasts) operate in excess of 150,000 cycles and are free from high levels of noise. The bulbs have no filaments or electrodes and are absolutely silent. High frequency sound can be disturbing to many canine species as well.

Conclusion –

Ultra-Tech™ Lighting has created highly specialized lighting with particular wildlife in mind. Port-Bright™ models are used to light ports, harbors, and waterways because they eliminate portions of the visual spectrum for sea turtles. Magnetic induction lights (MIL) can be designed to output any light frequencies at various intensities. In all instances where outdoor lighting is the objective, animal-friendly and neighbor-friendly design is a paramount consideration. For indoor lighting, Ultra-Tech™ Lighting has created fixtures that produce the Health-Bright™ full spectrum that has been associated with up 20% greater productivity among office and factory workers as well as students.

All artificial night lighting may influence nocturnal wildlife. The Snow-Bright™ design team provides the least obtrusive and most effective lighting for a very specific application… lighting snow surfaces. The highly reflective crystal white surface of snow presents particular challenges that are only addressed by Snow-Bright™ technology. Even the silence of Snow-Bright™ drivers (ballasts) was an important consideration for the welfare of bats that do not rely upon vision, but can be confused by high frequency hum and noise.

For more information call:
(201) 784-1233

EXHIBIT 3

UNDERSTANDING "EFFECTIVE ZERO" LIGHTING FOR SITE RENDERINGS AND PLANS

Overview –

Light pollution and light incursion issues are becoming increasingly important as communities become more concerned about adverse outdoor lighting affects upon property owners and nature. To address these issues, photometric engineers are using computer light simulation programs to provide predictive models for proposed lighting. In order to maintain accuracy, these models take the maximum expected ambient light into consideration, which is generally defined as full moonlight on a clear evening. This means that a zero effect of outdoor lighting on a photometric study will still take into consideration the ambient light expectation for the site.

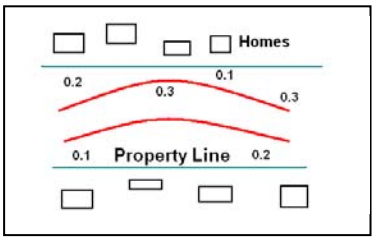
Understanding "Effective Zero" Lighting –

Depending upon the location, the maximum expected *natural* ambient light for any outdoor area will range from 0.2 lux at sea level to as much as 1.0 lux on a snow-covered mountain. The reflective nature of the area will determine luminance as it relates to the spectral output of the full moon. For example, a full moon reflecting off a body of water can increase ambient light levels measured on a white sandy beach.

A full moon reflecting off a water surface can increase ambient light measured at the water's edge

Snow is the most reflective natural surface; capable of picking up the specific moonlight spectrum; i.e. reflected solar light. When measured at increasing altitudes, moonlight tends to have a higher violet bias. This is why snow-covered mountains and fields take on an increasingly blue hue above 5,000 feet.

In addition to natural ambient light, accurate photometric studies may indicate the effects of surrounding artificial light sources such as street lighting or neighboring buildings. The combined impact of natural and ambient light will always be greater than 0.2 lux. This means that the effective range of a light source becomes zero when expected reflected levels drop to approximately 0.25 lux or less. This is generally referred to as "effective zero" since it is impossible to attain an absolute reading of zero.



When a 0.0 reading is displayed on a photometric layout, it usually means the area is beyond the data scope. Therefore, no reading is generated by the computer model. In residential areas, readings below 1.0 lux are considered ambient light. This implies that there is no net increase in light being generated by the artificial light source, even if the specific light source like a street lamp is visible.

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