Lighting Depth

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Introduction

The Lighting Depth for this thesis proposal is the starting point from which much of the integration of the remaining thesis topics are derived. Based on the desired lighting scheme, the structure had to be modified (if only slightly), the electrical system was affected in its layout, and the architecture of certain spaces had to be developed altogether. Based on the architectural work put into the project, it only made sense to light the newly created spaces to get an idea of how they would actually appear under a realistic lighting condition.

The Lighting Depth analyzes 6 distinct spaces: the Façade, a Parking Level and Parking Lobby, the Entrance Lobby, an Office Reception, an Office Conference Lobby, and an Open Office space. Each of these areas had their own distinct criteria and each of them resulted in a differing lighting design. Based on an ideal that the building was to be completely owner-created, the lighting in all of the spaces attempted to make use of as many of the same luminaires as possible.

The overall theme for the general building (notice, this theme does not apply to the office tenant spaces) was one that compliments the city and its lake-oriented personality as well as the architecture of the building.

Research

A great deal of research went into the Lighting Depth and became the focus of the depth itself+. Such design aspects as control issues, dimming systems (DALI, GrafikEye, etc.), and building management systems fell out of the scope for this particular thesis. Instead research was conducted on the digital modeling of ray-trace modeling of materials, luminaire distributions for illuminated works of art, basic luminaire reflector design, LED systems, and integration of lighting into desk systems. The research was directly implemented in its entirety into the spaces design for the Lighting Depth.

Ray-Trace Modeling of a Diffuse Glass

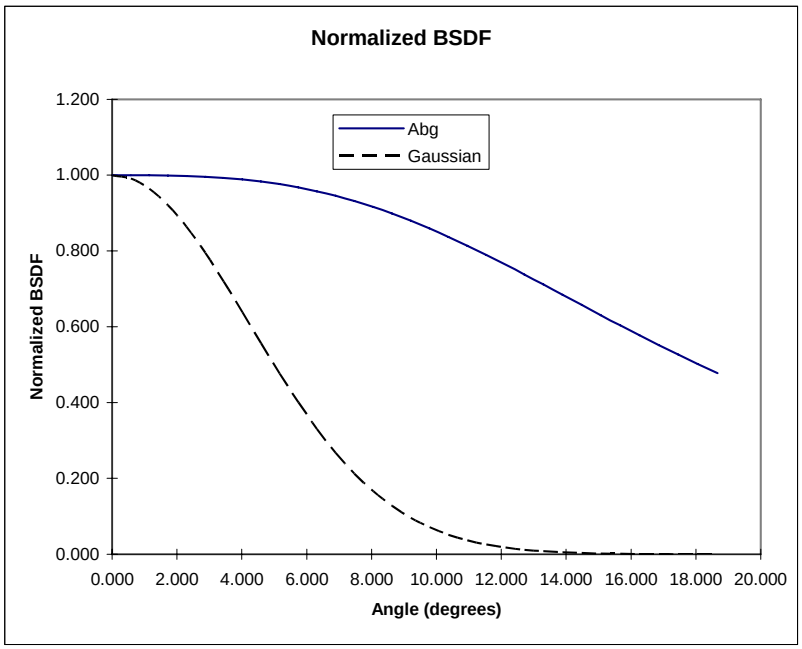
The ray tracing modeling of a diffuse glass was the basic need for the design of two of the additional researched luminaires. To appropriately model the diffuse characteristics of the artwork pendants hanging in the Entrance Lobby space, a surface characteristics was needed that would both transmit and reflect light similar to a sand-blasted glass design. TracePro was used to determine the light distribution for these lamps, but an appropriate model could not be obtained with the standard transmissive glass or opaque reflector materials provided. This necessitated the calculation and modeling of my own surface. While this endeavor was undertaken specifically from the ideas provided by TracePro consultants, it nonetheless was required of me to fine-tune the material to account for absorption within the glass and the appropriate levels of specularity and diffusivity provided by the glass.

Lambda Research provides a spreadsheet and instructions for creating a surface of "ground glass" based on the A, B and g values defining the BRDF and BTDF properties of a material. Per the instructions, a variable value of B and g was changed altering the Normalized plot of the BSDF in the spreadsheet. A number of calculations were used altering the Absorptance between 0.05 and 0.08, the Specular Reflectance between 0, 0.05, and 0.1, the B value between 0.01, 0.03, and 0.1, and the g value between 0.5, 1 and 3. The final distribution that was thought to approximate the glass type that coincided with the artwork (and subsequently the diffuse glass desired for the desk system) used an Absorptance of 0.08, a Specular Reflectance of 0.05, a B value of 0.03, and a g value of 3. The Normalized graph for the BSDF of this material according to the Lambda Research spreadsheet is below.

ABg model coefficients

A	0.03		
B	0.03	Gaussian	
g	3	1sigma =	6 degrees

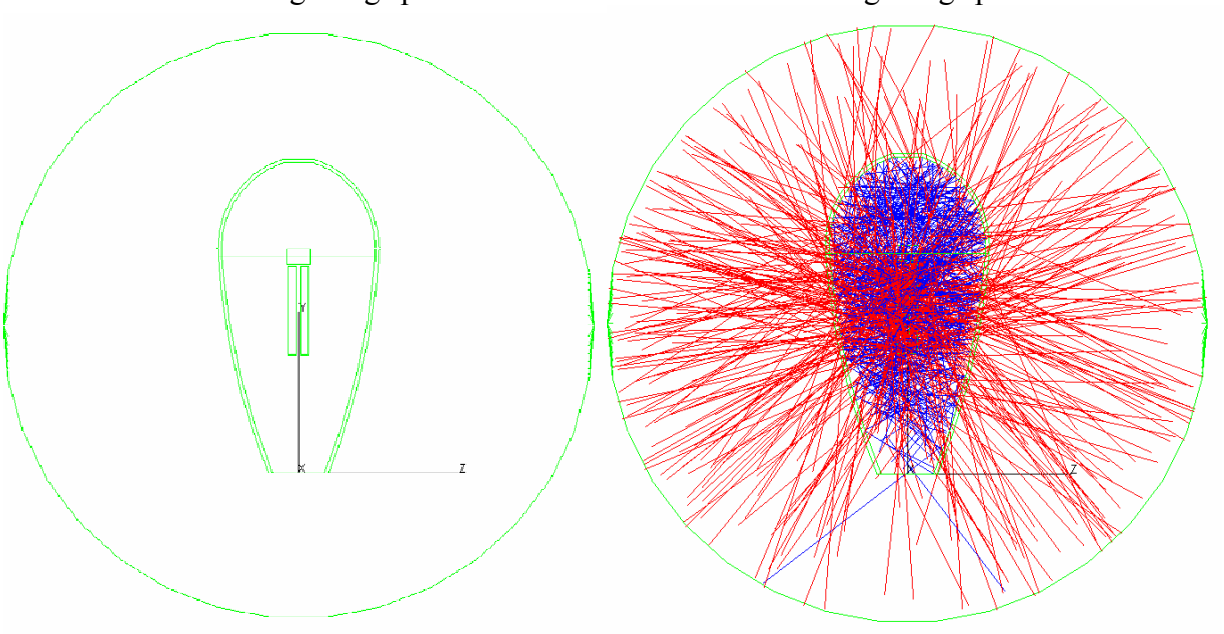
b-b0	Abg	Gaussian	degrees
0.000	1.000	1.000	0.000
0.010	1.000	0.991	0.573
0.020	1.000	0.964	1.146
0.030	0.999	0.921	1.719
0.040	0.998	0.864	2.292
0.050	0.996	0.795	2.866
0.060	0.993	0.719	3.440
0.070	0.989	0.639	4.014
0.080	0.983	0.557	4.589
0.090	0.976	0.476	5.164
0.100	0.968	0.400	5.739
0.110	0.958	0.330	6.315
0.120	0.946	0.268	6.892
0.130	0.932	0.213	7.470
0.140	0.916	0.166	8.048
0.150	0.899	0.128	8.627
0.160	0.880	0.096	9.207
0.170	0.859	0.071	9.788
0.180	0.837	0.052	10.370
0.190	0.814	0.037	10.953
0.200	0.789	0.026	11.537
0.210	0.764	0.018	12.122
0.220	0.738	0.012	12.709
0.230	0.711	0.008	13.297
0.240	0.685	0.005	13.887
0.250	0.658	0.003	14.478
0.260	0.631	0.002	15.070
0.270	0.604	0.001	15.664
0.280	0.577	0.001	16.260
0.290	0.552	0.000	16.858
0.300	0.526	0.000	17.458
0.310	0.502	0.000	18.059
0.320	0.478	0.000	18.663



Using this material and solving for the BRDF function and BTDF function in the Surface Properties editor the resulting distribution when applied to one of the luminaires results in this raytrace.

Original Luminaire and Lamp
In integrating sphere

Raytraced Luminaire and Lamp
in integrating sphere



As one can see, a large portion of the light is allowed to escape, and the remaining portion reflects around in the luminaire. This material was chosen because the distribution (shown below) seemed to be the most likely based on acquired knowledge of luminaire distribution.

While not an overly complex research project, and with limited knowledge of the functions associated with the Lambda Research spreadsheet, a basic knowledge of BRDF and BTDF functions as acquired in the Graduate courses allowed me to make a fair judgment on values I should use. Through trial and error, the final values were decided upon through experimentation with TracePro.

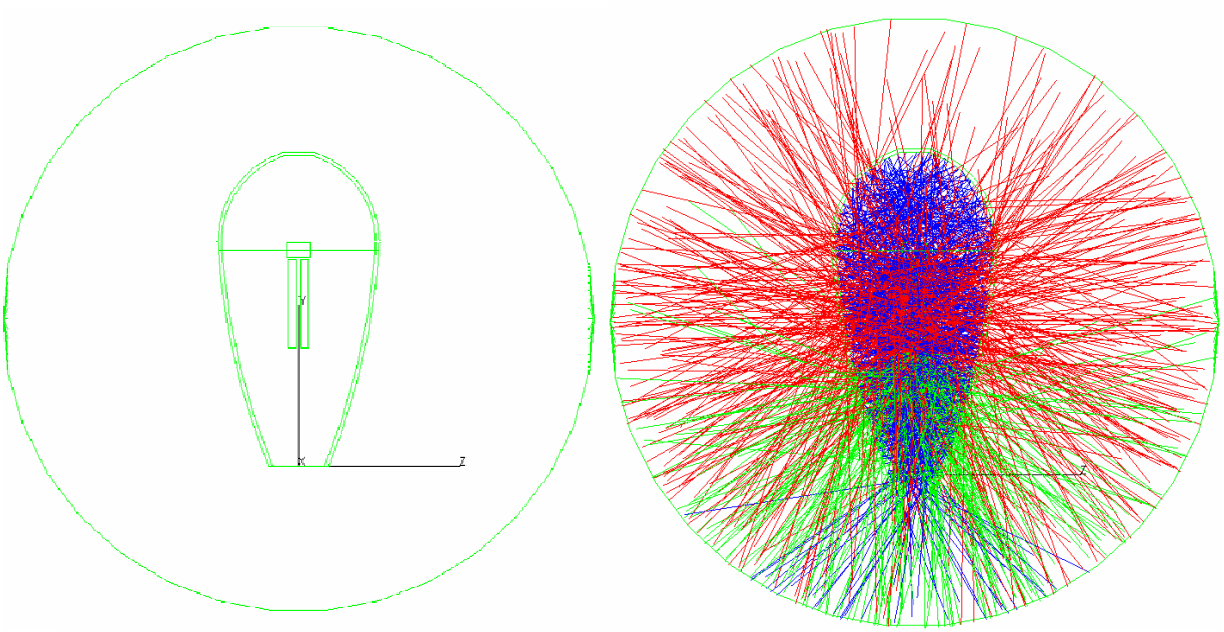
Light Distribution for Luminous Works of Art

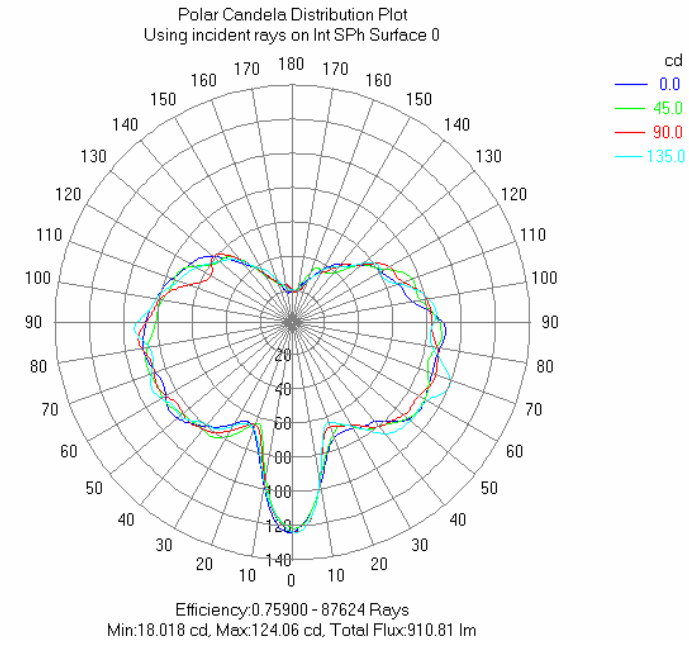
For the glass-sculptured luminaires throughout the Entrance Lobby, an appropriate distribution was necessary to accurately model the space as much as possible. The sculptured pendants comprise a considerable portion of the lighting within certain volumes of the space.

Each of these sculptured luminaires was modeled in AutoCAD 2006 and exported as an ACIS file (3D solid required). These solids were then imported into TracePro and an approximation to a compact fluorescent lamp was built from Primitive Solids. The values for an 18W compact fluorescent were obtained from Sylvania.com and applied to the 4 luminous tubes of the faux-CFL in TracePro.

Using some 84,500 rays, an approximation to the distribution was constructed for each of the three luminaires. The Monte-Carlo based raytrace solutions with a 1% ray sorting parameter and resulting candela distributions are shown below.

