MEMORANDUM

FROM: James Allen; Public Works Department, Plant Manager
Tom Kapushinski; Public Works Department, Senior Engineer
Diego Martinez Garcia; Public Works Department, Engineer

TO: Claire Raybould, Planning Department

PROJECT: Local Advanced Water Purification System

DATE: March 21, 2024

SUBJECT: Investigation of correlated color temperature (CCT) reduction at the Local Advanced Water Purification System located inside the Regional Water Quality Control Plant (RWQCP).

On February 28, 2024, the Planning and Transportation Commission held a regular meeting where the Local Advanced Water Purification System (Project) was discussed. The Commission recommended approval of a Site and Design Application to construct the Project at the Regional Water Quality Control Plant (RWQCP or Plant). A commission member requested an investigation to use 2700K correlated color temperature (CCT) lighting instead of the designed 4000K CCT lighting.

Background
Staff evaluated color temperature with the designer (Black & Veatch), a third-party specialty consultant (TJC and Associates), and independently at the staff level. The consultant's technical memorandum advising on color temperature for this facility is attached (Appendix A). The RWQCP is an essential industrial facility providing wastewater treatment services. Onsite workers perform duties day and night. Numerous workers provide services during night hours including operators, mechanics, electricians, laboratory staff, technologists, engineers, contractors, chemical delivery drivers, and so forth. All workers need to perform work safely during the night hours. The new facility under consideration has areas that need proper lighting due to continuous operation and maintenance needs (e.g., around highly hazardous chemicals, rotating machinery, and power distribution equipment).

Correlated Color Temperature (CCT)
Compared to warm colors, higher color temperature lighting details natural color and work environments more accurately. The proposed lighting gives Plant staff a more realistic view during night hours. High color temperature will provide better visibility and ultimately create a safer working environment by reducing the risk of accidents and injury. The higher color temperature lighting supports employee safety, consistent with the City's Injury and Illness Prevention Plan and industry standards.

A third-party electrical engineering firm and the designer recommended using a minimum CCT of 4000K following manufacturer Illuminating Engineering Society (IES) guidelines. Color temperatures between 4000K to 5000K benefit industrial facilities. This range provides brighter, natural-looking light, improves

visibility, enables worker awareness, promotes alertness, enhances focus, and increases productivity. Studies[1,2] show that white light stimulates wakefulness and heightened cognitive function by suppressing melatonin levels, keeping workers awake and alert. Conversely, warm lighting induces fatigue resulting in reduced efficiency and performance[1, 2] making them undesirable for industrial facilities. Warm light emits a less bright, yellow-orange light that can hinder worksite visibility.

Local AWPS Lighting Design

The AWPS provides illumination that is safe and functional for onsite staff as well as being designed to reduce illumination impacts on nearby areas. The design promotes alertness, high productivity, and visual discernment of details. The Project is equipped with onsite control panels, pumps, valves, and electrical gear that need continual attention. Additionally, multiple hazardous chemicals are required to keep filtration and reverse osmosis membranes running under optimal conditions.

Addressing light pollution is a growing issue. The RWQCP is sensitive to its proximity to the natural resources of the Baylands. The AWPS design keeps lighting focused within the project area and out of the Baylands. Using the DarkSky Association and the Illuminating Engineering Society guidelines, the AWPS lighting design incorporates five lighting principles for responsible outdoor lighting, including:

1) Useful – All light should have a clear purpose.

   The lighting design only includes external fixtures under the canopy and equipment area where workers need access to perform routine operations and maintenance duties 24/7.

2) Targeted – Direct light so it falls only where needed.

   The canopy ceiling lighting fixtures provide illumination targeted to the equipment area. The selected lighting fixtures provide a higher delivered footcandles in the work area, thereby avoiding light dispersion. On the north corner of the Project, there are pendant type lights installed in the roof structure with minor spill out towards the Project boundary. To further minimize light dispersion from the canopy, the Project includes an architectural aluminum panel to be installed in the upper canopy (Figure 1).

3) Low Level – Illumination design is code-based for an industrial facility like the RWQCP.

4) Controlled – Use light only when it is needed.

   The design incorporates provisions for timers, motion sensors, and photocells.

5) Warm-colored – Industry standard recommendation is around 5000K to promote safety and alertness.

[1] Ju, J., Chen, D. and Lin, Y. (2012). *Effects of correlated color temperature on spatial brightness perception.* Color Res. Appl., 37: 450-454. https://doi.org/10.1002/col.20711

[2] Huang, R.-H., Lee, L., Chiu, Y.-A. and Sun, Y. (2015). *Effects of correlated color temperature on focused and sustained attention under white LED desk lighting*. Color Res. Appl., 40: 281-286. https://doi.org/10.1002/col.21885


Figure 1. Architectural aluminum panel for increased screening and to prevent light dispersion

Local AWPS Lighting Study

During the AWPS design, the designer conducted lighting calculations[3] to determine point-by-point illuminance on any workplace or surface utilizing lighting fixture families and surface geometry present on the model. After receiving Architectural Review Board feedback, the design team updated the model to include a larger area outside the main canopy area. The results (see Appendix B) indicate a maximum illuminance of 21.7 foot-candles outside the canopy area with an average of 1.3 foot-candles. Areas near the boundary wall and the boundary with Embarcadero Road and contiguous properties show illuminances near zero foot-candles. The model also simulated illuminance as a function of height. The results indicate that there will be low illuminance in the north wall near the corner of the canopy at between 1.0 and 2.0 foot-candles with a maximum of 2.7 foot-candles. For instance, the average illuminance inside the canopy would be 157 foot-candles.

Conclusion

The RWQCP promotes a safe, well-lit work environment; lighting is selected and used to enhance concentration, productivity, and alertness. An independent electrical engineering firm and the design engineer were consulted, and their recommendation is to use a minimum CCT of 4000K following manufacturer Illuminating Engineering Society (IES) guidelines. Color temperatures ranging from 4000K to 5000K offer numerous safety benefits in industrial facilities, including brightness, natural-looking light, improved visibility in low-light settings, and better worker awareness The AWPS design provides lighting that is safe and minimizes offsite impacts. The AWPS lighting design incorporates the five DarkSky Association lighting principles for responsible outdoor use, which includes using the minimum light needed to safely perform tasks and avoiding light dispersion. Lighting software was used to confirm proper lighting onsite and offsite. Areas near the boundary wall and the boundary with Embarcadero Road and contiguous properties show illuminance levels near zero foot-candles.

[3] Black & Veatch uses ElumTools software

Appendix A - Professional Opinion Memorandum Concerning Correlated Color Temperature Reduction in Water and Wastewater Treatment Plants

TJC and ASSOCIATES, INC.

Structural Engineering

SCADA

Electrical Engineering

Instrumentation

Controls

Control Systems Programming

Technical Memorandum

To:	*Diego Martinez Garcia, City of Palo Alto*
From:	*Andrew Calma and Eileen Nakamura, P.E., TJC and Associates Rick Chan, P.E., Carollo Engineers, Inc.*
Project Name:	*City of Palo Alto On-Call Engineering Services Task Order No. 6 Investigation of Correlated Color Temperature Reduction*
Project Number:	*124016*
Subject:	*Professional Opinion Concerning Correlated Color Temperature Reduction in Water and Wastewater Treatment Plants*
File to:	*124016 - 6.02*
Date:	*March 21, 2024*

This memo provides our professional opinion regarding how essential facilities such as treatment plants can address correlated color temperature reduction and minimize light pollution.

1. Correlated Color Temperature

Correlated Color Temperature (CCT) is a measure of the color appearance of a light source and is measured in degrees Kelvin. It is a gauge of how yellow or blue the color of the light emitted from a lighting fixture appears. Selection of lighting fixture CCT depends on the environment or application. A lower (warm) CCT includes hues of yellow or amber light colors, while a higher CCT appears as hues more associated with daylight or bright white light colors.

The Illuminating Engineering Society (IES) recommendations for industrial facilities lighting can be found in ANSI/IES RP-7-21. In Chapter 3, the IES recommends using LED light sources having a higher CCT, with typical values ranging from 4000K to 5000K. Lighting manufacturers also recommend using LEDs with daylight light color temperatures ranging from 4000K to 5000K. Sometimes, a CCT higher than 5000K is used for task lighting and distribution centers to help increase productivity and energize individuals.

Lastly, according to studies from the National Library of Medicine, warm color temperatures may help increase melatonin production and lights with high color temperatures help suppress melatonin production, promotes focus, and maintain alertness.

In contrast, for restaurants, hotels, and other hospitality-type establishments, the IES and lighting manufacturers recommend using LEDs with warm color temperatures ranging from 2200K-3500K, to create a friendly and relaxed ambiance. Warm color temperatures at 3000K and below (with hues of orange, amber, and yellow) are commonly used in hotel rooms.

Sacramento Office:
P.O. Box 2059
Folsom, CA 95763
p 916.853.9658

Oakland Office:
1111 Broadway
Suite 300
Oakland, CA 94607
p 510.251.8980

Concord Office:
2300 Clayton Road
Suite 1450
Condord, CA 94520
p 925.357.2676

f 800.948.5604

www.tjcaa.com

2. Light at Night

Light at Night is a collaboration between DarkSky International (formerly known as International Dark-Sky Association) and the IES to address the issue of light pollution or light spills that negatively affect the environment and human condition. The requirements for light pollution reduction for industrial facilities can be found in the California Green Building Standards Code (CALGreen), Section 5.106.8. This Section documents the allowable backlight, uplight, and glare ratings as determined by the State of California.