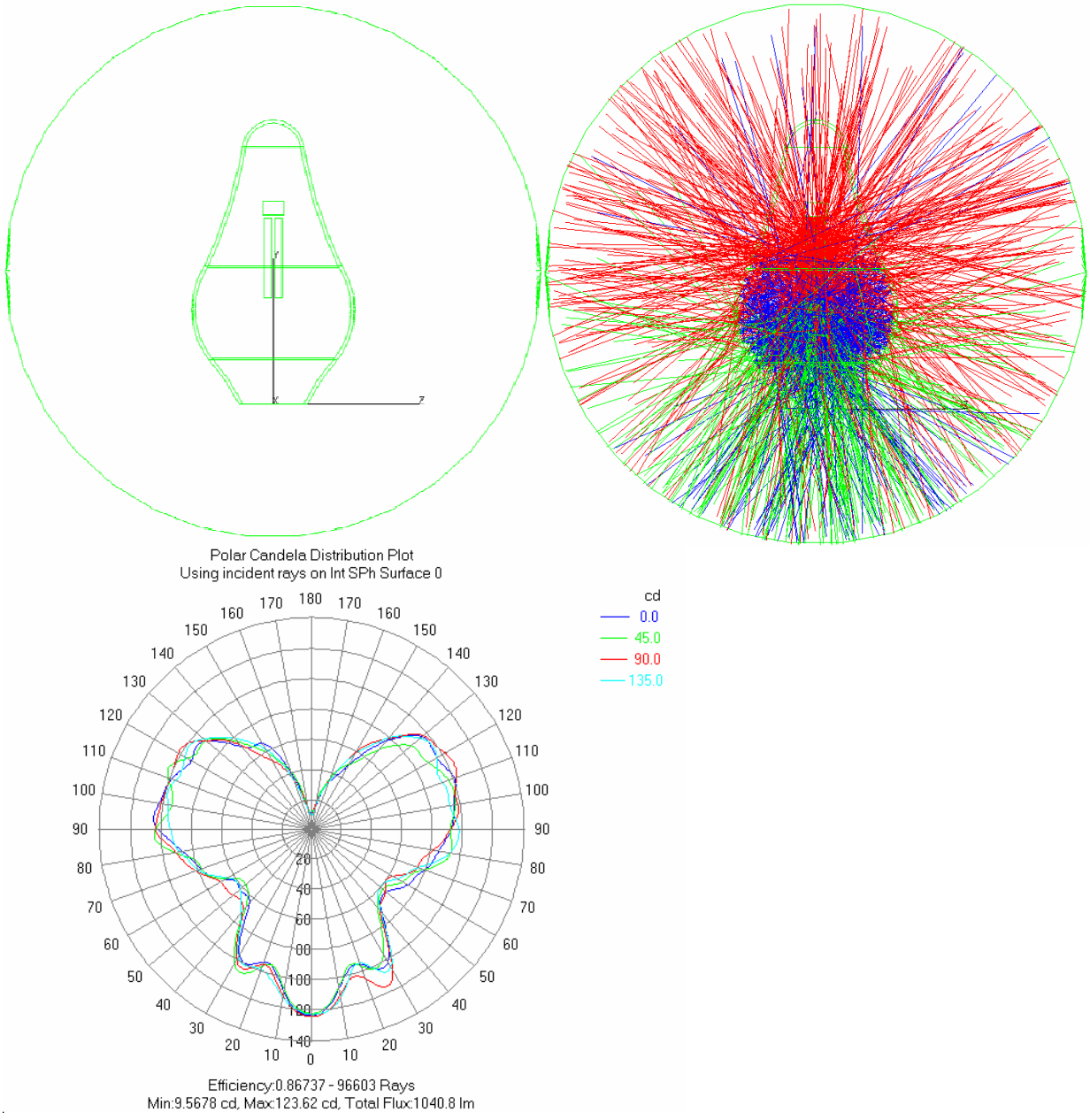
"Tuby" – assumed to be a flower in its early stages of blossoming – 18W CFL





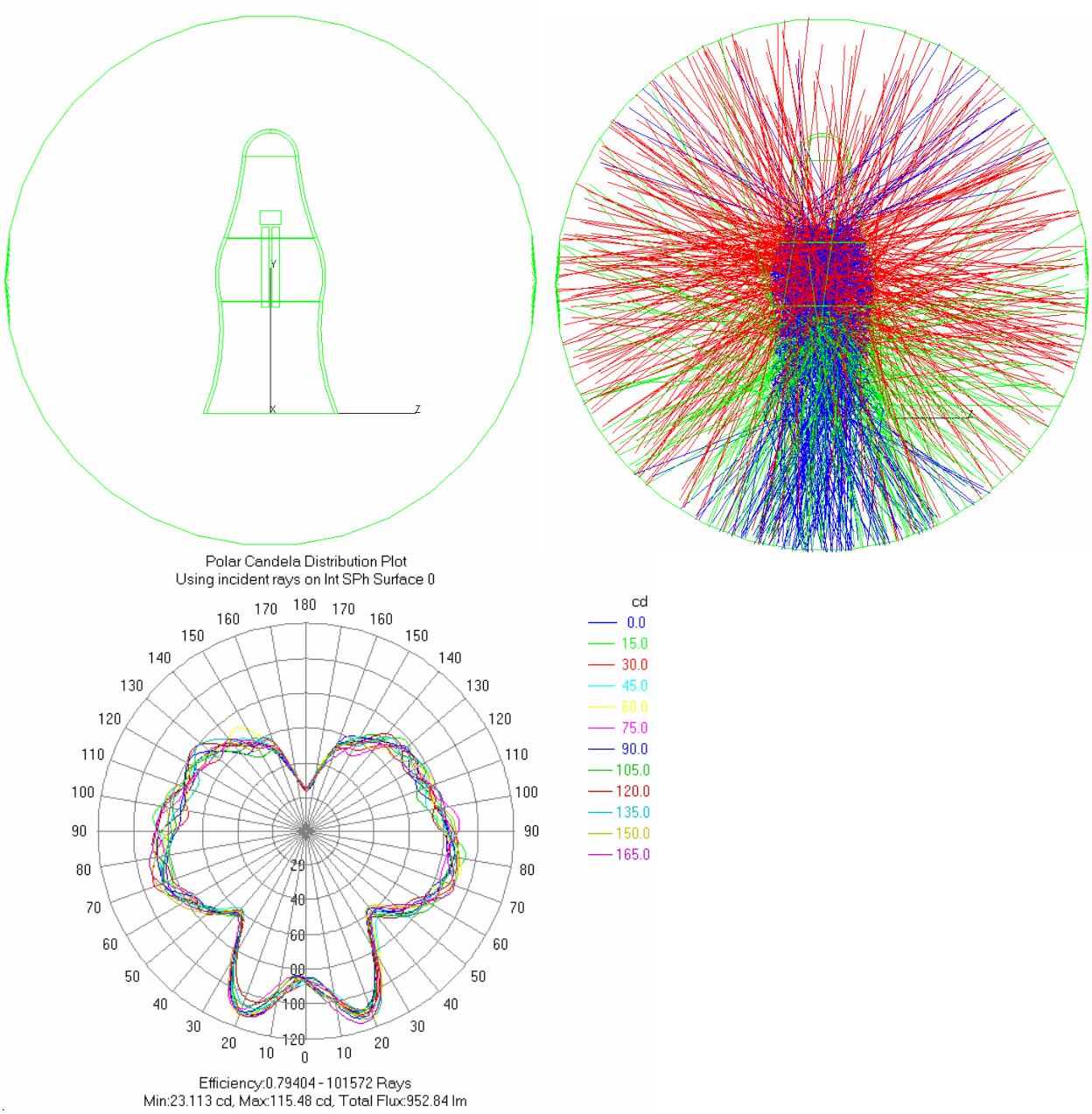
As one can tell from the raytrace and the distribution, a large amount of diffuse light is cast mainly to the sides with the highest intensity exiting the open bottom of the luminaire. Also, the efficiency of the luminaire is cited as 76%, a reasonable approximation for an absorbing glass luminaire.

"Bulbous" – assumed to be a flower in its mid stage of blossoming – 18W CFL



From the raytrace and the distribution, a considerable amount of diffuse light is cast upward and less is cast to the sides. The highest intensity still exits the open bottom of the luminaire. The efficiency of this luminaire is cited as 86.7%, a reasonable approximation for an absorbing glass luminaire with a larger open bottom.

"Ghosty" – assumed to be the same flower in full bloom – 18W CFL



From the raytrace and the distribution, a large amount of diffuse light is cast upward and to the sides. The highest intensity still exits the open bottom of the luminaire, but at 20˚ angles. The efficiency of this luminaire is cited as 79.4%, a reasonable approximation for an absorbing glass luminaire with a bottleneck in the middle and a wide opening at the bottom.

These distributions seem to fit the luminaires fairly well based on previous experience modeling luminaires. TracePro will have accounted for any inaccuracies that would arise from simply "estimating" the luminaires as a Louis Poulsen fixture, and the space will have a more accurate radiosity solution. All of these candela distributions were converted into IES files and the luminaires used specifically in the Entrance Lobby Space.

Basic Reflector Design for an Area Source Ceiling

The basic reflector design for the Entrance Lobby "wave ceiling" was developed and eventually altered completely negating the main impetus of this research project. While the ceiling changed significantly, the luminaire was still used because an area source was needed to achieve a similar effect.

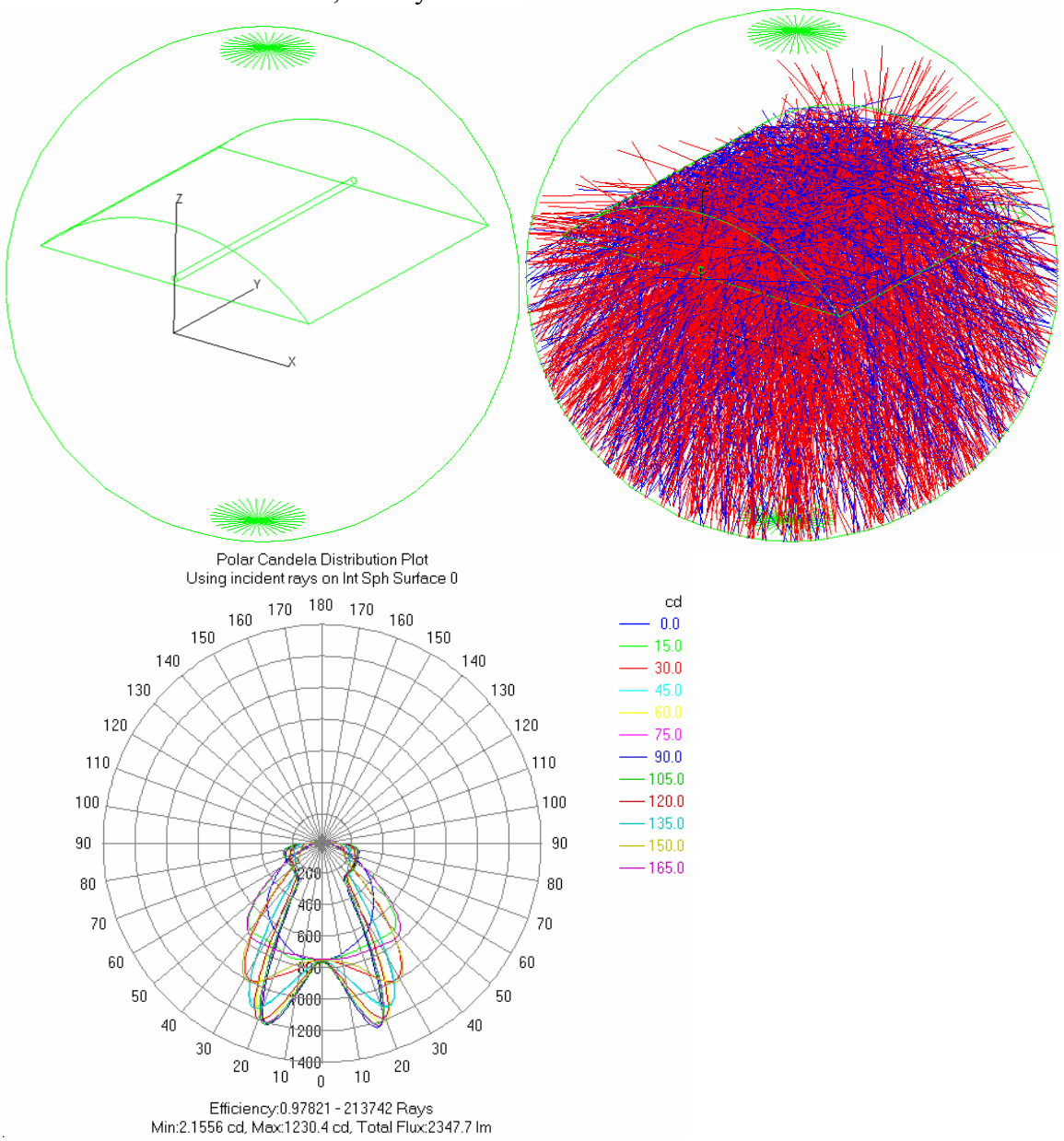
Initially the wave ceiling was designed as a combination of laminated translucent strips of varying width, and oriented broad-side down. As can be seen from the rendering of the Entrance Lobby space, the orientation of the same strips is now edge-side down. The broadside was to transmit a large amount of colored light down into the space wherein the variance in width would simulate a three-dimensional wave pattern. Because of the low transmittance value, the necessarily high lumen output of the lamps, the exorbitant power density, and the realization that only blue and green hued light would be illuminating the space, the original design was scrapped for the current one. The current design still required an area source, however – except one that was more efficient and provided white light to the space.

The luminaire was constructed in AutoCAD of 3D solids and imported to TracePro in an ACIS file just as before. The intention was to use a T8 lamp across the bottom of the "barrel" reflector to get as better approximation of parallel rays of light a slight emphasis on increased illuminance at the center to offset the larger-than-anticipated transmissive gradient of the colored strips. For constructability and installation which would keep the cost of such a luminaire low, the reflector was modeled as a large-radius cylinder (as compared to the requisite parabola for parallel light rays). The lamp position was then adjusted from center until the final illuminance distribution on an area plane coincided with the needed illuminance to produce the "wave" effect.

Realizing that the full-size barrel luminaire would be centered at the "openings" of the strip-sets and not at the middle of the strip-sets as was originally intended, a "half-barrel" luminaire was also calculated from the same form and shape, but with a reflecting block placed at the extreme edge where the luminaire would meet the ceiling plenum wall.