To comply with the light pollution reduction requirements of CALGreen, the measures that are applied to outdoor lighting include:

- Selecting a wedge-shaped lighting fixture having reduced uplight.
- Choosing a fixture with "sharp-cutoff" photometrics for a more downward light aim and associated glare reduction.
- Installing accessories such as "light shields" to reduce light spills, glare, and backlight.

3. Professional Opinion on CCT Selection

Our experience at industrial establishments, including water and wastewater facilities, commonly use a CCT of 4000K minimum following manufacturer and IES recommendations. Lighting design criteria for industrial lighting generally emphasize safety and visibility. The measure used to ensure a safe working environment is to select lighting fixtures with high CCT's to enhance visibility of potential hazards and provide clear egress and exit paths to minimize accidents and injuries. Similarly, a brighter appearing space is generally more pleasant to perform tasks that require focused visual effort, thereby enhancing productivity. Reducing lighting fixture CCT to values lower than 4000K in industrial facilities would increase the risk of accidents and injuries and would not be compliant with IES recommendations.

4. Professional Opinion for Light Pollution Reduction

To comply with light pollution reduction requirements, industry standard practices rely on a number of design schemes. House shields are typically installed in outdoor lighting fixtures to reduce light spills and are commonly used on pole-mounted fixtures. For lighting fixtures mounted on exterior walls, a wedge-shaped lighting fixture is commonly installed to focus light downward and not outward. Lastly, fixture photometrics that complement the physical placement of the fixtures (e.g., sharp cutoff characteristics) can maximize the lighting at the intended area while limiting light spills outside that area.

5. References and Resources

5.1 References

2022 California Green Building Standards Code, Title 24, Part 11 – Chapter 5, Section 5.106.8 Light Pollution Reduction. Accessed March 18, 2024. Accessed at https://www.dgs.ca.gov/BSC/CALGreen

Correlated color temperature and light intensity: Complementary features in non-visual light field. Accessed March 18, 2024. Accessed at https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8274909/

Red light and the sleep quality and endurance performance of Chinese female basketball players. Accessed March 18, 2024. Accessed at https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3499892/

Effect of exposure duration and light spectra on nighttime melatonin suppression in adolescents and adults. Accessed March 18, 2024. Accessed March 18, 2024. Accessed at https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6561500/

The inner clock-Blue light sets the human rhythm. Accessed March 18, 2024. Accessed at https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7065627/

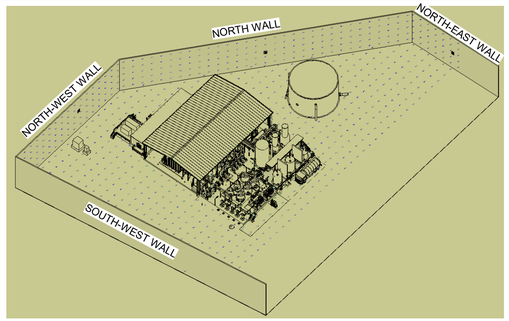
5.2 Resources

2022 California Green Building Standards Code, Title 24, Part 11 (CALGreen)

ANSI/IES RP-7-21 Recommended Practice: Lighting Industrial Facilities

https://www.ncbi.nlm.nih.gov/

Appendix B - AWPS ELUM General Lighting Calculation for Outside Area



3D VIEW

ASSUMPTION:

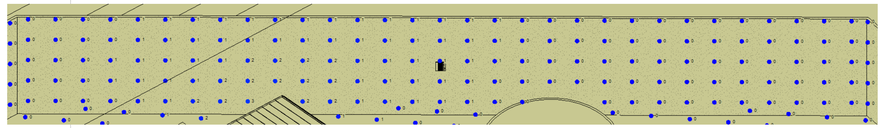
WALL HEIGHT - 50'-0" ABOVE FGL
CEILING HEIGHT - 50'-0" ABOVE FGL

PALO AWPS OUTSIDE AREA LIGHTING CALCULATION

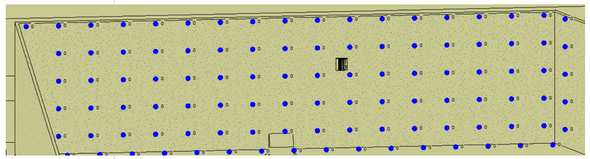
1" = 20'-0"

GENERAL NOTES

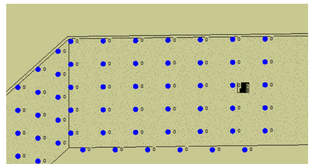
1. SEE DRAWINGS E-00-001 AND E-00-002 FOR ELECTRICAL LEGEND, ABBREVIATION AND NOTES.



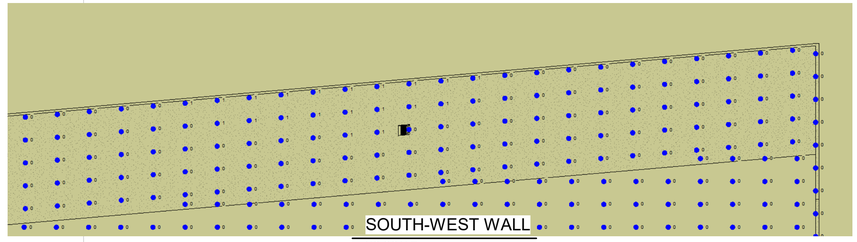
NORTH WALL
NO SCALE



NORTH-WEST WALL
NO SCALE



NORTH-EAST WALL
NO SCALE



SOUTH-WEST WALL
NO SCALE

ElumTools General Use Illuminance Results

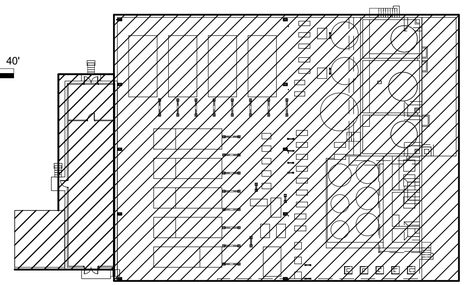
Calculation Points Name	Average	Maximum	Minimum	Space: Specified Lighting Load/Area
OUTSIDE AREA	1.3 fc	21.7 fc	0.0 fc	
INSIDE AREA	15.7 fc	38.4 fc	0.0 fc	
SOUTH-WEST WALL	0.4 fc	0.6 fc	0.1 fc	
NORTH-WEST WALL	0.2 fc	0.5 fc	0.0 fc	
NORTH WALL	0.6 fc	2.7 fc	0.0 fc	
NORTH-EAST WALL	0.0 fc	0.0 fc	0.0 fc	

Lighting Fixture Schedule

Family	Fixture Type	Photometric File Name	Lamp Count	Luminaire Input Watts	Luminaire Lumens	Total Light Loss Factor	Mounting Height
PVML (Pendant / Ceiling Mount)	1	PVML-11-UNV1-S891.ies	24	91 W	10676 lm	0.85	SEE PLAN
PVML (Pendant Mount Emergency)	1E	PVML-11-UNV1-S891.ies	26	91 W	10676 lm	0.85	SEE PLAN
PVML (Pendant / Ceiling Mount)	2	PVML-3-UNV1-S891.ies	4	27 W	2756 lm	0.85	7'-10"
PVML (Stantion Mount)	3	PVML-3-R3-UNV1.ies	12	26 W	2726 lm	0.85	7'-6"
PVML (Stantion Mount)	4	PVML-7-R3-UNV1.ies	3	59 W	6285 lm	0.85	7'-6"
Street_Light-LED-Lithonia-DSX1-MA	5	DSX1_LED_30C_700_40K_T3M_MVOLT_MA.ies	26	68 W	7345 lm	0.85	10'-0"
PVML (Wall Mount)	6	PVML-3-R3-UNV1.ies	4	26 W	2726 lm	0.85	7'-6"
WSQ-LED	7	WSQ LED P1 SR3 40K MVOLT.ies	5	20 W	2244 lm	0.85	8"
Grand total: 104			104				

20' 10' 0 20' 40'

1" = 20'



KEYPLAN
NO SCALE

(SCALE BAR IS 4" AT FULL SCALE) 0 1/2 1 2 3 4

BLACK & VEATCH

Black & Veatch Corporation
Walnut Creek, California

CITY OF PALO ALTO

CITY OF PALO ALTO
RWQCP ADVANCED
WATER PURIFICATION
SYSTEM

ARCHITECTURAL REVIEW BOARD SUBMITTAL
NOT FOR CONSTRUCTION

2	09/22	90% DESIGN SUBMITTAL
1	04/22	60% DESIGN SUBMITTAL

REVISIONS AND RECORD OF ISSUE

DESIGNED:	HK
DETAILED:	CP
CHECKED:	CRM
APPROVED:	PV
DATE:	05/2023
PROJECT NO.:	408520

AWPS

ELECTRICAL

AWPS
ELUM GENERAL
LIGHTING CALCULATION
OUTSIDE AREA

E-EC-101

OF 215

PLOTTED: 11/28/2023 4:28:50 PM
FILE: C:\Users\pat79142\OneDrive - Black & Veatch\Desktop\Charan Patil (Dont Delete)\Office Work\1) Working Projects\Palo Alto Project\Palo Alto Outside Area Elum Calculation\Palo Alto detached_Model (Floor & Wall Calculation).rvt
D1 1000