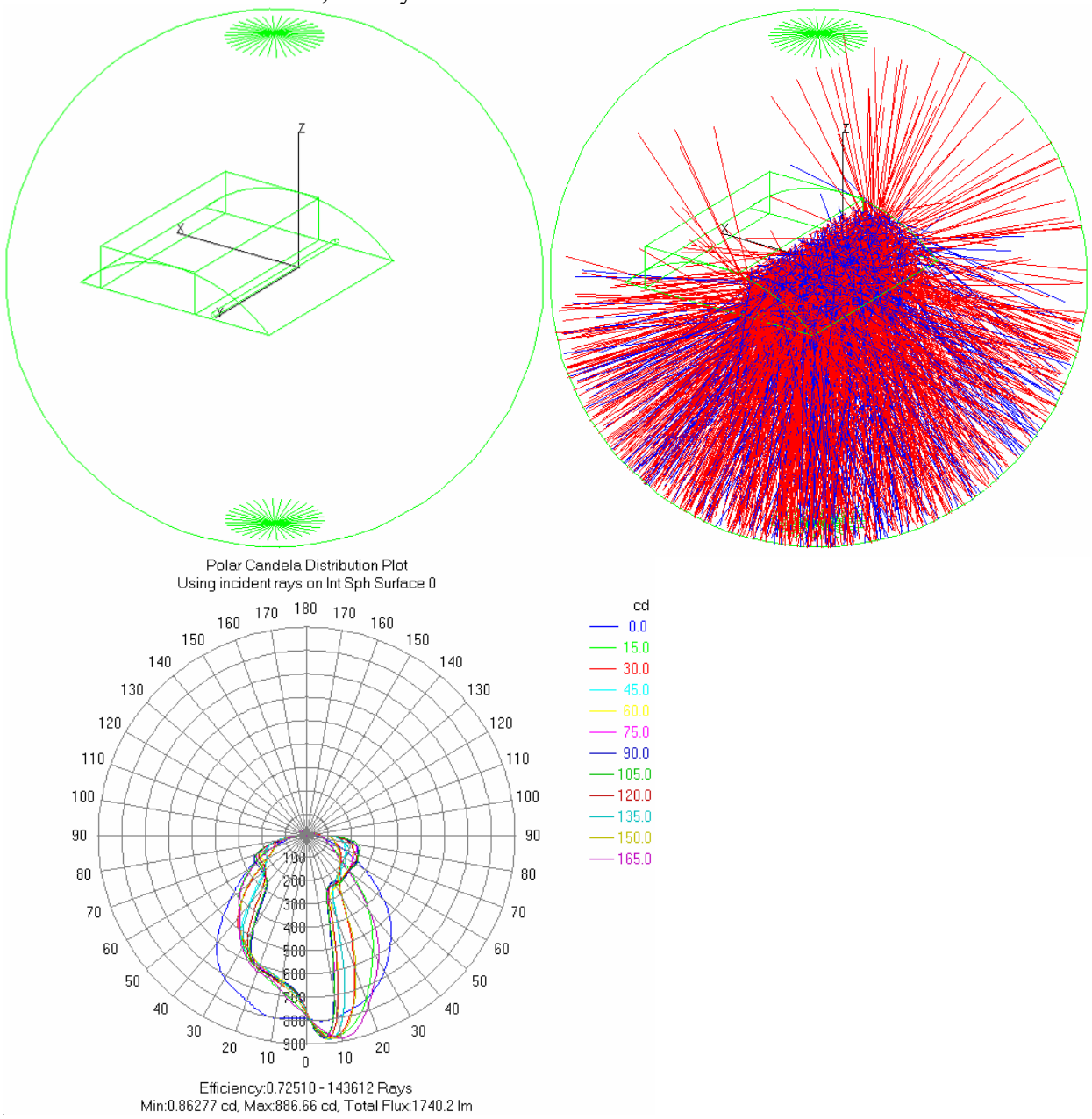
The ray trace is shown below with the chosen design, and the candela distribution follows.

Full Barrel – 32W T8 – 150,000 rays



The distribution has a little more angle than would be preferable, but with the placement of a highly transmissive translucent plastic sheet on the back to avoid direct glare issues with the bare lamps being exposed, the peaks will join closer together. The important fact here is that all of the light is reflected downward at a 97.8% efficiency.

Half Barrel – 32W T8 – 150,000 rays

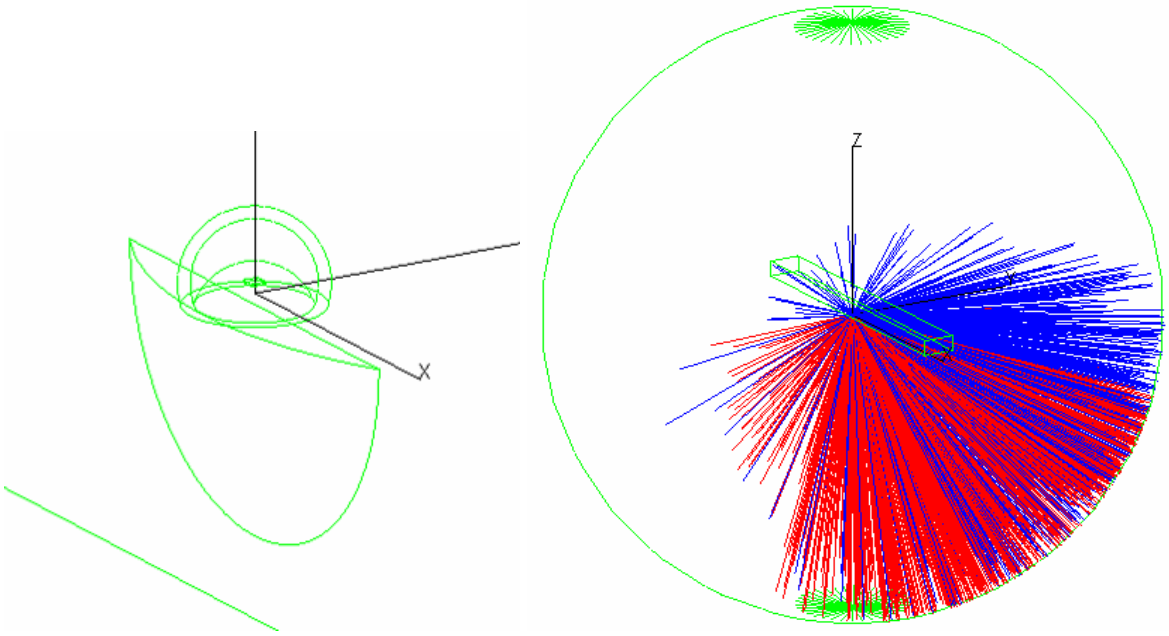


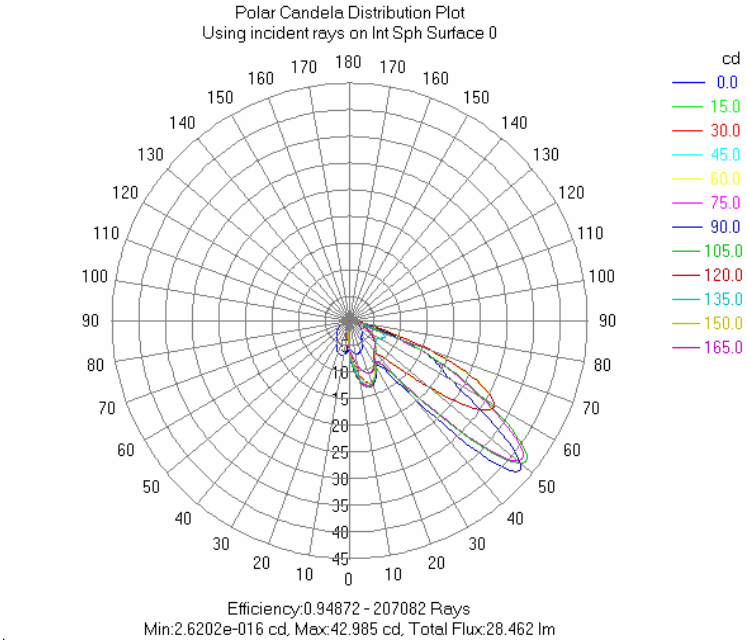
The distribution has a fairly significant downward peak which was desired to maintain the wave appearance, and the falloff toward the uninhibited side is smooth enough to accurately play into the area source model (via the same glare-reducing translucent backing).

LED Emitter Use in a Linear Luminaire System

There were two research concepts that went into the development of the LED system used on the façade. First the distributions of all LEDs by themselves are either Lambertian or Batwing for the purposes and at the light output levels this thesis is concerned with. It is possible to purchase narrow "spot" LEDs but they are used for extremely low light output levels. The LEDs chosen for the design of the façade lighting were the Philips/Lumileds Luxeon emitters and/or stars. The overall LED chosen was the Luxeon K2 emitters because of their tremendous light output, low power consumption, and many available colors (required for the lighting design as described later).

The only problem is that the LED comes as a lone emitter, or as part of a tape of emitters and it only distributes light in a Lambertian distribution. The needed distribution was a wall-wash type and thus a reflector system had to be designed for it. Using the same modeling procedures as for the previous two research concepts, the LED was modeled as a point source and a small reflector placed around it. This reflector was not of congruent circular radius as the point source itself so as to broaden the distribution in along the wall, but curtail any distribution that was beyond 0˚ in the direction away from the wall. After applying the raytrace, the following results were obtained.





From the distribution, it is easily seen that the reflector was effective in redirecting all of the light toward a single wall. The light has a considerable distribution toward the 45˚ and 50˚ vertical angle, but this was assumed to be fine. The higher the luminance at a given point, the more that point will stand out, and for a 17-story building the linearly distributed "hot spots" will seem to form a nice line.

The actual installation of the LED module and the typical concerns of heat dissipation, lumen maintenance, and light output as a function of temperature was also researched thoroughly using the technical data provided on the Lumileds website.

From the LED cut sheets, the typical luminous flux for an example white LED used in the design is 60 lumens at a junction temperature of 25˚C, which is relatively low for the junction temperature of any electrical component. The corresponding drive current with this test method was 350mA and under the 3.6V forward voltage, corresponding to a wattage of 2.4W at full output and full driving current. This type of LED at this driving current would be used as it provides more light than any other system searched for otherwise.

Of first concern is the relative light output for a given junction temperature. From the Lumileds datasheets, the following graph was obtained.

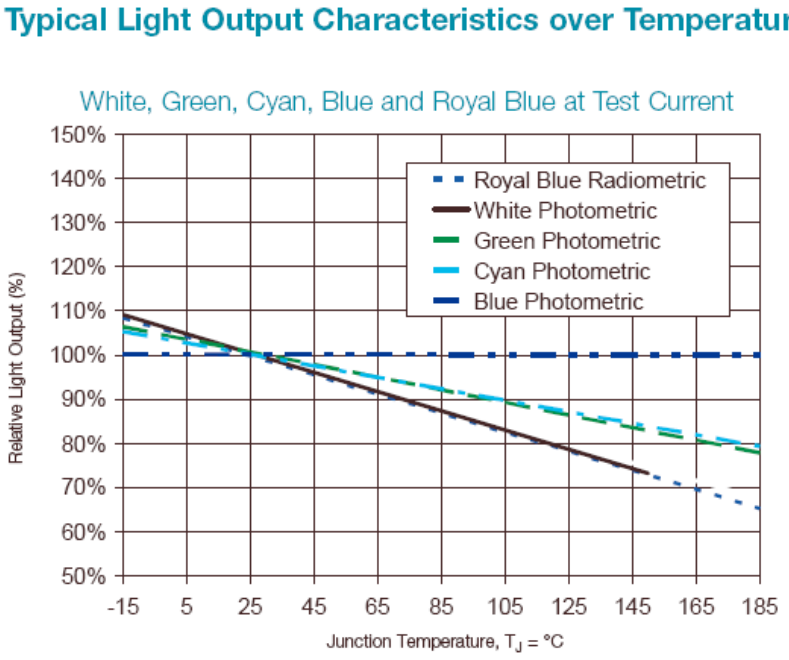
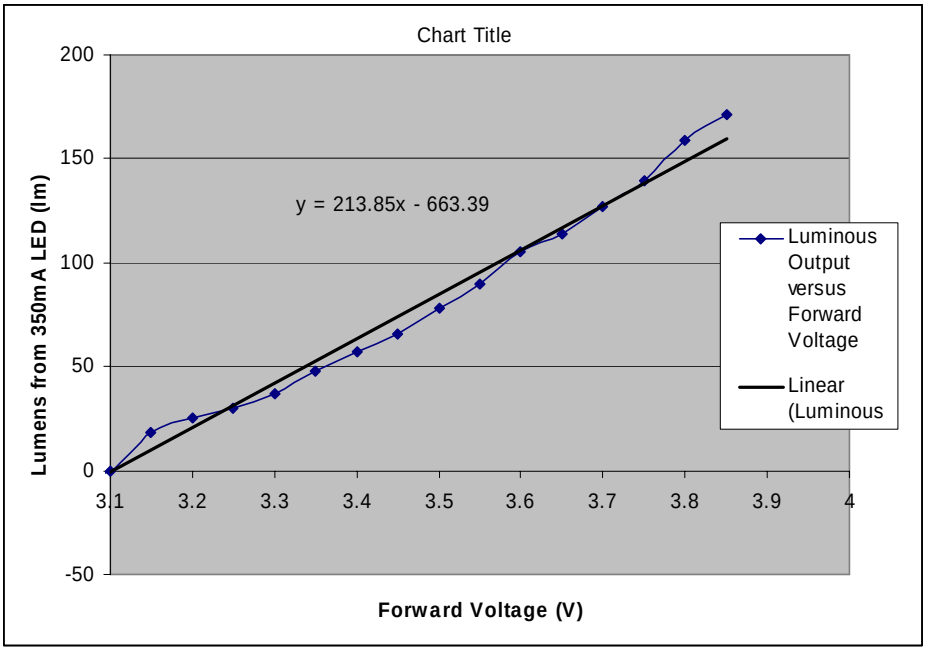
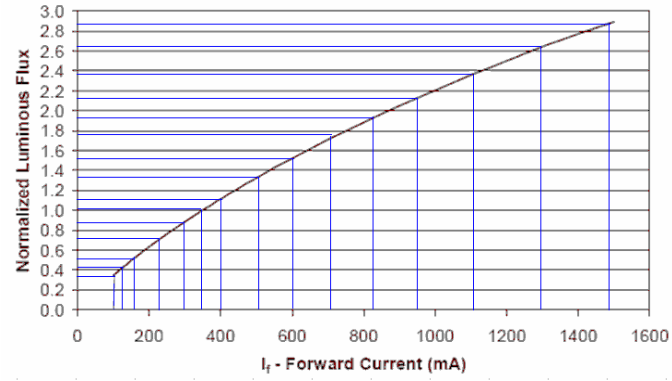


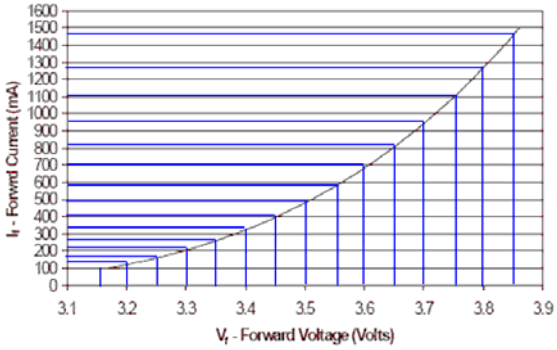
Figure 7. Relative light output vs. junction temperature for white, green, cyan, blue and royal blue.

One can see that the light output decreases dependent on both junction temperature and color of the LED. Assuming the worst conditions (White and Royal Blue LEDs), the maximum relative light output factor can be assumed to be around 85% for the worst case realistic scenario. This output corresponds with a junction temperature of 95˚C – just below the boiling point of water. The lighting design implementation of these LEDs is limited to the blue, green and white ranges, so the light output of red-hue LEDs is not considered (although it can be noted that their performance at higher junction temperatures is much worse). The typical junction temperature for an Intel Pentium Processor (the worst thermal processors on the market) is specified as 90˚C. It can be assumed that the junction temperature for the LED can be modeled with this gauge. Considering the heat source is much smaller for an LED, it may even be considered a conservative estimate. The processor analogy is also applied to heat dissipation of the LED and will be described shortly.

The light output is also reduced by the driving voltage and the driving currents. Two graphs were specified in the datasheet relating drive current with forward voltage, and drive current with luminous output. The two graphs were taken out further charted, and the data plotted against one another to relate the forward voltage to the luminous output. Considering current is a function of forward voltage, and light output as a function of current, the only variable affecting luminous output directly is forward voltage. The resulting graph from relating the two is given below.







Following the junction temperature analysis, consultation of the Lumileds datasheets produced a few additional factors that must be taken into consideration when powering and installing the LED emitters. To better understand the light output relative to the driving voltages and currents, as well as with respect to the ambient temperatures, the thermal design of the actual LED emitter was also researched.

From the Lumileds datasheets, a linear range of R-theta thermal resistances for board-to-ambient conditions was given. Each LED emitter has an R-theta junction-to-board value of 17˚C/W. This basis allows one to simply analyze the board to ambient conditions to understand the thermal heat dissipation characteristics of the LED. Within the datasheet a number of control experiments were conducted which are only fairly

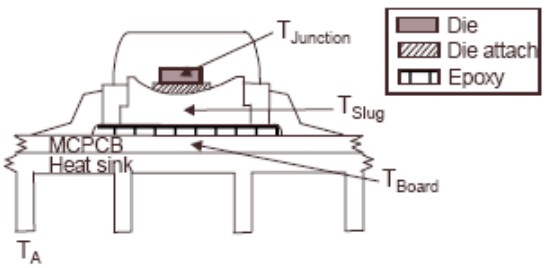


Figure 1B. Emitter Cut-Away

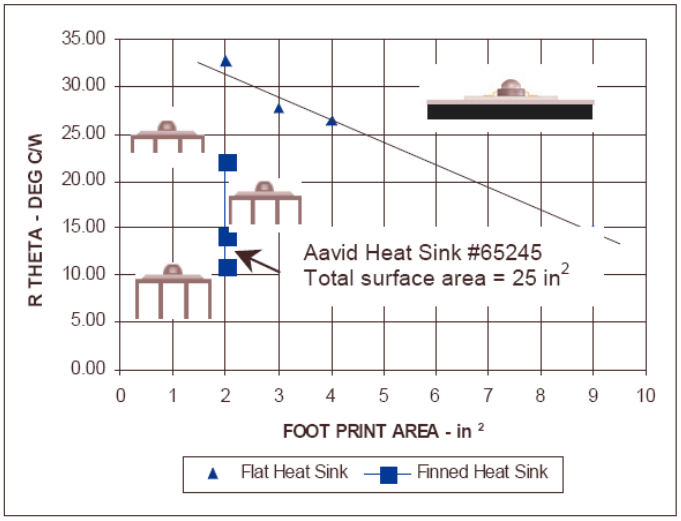
Equation 2. Thermal Resistance Model

$$R\Theta_{Junction\text{-}Ambient} = R\Theta_{Junction\text{-}Slug} + R\Theta_{Slug\text{-}Board} + R\Theta_{Board\text{-}Ambient}$$

applicable (for the level of accuracy this thesis desires to retain). Certain negative factors stated in the text include: a) the lack of thermal grease in the connection of heatsinks; b) the lower quality of the heatsinks (compared to the high polish finish and flatness applied to computer processor heatsinks); c) the use of fixed footprint heatsinks with and without fins; and d) the design emphasis on natural convection within a closed space.

The results of the experiments show that the finned heatsinks have a much lower R-theta value than the flat heatsinks. Because of the nature of the design implemented on the façade, a "poor" average of the finned and flat heatsinks could be used conservatively with a resulting R-theta board-to-ambient of about 25˚C/W. This means each emitter has a total R-theta of 42˚C/W. This value, while still conservative, will be used in the further analyses of light output versus ambient temperature.

It should be noted at this time, the use of a thermal grease (anything as simple as the most common heatsink binding paste up to the highly conductive Arctic Silver used by computer enthusiasts) will also decrease this thermal resistance. Also, in the proposed design of the LED system, the spacing of the emitters is much further apart than the technical datasheet specifies is necessary to treat every LED as a discrete thermal source. Couple this with the fact that the mounting for each LED is the underside of an aluminum mullion and the effective footprint of the "heatsink" is increased considerably.



After the thermal characteristics had been analyzed, and the installation "approved" for realistic application, further analyses of the light output degradation were conducted. The first analysis was the current derating based on the ambient temperatures and a maximum junction temperature of 150˚C. The curve for 350mA white LEDs is shown below. A very similar graph is also contained within the datasheet for the Blue/Green/Cyan LEDs as well, and differs only in the fact that they can withstand greater ambient temperatures before current is derated.

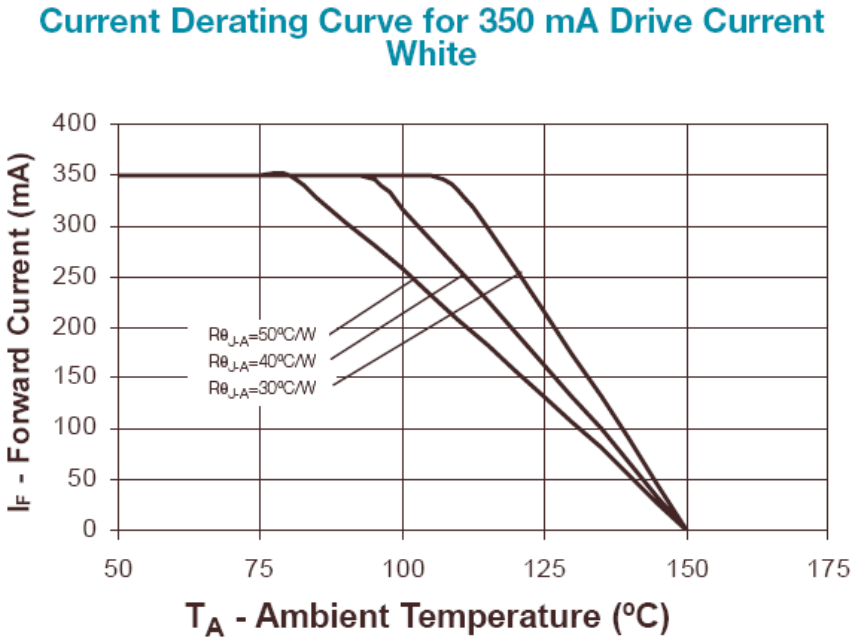


Figure 14: Maximum forward current vs. ambient temperature, based on T_{JMAX} = 150ºC.

Note that the curve in question for the "worst-case scenario" developed during the research is to 40˚C/W curve, allowing the ambient temperature to reach 80˚C before derating must occur. This ambient temperature should not be reached within the design even if a 1" convection-less bubble was considered around the luminaire installation site. Within the design proposed one will also make note of the outdoor location, where free convection only occurs on a select few days a year, if at all. Wind will always be present thus forced convection can be considered the norm, thus further reducing the heat dissipation requirements. Add to the fact that the luminaire system will only be used at night when the temperature is lower than the recorded high, and also that the highest recorded temperature in Milwaukee was 105˚F, or 40.5˚C – considerably lower than all of the previous data considers a limit.

All of the heat characteristics have been taken into consideration, and the only remaining factor requiring attention is the length of time the luminaires will be used, or the lumen maintenance. From yet another datasheet provided by Lumileds, the lumen maintenance curve for an ongoing experiment involving the life of the LED has been provided. Two distinct graphs shown below show very interesting results obtained through direct experimentation. For an LED driven at 350mA (as in the installation proposed), having a case temperature of 25˚C and junction temperature around 45˚C, the lumen output actually increased over the course of 4000 hours of operation. This condition may seem a bit "aggressive" if it were to be applied to the thesis proposal, as it makes use of an obviously well designed condition. Contrasting this, an experiment conducted with a case temperature of 85˚C and junction temperature of 105˚C and the lumen maintenance decreases by 7.5% over the course of 2000 hours. Placing the proposed design conditions in-between the two would suffice as an accurate approximation and the lumen maintenance over a 10,000 hour life could be estimated at 0.9. This would correspond to almost

3.5 years of operation at 8 hrs/day with relative light output remaining constant. The lumen maintenance graphs are shown below.

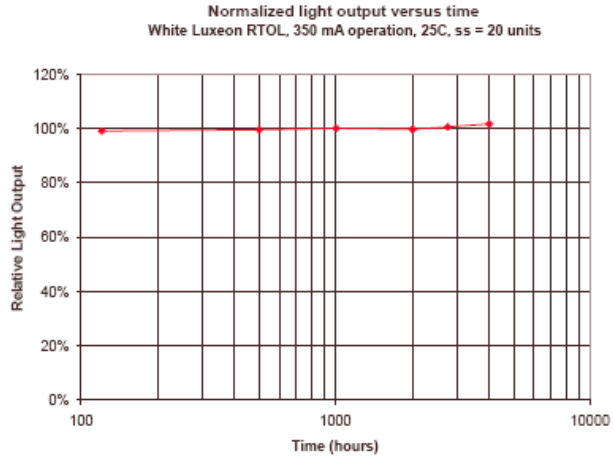


Figure 4. Relative light output for white Luxeon Power Light Sources driven at 0.35A, 25°C case temperature ($T_J \cong 45°C$).

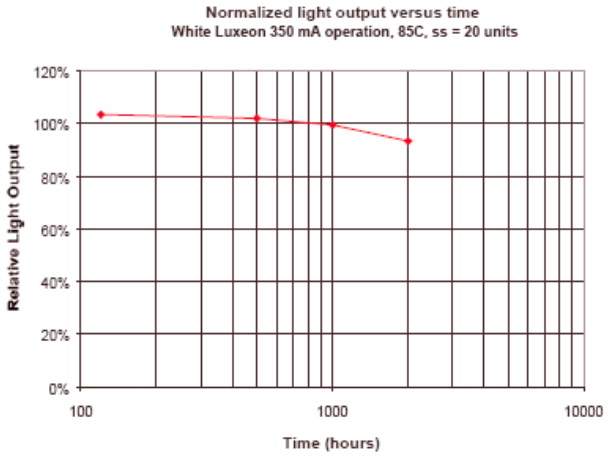


Figure 5. Relative light output for white Luxeon Power Light Sources driven at 0.35A, 85°C case temperature ($T_J \cong 105°C$).

Overall, the LED system seems quite feasible as an architectural façade lighting design solution. Even considering all of this "positive" data, a "safety" factor was also included to account for all remaining luminaire degradation issues.

For the dimensioning and detailing of the proposed LED system please see Appendix C

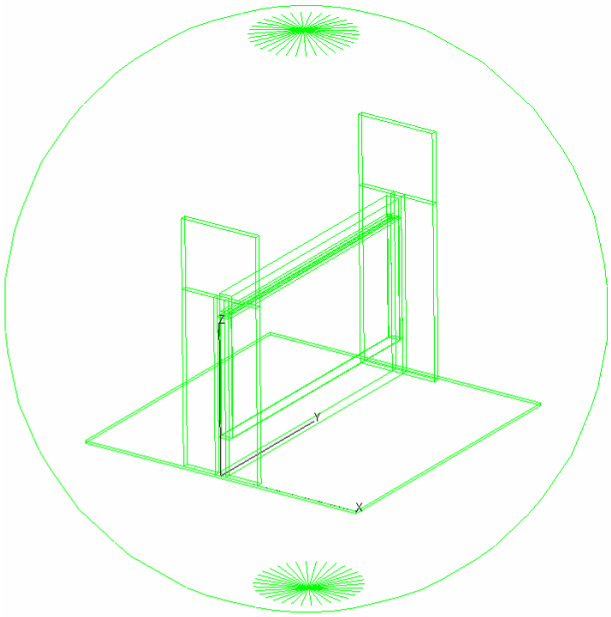
Integration of Luminaires into Desk Systems

The Open Office design focused on a system that conceptualized to investigate the alternative to typical open office lighting design. After the architecture of the space was laid out, the desk systems was modeled and laid out in the space relative to the available space requirements. What was needed was the distribution for the light source through the top opening and through the translucent glass panels on the sides.

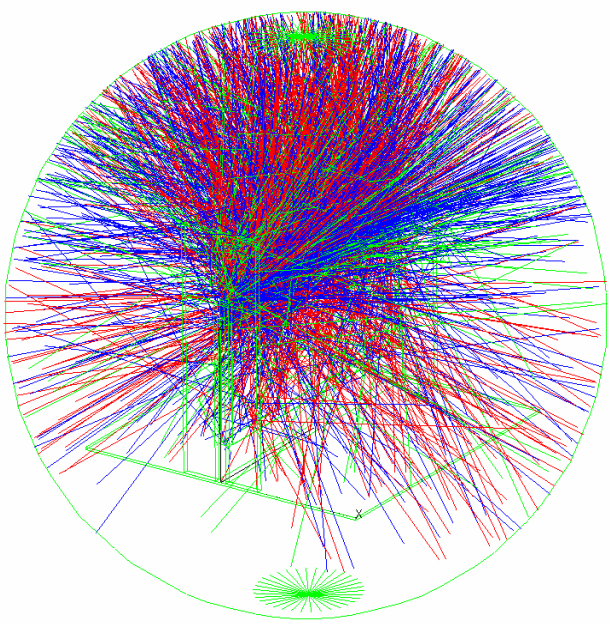
Using the same modeling method as all of the previous research, the desk system was devised, appropriate glare angles calculated (based on an eye height of 6' – the equivalent of a 6'4" person on the low-end) and brought into TracePro. All of the surfaces within the "luminaire" – closest to the lamp and receiving the highest number of rays – were assigned a specular Miro surface. The glass walls were given the same glass properties that were used in the sculpted luminaires to approximate a diffusing glass surface. The lower half of the "glass trough" was also given a specular Miro surface to reflect any light back up toward the lamp or around and out through the glass of the desk system.

Once the rays were traced, individual sections of the luminaire's surfaces, namely the top, and each individual side, was used as the candela distribution surface and the appropriate candela distributions were applied. The top and the side distributions were saved as IES files separately to better model the effect of the luminaire in AGI32. The raytraces and the candela distributions are shown below.

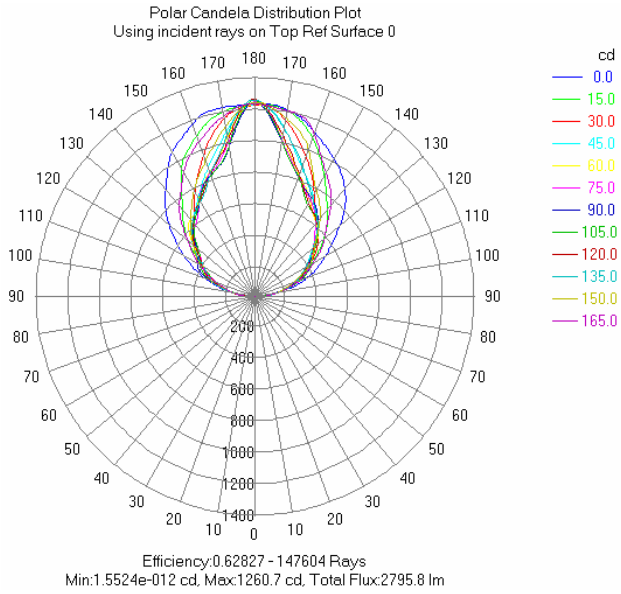
Full Distribution Desk System – 54W T5 – 100,000 rays

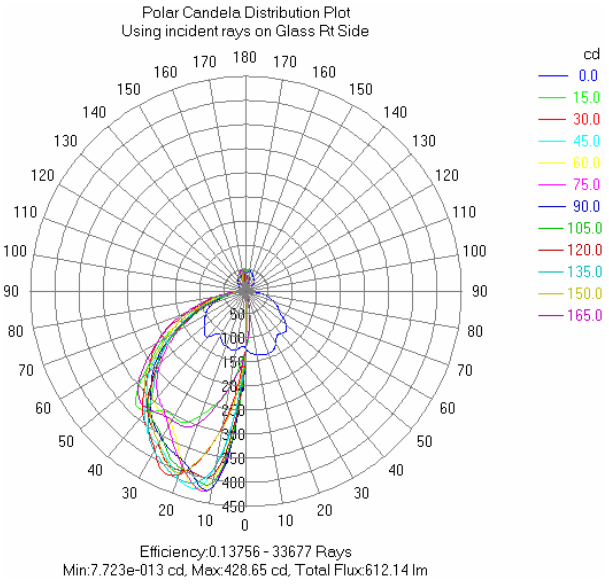


Top Exiting Surface Candela Distribution



(Symmetrical) Side Candela Distribution

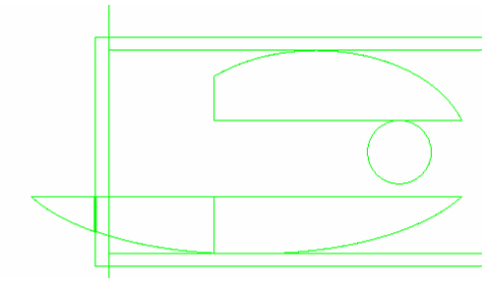




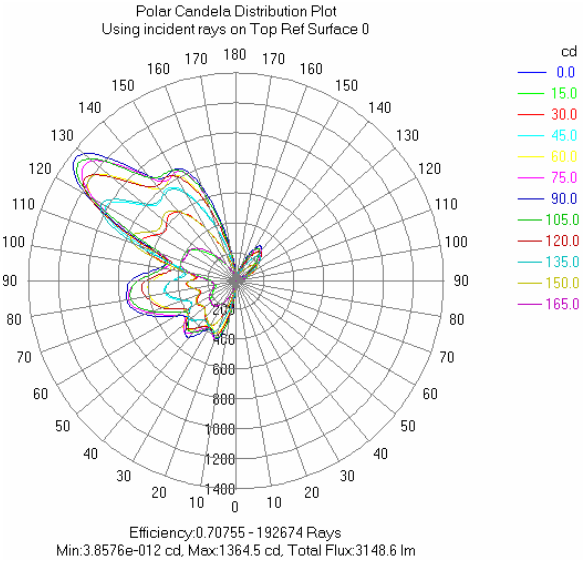
As can be seen from the distributions, the candela value for the single T5 lamp distributing upward was considerable, especially since there was nothing to prevent its distribution (like luminaire housing or lenses and other transmissive surfaces. The side distribution on the other hand has a nice high immediate downward component and a very smooth falloff distribution at higher angles. This implies that the luminance directly affecting the desk occupant will not blind them. The luminance is highest toward the desk surface and falls off gradually, but quickly. The efficiency of each component is listed, and the efficiency of the overall system is 89% which seems very reasonable for such an open upward aperture and low component downlight.

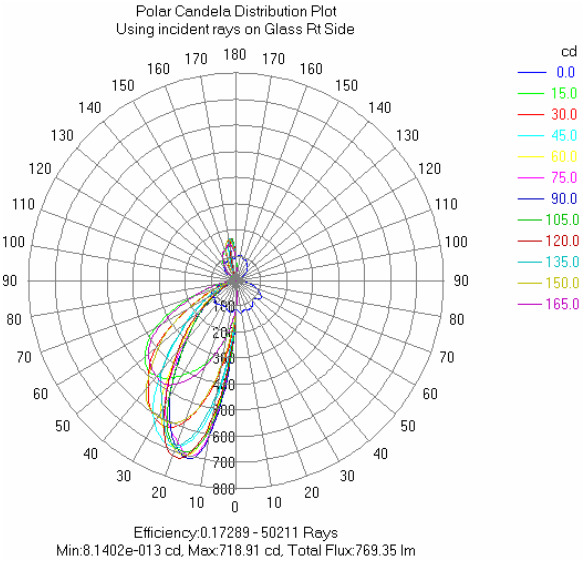
The half distribution system was also developed for those desks that abutted walls and not another desk. Instead of wasting the light and creating a very heavy shallow scallop on the wall, the light is attempted to be redirected into the space and above the desk user. One side of the glass partition is also given a specular Miro surface such that a lower lamp wattage can be used. Using an extra-long reflector at the top and an additional reflector in the glass, the lower wattage lamp should produce a similar luminance for the upward component and a similar luminance through the glass as well. The section showing the new reflector and the associated top and side candela distributions are illustrated below.

Half Distribution Desk System – 28W T5 – 100,000 rays



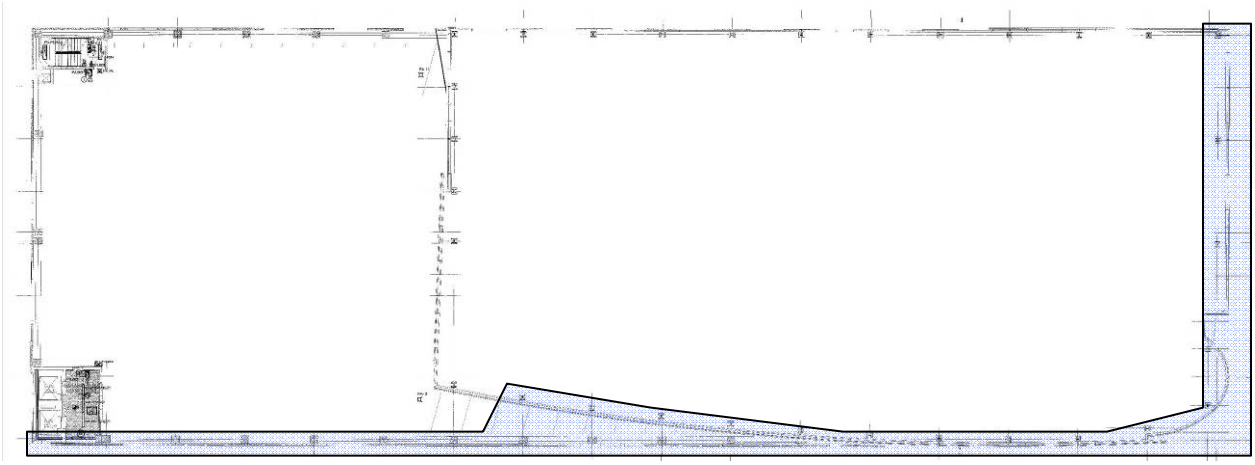
** A similar raytrace is produced, but will not be shown.





Based on these two systems, the Open Office plan was constructed and these luminaires used as the primary lighting elements of the space. Based on the TracePro output for the luminaires, they seem to be an extremely useful alternative to suspended fixtures if one wishes to keep the ceiling open and clear. This could also be a viable system to use when the ceiling height is extremely high or "non-existent" as might be the case where a glass atrium ceiling is used.

Façade



Special Luminaires

The façade lighting design makes use of two types of fixtures. The Erco Beamer IV is used as the only long-throw metal halide and can be found in the cut sheets in Appendix C . The other luminaire is of a design created specifically for this thesis project. The LED fixture researched and modeled specifically to be install on the mullions of the building (and underside the canopies) is detailed in Appendix C. Please refer to these drawings for the design dimensions and parameters. One will note that while two "differing fixtures" are used to model the space, the installation is almost identical – one with the reflector, and one without.

Thematic Description

The theme of the façade arose from the architectural form itself, as well as a conceptualized view of the proposed lighting scheme, was based around a water fountain or free-flowing water. The concrete parking garage forms the "basin" of this fountain, or the rock face from which the water freely flows. The entire glass façade reflects the blue skies and lake in the distance giving it a bluish-green "tint" from an outside on-looker's perspective. Since it is relatively reflective, but still see-through, it gives the impression of water in a deep lake – the observer knows it is transparent, but cannot always see to the bottom. The goal of the façade lighting design was to accentuate this point at night through the use of variable colored light sources, and create a "free-flowing" form in a spatial dimension that complimented the building's curved façade.

As a compliment to the free-flowing water, the concrete "basin" needs to be accentuated as well. The building also required the illumination of the building's limits such that the water and basin didn't seem to appear to fade into bleak nothingness. The linear accentuation across the top of the building is complimented as well by a light cast at a very low grazing angle down at the edges of the parking structure.

Surface Materials

The roof façade is composed almost entirely of aluminum paneling. The aluminum shown here is from a large section of the roof paneling, but is typical of all of the aluminum used throughout the 17th floor and roof façades.

Reflectance: 0.6

The aluminum shown here is typical of the entire façade. It is a little bit lighter than the roof façade but a little duller. There is no specularity associated with this aluminum façade paneling at all which accounts for its slightly increased reflectance compared to the aluminum above.

Reflectance: 0.59

The granite base material shown here is only located at the ground floor, on and around column lines, between retail facades, and no higher than 3 feet off of the ground. The granite is used as an accent piece to the lower façade.

Reflectance: 0.31

The green glass shown here accent outdoor entrances and garage entrances, as well as the accent glass around the retail facades. It is purely opaque, and therefore has no transmittance.

Reflectance: 0.57

The major component to the façade, on the parking structure side, but the majority surface material nonetheless is the concrete precast panels. The precast panels are not just concrete, but have been infused with small specks of black glass to give it a more stone-like or marble look.

Reflectance: 0.68

The sidewalk pattern shown here is more for informative purposes and is important to the façade lighting. Not a whole lot of downlighting should be used to avoid mixing and bleeding the colors up against the building or against any adjacent building.

Reflectance: 0.42

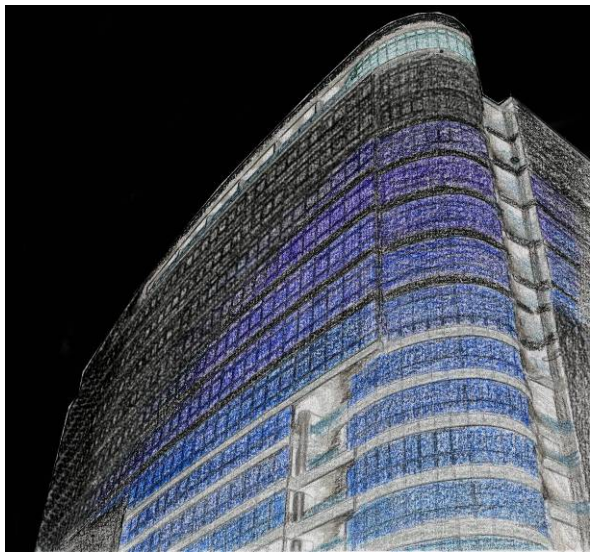
Glazing Specifications – Transmittance and Reflectance

The glass on the exterior, shown to the left, has a slight reflectance and a high transmittance. Because of the viewing angle, a considerable amount of the street can be seen. It is a light hue of blue, but not to the contrast that the picture shows (combination of daylighting and camera quality).

Further information on the glazing is shown below.

Type:	Insulating Glass - Surface #2 Coating – NP-61
Reflectance Outdoors:	0.21
Transmittance Visible:	0.61
Solar Heat Gain Coefficient:	0.4
U-Value:	0.31 (winter and summer)
Light to Solar Gain Ratio:	1.53
Thickness and # panes:	(2) 6mm panes with ½" airspace between

Design Concept



The design concept for the building as developed in the fall semester is illustrated below. The design hinges on the use of LED point sources located at a standard distance from one another to give the impression of a soft, continuous light source that spans the given length for each floor's layout. The use of LEDs was chosen because of their thermal characteristics – namely their resistance to light loss with decreased temperature. The use of LEDs was also useful in determining whether or not their efficiency was greater or less than that of standard lighting solutions and could provide the owner with a viable, long-term solution.

One will note that the design concept as used in the fall semester was altered in significant detail at the parking garage façade. This was to eliminate light pollution and trespass problems arising from the uplighting solution initially proposed.

Design Criteria

Appearance of Space and Luminaires – Rating: 10

The appearance of the façade is of dire importance. Not only does it proclaim the materials used on the building's exterior but it presents the building as a showpiece to the surrounding area and the city given its appropriate size and visibility. Functionally, lighting the façade also accents the skyline. It gives a form to the building at night and distinguishes its boundaries when the interiors are dark.

At ground level, the façade lighting can also act as a highlight to the retail and restaurant spaces that otherwise have no verticality to their advertising, signage, or landmark accentuation. Façade lighting draws an individual to it both spatially and psychologically, and therefore acts as an advertisement for the building – not only at ground level, but in its entirety.

Luminaires should not be as prominent in the lighting solution and their goal is to be not seen at all. Façade lighting should seem mystifying, if not magical. To view the luminaires that illuminate the façade takes away from the mystery and wonder, and then detracts from the landmark status of the building.

Color Appearance and Contrast – Rating: 7

Because the majority of the building is glass, it is hard to illuminate (save from the inside), and the color scheme of the building at night would seem to be rather plain. Highlighting the aluminum paneling or the precast concrete walls of the parking structure by themselves becomes no daunting task as the color variety does not exist. Nonetheless, for a nighttime scenario, one does not wish to light the building façade with a warm light and impress upon it a reddish tone when the nighttime sky reflects well of black and dark hues of blue.

Direct Glare – Rating: 7

In-ground fixtures are a cause for concern for direct glare. Additional façade lighting results in direct glare of particular concern considering vehicular traffic. Given the building's proximity to the street on three of four sides, façade lighting intended for sidewalk illumination and side-building illumination can become major direct glare issues as well. Sharp cut-off angles are required for fixtures installed outside such that they do not distract or, worst-case scenario, blind passing drivers.

Light Distribution on Surfaces – Rating: 8

Harsh scallops on the façade will alter the linearity of the building and create an unpleasant wave-effect on the lower portions of the building. Depending on the lighting design intentions, spots should be aimed to accent certain areas, but narrow beams should not be used to reach a large number of floors simultaneously unless highlighting a specific linearity.

Luminance of Surfaces – Rating: 6

Surface luminance is not of great concern because of the obvious characteristic of the surfaces. The bright white precast concrete walls will have a great luminance, while the glass panels will have very little. Balancing these light levels or creating an appropriate gradient will be very important to the design scheme.

Light Pollution and Trespass– Rating: 9

Light pollution from the glass façade may be considerable. Without appropriate lighting (not currently utilized) dark sky recommendations cannot be met. Light trespass to adjacent properties is also of concern due to the variety of zoning in the immediate vicinity. With residential areas to the north and east of Cathedral Place, light trespass will not be tolerated by current residents. Light pollution and trespass should be minimized as an example to future new construction and as a courtesy to those neighboring properties and their current occupants.

Modeling of Faces and Objects – Rating: 6

The modeling of faces and objects is important at ground level for easy and accurate facial recognition and general safety concerns. Bollards, curbs, wall extensions or protrusions, and spatial awareness are a necessity at ground level when considering façade lighting for the safety of the pedestrian, and passer-by, as well as for vehicular access and awareness.

Points of Interest – Rating: 8

Façade lighting, when not independent to the tenant space such as a restaurant or retail shop, is important to identify the entrance(s) and exit(s) to a building. Considering this building's use, the entrances and exits to the parking garages (and the differentiation between them) is extremely important as points of interest. These areas should have a higher illuminance than the adjacent spaces.

Shadows – Rating: 8

Shadows at the ground level should be avoided as a general safety concern as well as vehicular-pedestrian safety. A poorly located shadow could make a pedestrian all but invisible to a car entering the parking structure, which would be a great safety concern.

Surface Characteristics – Rating: 6

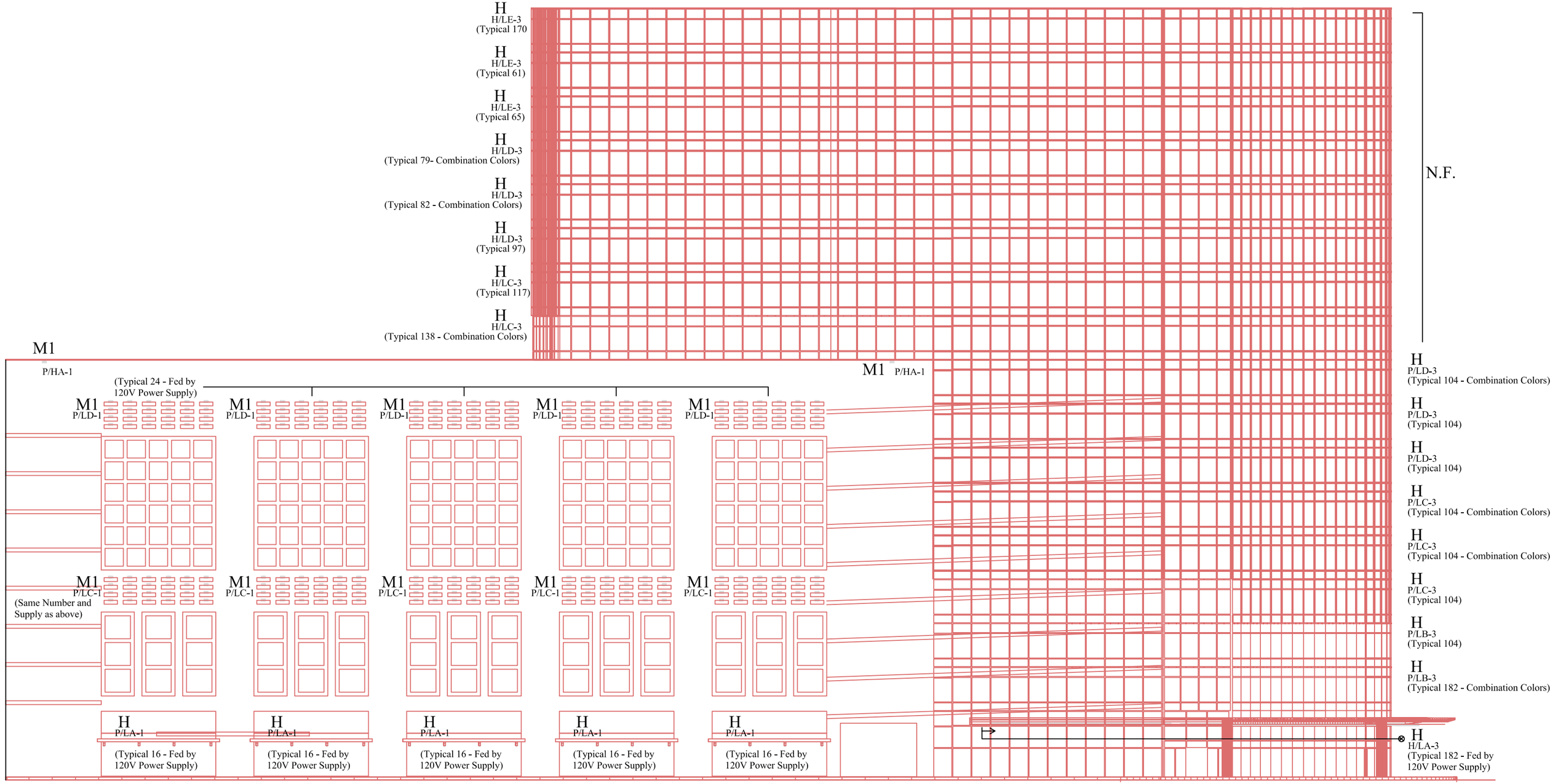
As previously noted, the surfaces of the building do not vary considerably, but they do have architectural appeal. For this reason, it would be in poor design taste to neglect these elements (such as the dark marble at the base of the columns between retail entrances, or the aluminum canopies over each retail and the main entrances).

Horizontal Illuminance – Rating: 8

The horizontal illuminance on the façade is extremely variable. Horizontal illuminance occurs mainly at ground level, and those values should range from 10 to 50 lux depending on the security condition and the proximity to a major building entrance. Under the canopies, illuminances should attempt to maintain 20 lux and increase in response to the "point of interest" criteria.

Vertical Illuminance – Rating: 6

Vertical illuminances of the façade are extremely variable dependent on the location of measurement. The vertical illuminances at the ground level should be the most uniform with an illuminance similar to that of a parking structure condition – 10 to 30 lux for facial recognition and general safety and spatial awareness concerns.



Facade Profile, Lighting Layout and Circuiting Diagram
Luminaires on the Northern Facade (labelled N.F.)
are included in the numbers listed for this profile.

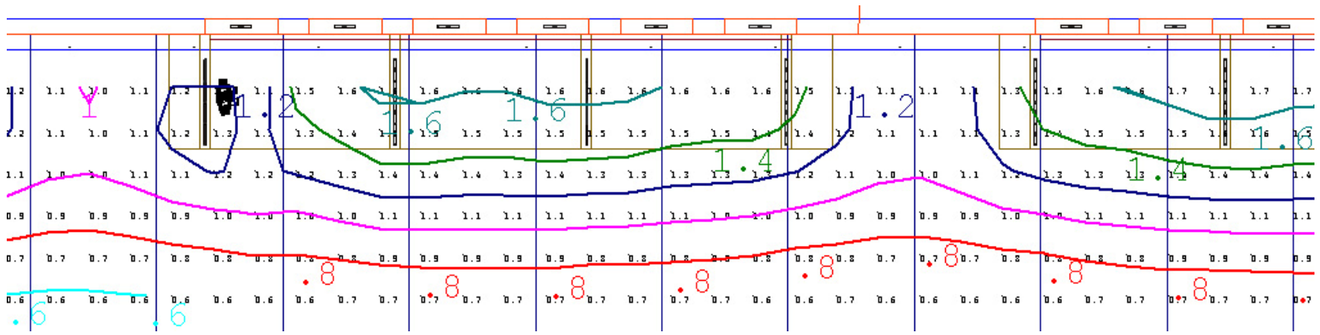
All Fixture information can be found in Appendix C or on the provided CD.

Not to Scale

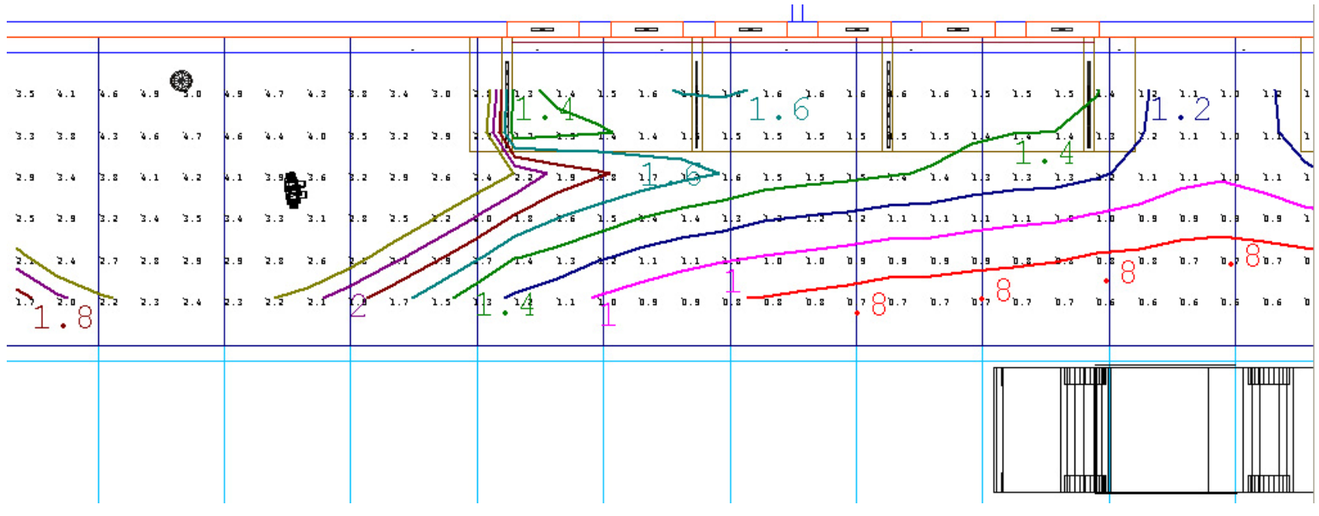
Performance

Sidewalk
Illuminance Values
(Fc)
Average=1.62
Maximum=5.8
Minimum=0.0
Avg/Min=0.00
Max/Min=0.00

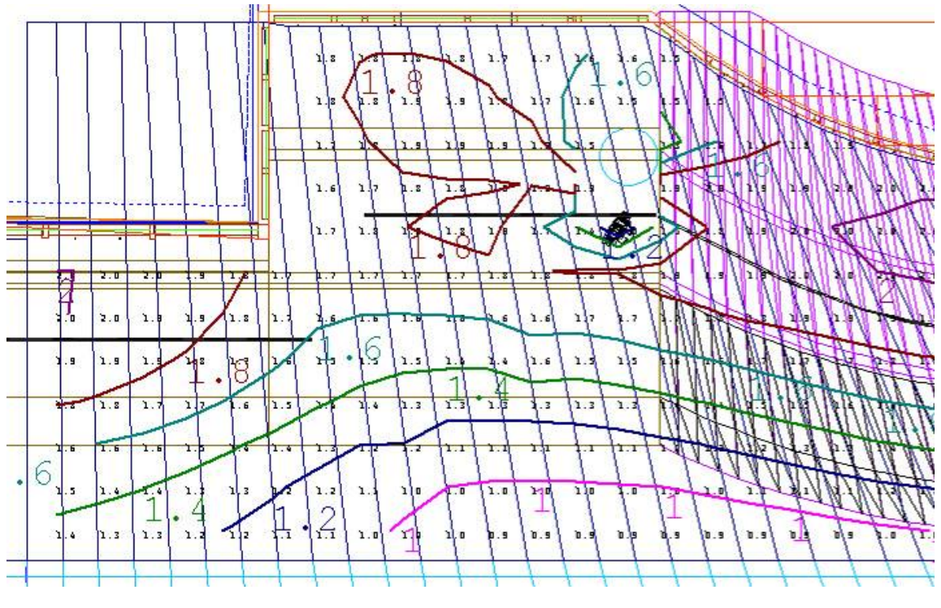
Main Canopy
Illuminance Values
(Fc)
Average=1.52
Maximum=2.0
Minimum=0.6
Avg/Min=2.53
Max/Min=3.33



Mid Sidewalk Portion



Far South Sidewalk Portion



Entrance to Lobby

ASHRAE Power Density Calculation

ASHRAE Power Density Allowance for Facade – Exterior Lighting: 0.25 W/sf façade lit

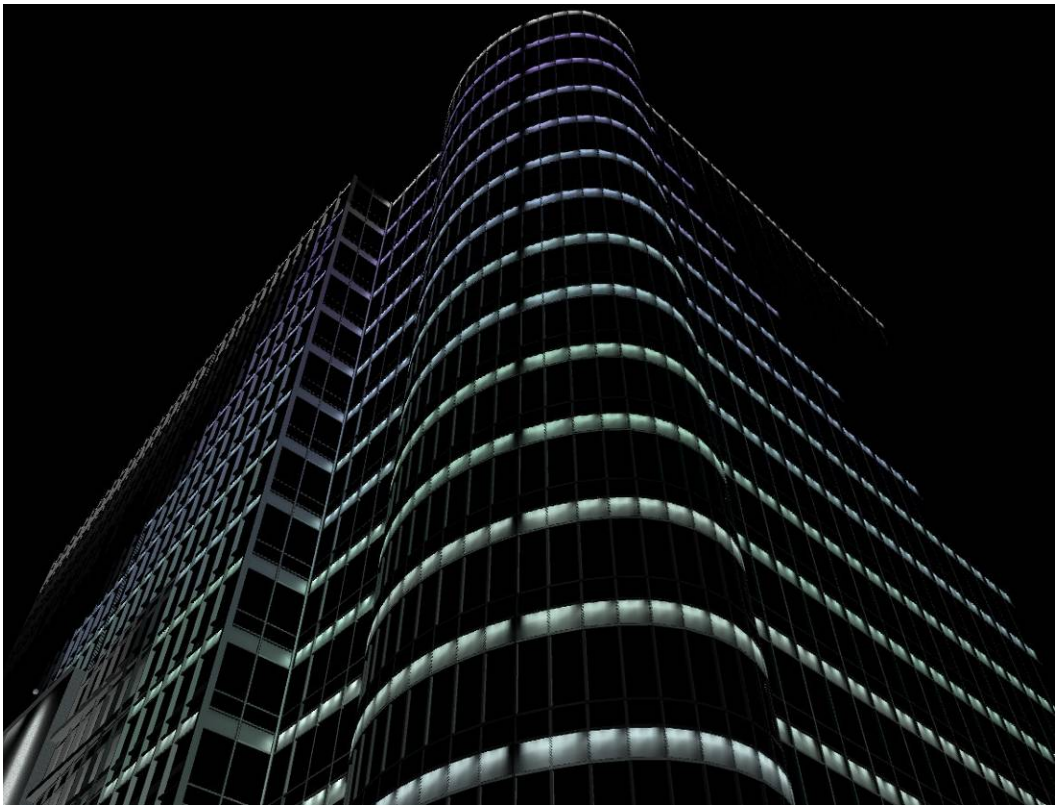
Façade square footage: 9700 sf(485' "perimeter" * 40' vertical illumination area)
ASHRAE allowance : 4850 W
Existing Power Density: 0.28 W/sf Does NOT meet ASHRAE 90.1

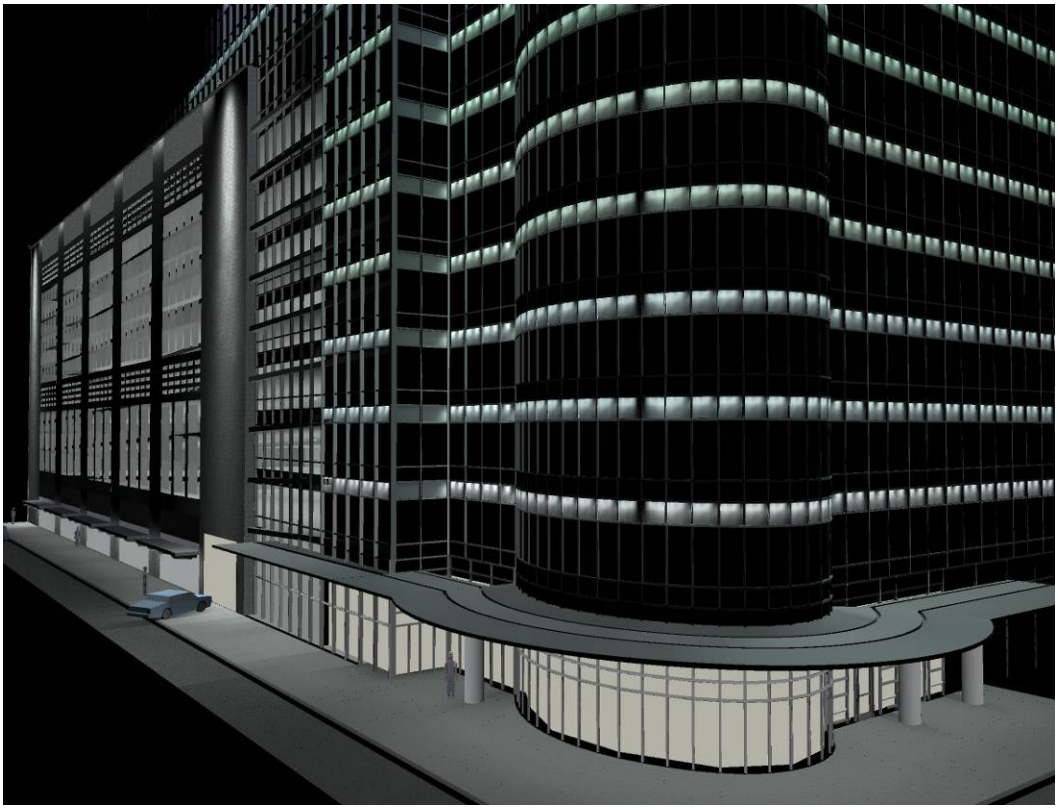
Façade	H	H1	H2	H3	H4	M1			
Luminaire	781	165	312	312	456	2			Power Density
Wattage	1	1	1	1	1	191	SUM (VA)	Area (sf)	
Total Power	1172	248	468	468	684	573	3612	9700	**0.372 W/sf**

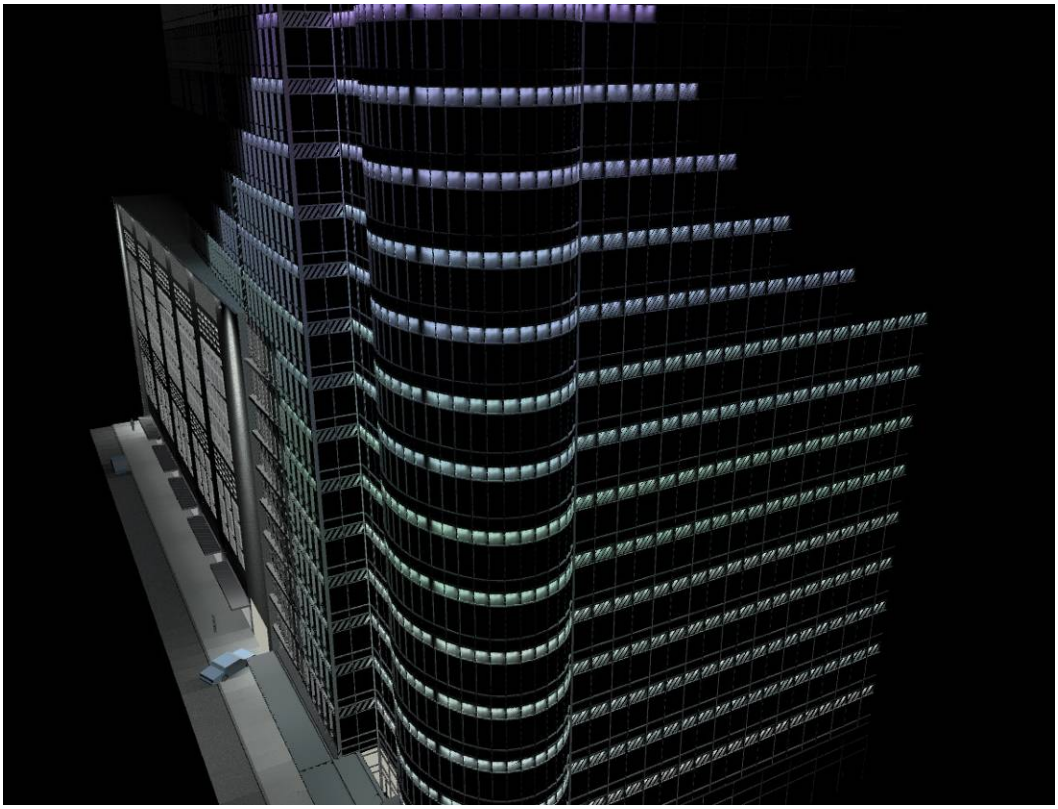
New design meets ASHRAE 90.1 Standard

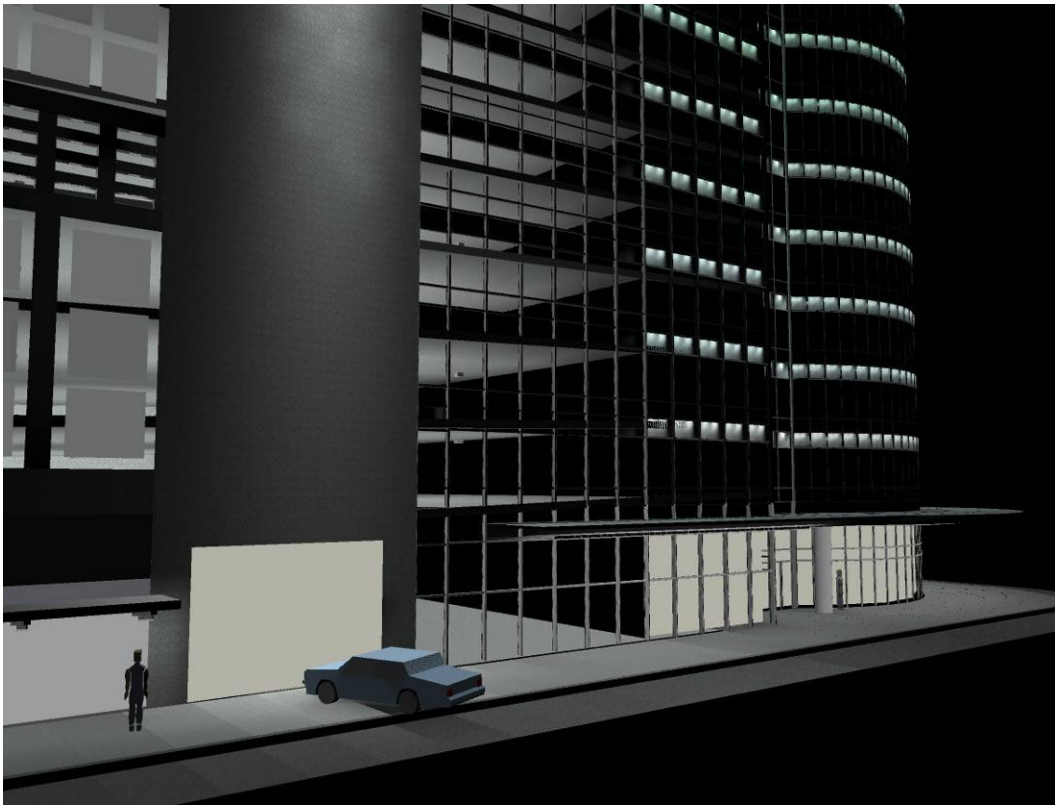
**It should be noted that the area used was calculated from the "per square foot of façade being lit" calculation. And the area determined above is a conservative estimate of the area actually being lit by all sources.

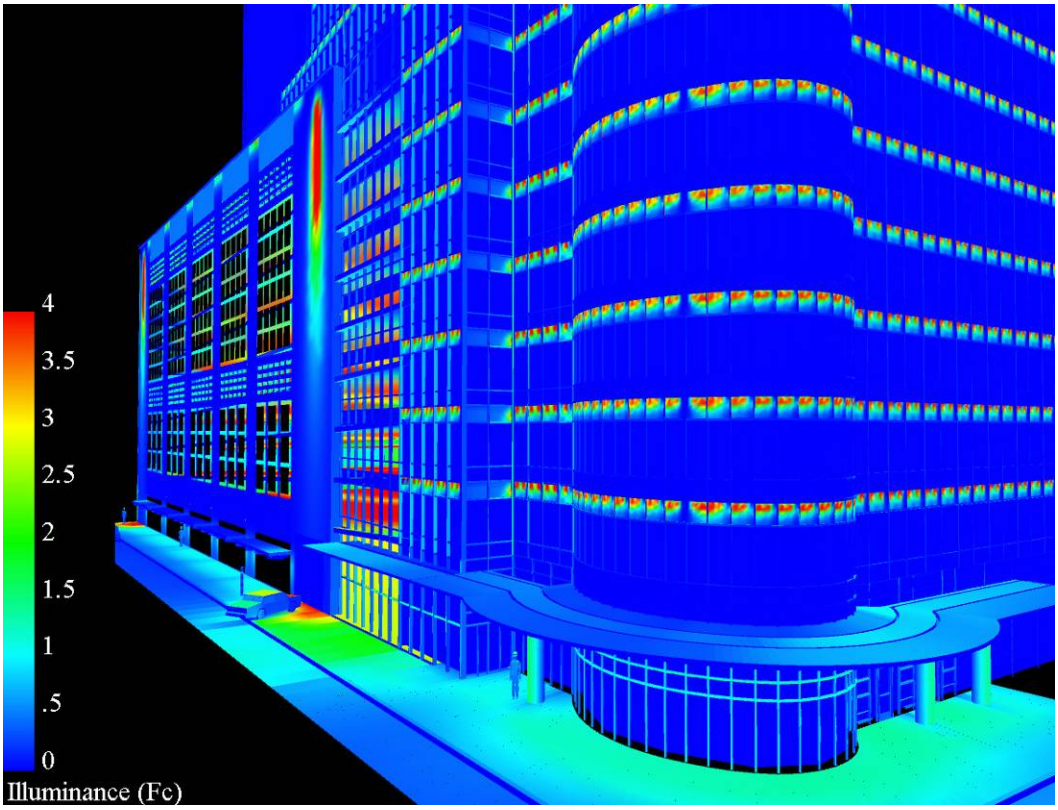
Renderings

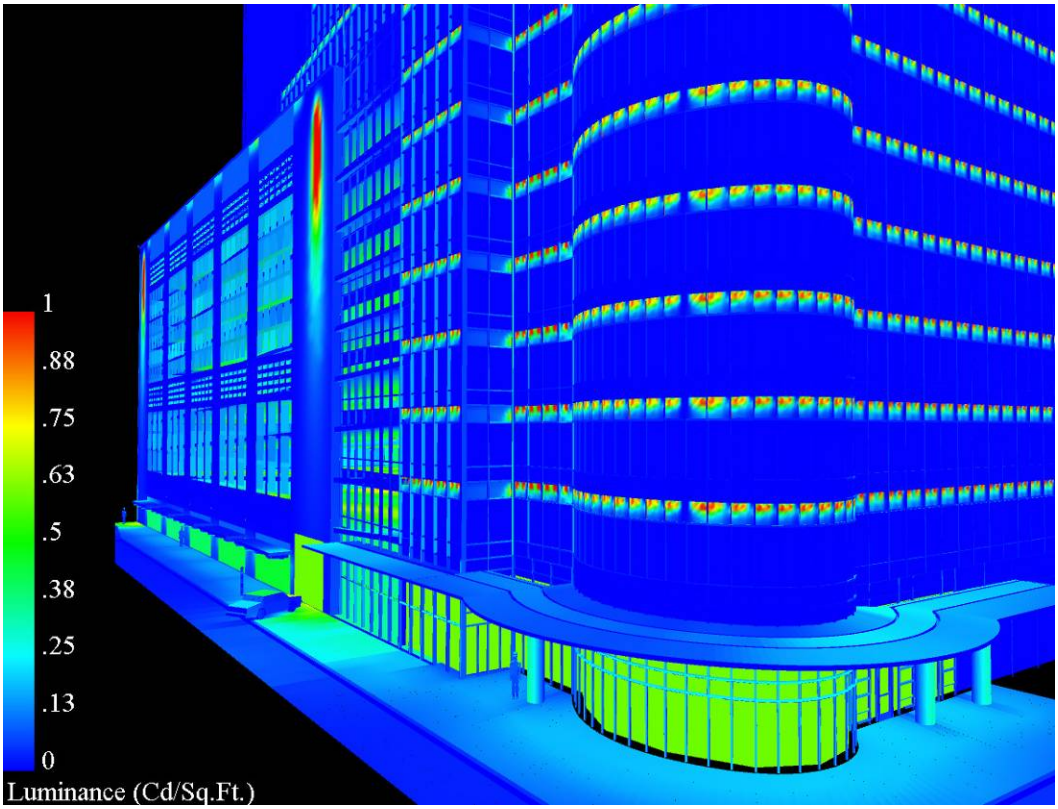


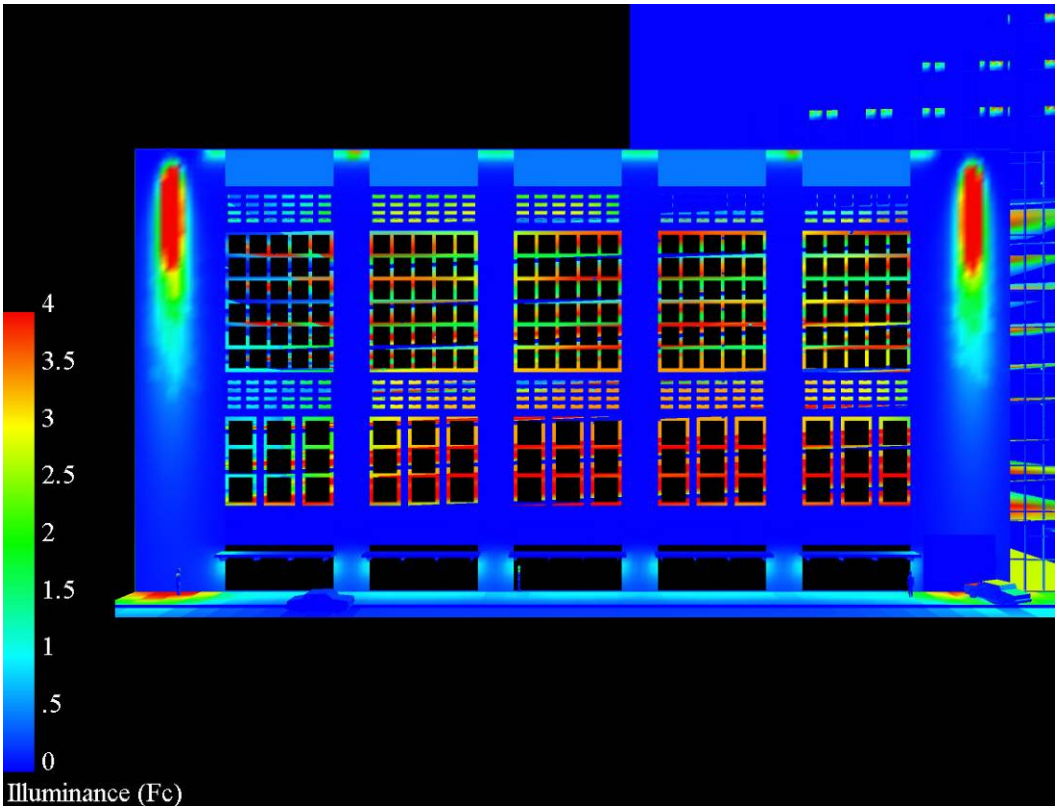




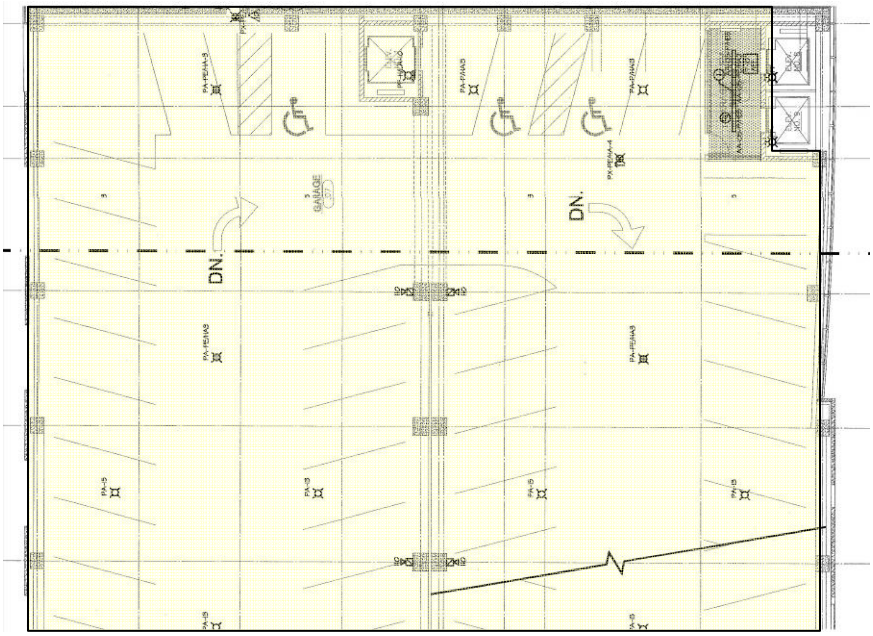



4
3.5
3
2.5
2
1.5
1
.5
0
Illuminance (Fc)


1
.88
.75
.63
.5
.38
.25
.13
0
Luminance (Cd/Sq.Ft.)


4
3.5
3
2.5
2
1.5
1
.5
0
Illuminance (Fc)

Parking and Parking Lobby



Thematic Description

The parking level and lobby theme was not as profound as the façade, and was never intended to be. The overall "water" theme was touched upon in the Parking Lobby where the materials of the space were changed to include a bluish tint, giving the vague impression that the individual was underwater. Considering the surrounding space is completely concrete, it was hard to bring any theme to fruition when a simple exterior glace would force the occupant to dismiss any vague notion.

Surface Materials

One of the main surface materials is the wall material, which, on interior load-bearing elements are cinderblock masonry walls. These concrete blocks with similar concrete mortar are all of the relatively same color and reflectance. They are a medium grey on average.

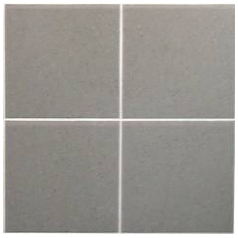
Reflectance: 0.41

The floor of the parking structure is uniform except for the elevator lobbies. The surface is a smooth concrete with a similar color and reflectance as the cinderblock walls. It, while dirtier and discolored more often, is an average medium grey.

Reflectance: 0.37

The walls and ceiling of the lobby are a simple white painted drywall. It is highly reflective when compared to the rest of the structure, and as such, stands out as a point of interest.

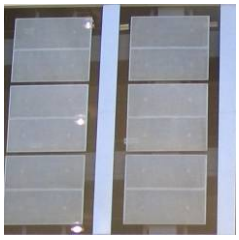
Reflectance: 0.81



The tile in the lobby on the floor and on the lower few feet of the walls (kick-guard tiling) is a deep grey with white grout. This dark surface requires little cleaning, and if so, it is very easy. It also complements the grey color of the structure and doesn't give a "color-bomb" appearance to the lobby.

Reflectance: 0.30

Glazing Specifications – Transmittance and Reflectance



While there is no technical glazing on the walls, there are any number of open portholes, and as shown to the left, large expansive openings with metal mesh inlays acting as "window screens". This metal mesh surrounded by open air is approximated with diffuse windows and transparent windows respectively.

Transmittance (screen): 0.33
Reflectance (screen): 0.66

Design Concept

The design concept for the parking garage was based on two specific goals – to maintain the illuminance in the parking garage at levels appropriate for a parking garage, and to decrease the number of luminaires used and therefore decrease the interior power density of the garage. A subsequent advantage of the alteration of the lighting design was the glowing appearance the parking garage will create throughout the precast structural area of the façade.

Design Criteria

Appearance of Space and Luminaires – Rating: 6

The appearance of the parking deck and the luminaires is not of great concern. A general attempt to deviate from the typical parking structure look and feel should be attempted. The appearance of the space from the exterior however, is a bit more important. To have a blue/white façade get drowned out by light pollution and trespass from an orange high-pressure sodium within the garage would not be prudent. Exterior appearance of the garage's interior is relatively important.

Appearance of the luminaires themselves is not very important either. While an attempt to furnish a more aesthetically pleasing luminaire should be made, the greatest importance lies in the efficiency of the luminaire, not its aesthetic pleasantness.

Color Appearance and Contrast – Rating: 8

Color appearance and contrast should be regarded as a more important to the design. The lighting design should attempt to use lamps with high CRIs as well as high efficacies. The lacking appearance of color and accurate rendering would be a significant safety concern. Additionally, the color appearance is important to the general façade lighting as mentioned previously. They must be intertwined.

Direct Glare – Rating: 5

Appropriate fixtures with adequate diffusing lenses should be used to eliminate the direct glare that can accompany low-ceiling parking structure lighting. Reduction of glare in typical parking structures is completed by placing the luminaires off-center of the driving aisle. However, in this building, the post tensioned concrete beams drop down so far below the ceiling level, direct glare is almost entirely masked.

Light Distribution on Surfaces – Rating: 5

Distribution of light should be uniform for all surfaces with as slight a gradient as possible. Harsh shadows from vehicles may impede this uniformity, but driving lanes and pedestrian walkways should maintain a consistent uniformity. Ceiling brightness is not of great concern, and scalloping on walls can be nearly neglected based on the positioning of the luminaires nearest the aisles.

Luminance of Surfaces – Rating: 2

Considering the entire structure to be concrete, luminance of surfaces only concerns the space itself, and the cars parked within it. The luminance of the walls, floor, and ceiling will be equal in ratios to their illuminances, and concern for spatial depth problems is nullified. Since the specularities of cars cannot be accounted for either, it too is neglected.

Light Pollution and Trespass– Rating: 9

Light pollution and trespass (one and the same at level 3) should be accounted for as previously noted in the space and color appearance sections. Pollution and trespass through the many openings in the precast concrete walls should be controlled as much as possible through appropriate luminaire placement and selection of appropriate IESNA type fixtures.

Modeling of Faces and Objects – Rating: 6

Similar to the façade ground-level reasoning for safety concerns and vehicular awareness, face and object modeling is relatively important and a higher light level should be maintained to account for these conditions. Given the exposed internal structure, the bollards around the exposed upper structure, and the precast panel walls, spatial and depth cues should be easily identifiable for all vehicles.

Points of Interest – Rating: 8

Higher illuminances at the elevator lobbies and pedestrian paths to said lobbies should be maintained as the only point of interest for a given floor. Exit stairs in the case of emergencies should also be highlighted points of interest in the parking structure.

Shadows – Rating: 7

Shadows, for safety concerns, should be minimized as much as possible and their existence should start at the center of the aisle (none) and become harshest at the head of a parking stall. Shadows created between cars from long throws of light in far fixtures should be minimized to maintain a certain safety factor.

Horizontal Illuminance – Rating: 6

The horizontal illuminance varies for points within the parking structure. As noted in chapter 22 of the IESNA Handbook, they should follow this schedule:

	Day	Night
Basic	10 lux	10 lux
Ramps	20 lux	10 lux
Stairs	20 lux	20 lux
Entrance	500 lux (incl. daylight)	10 lux

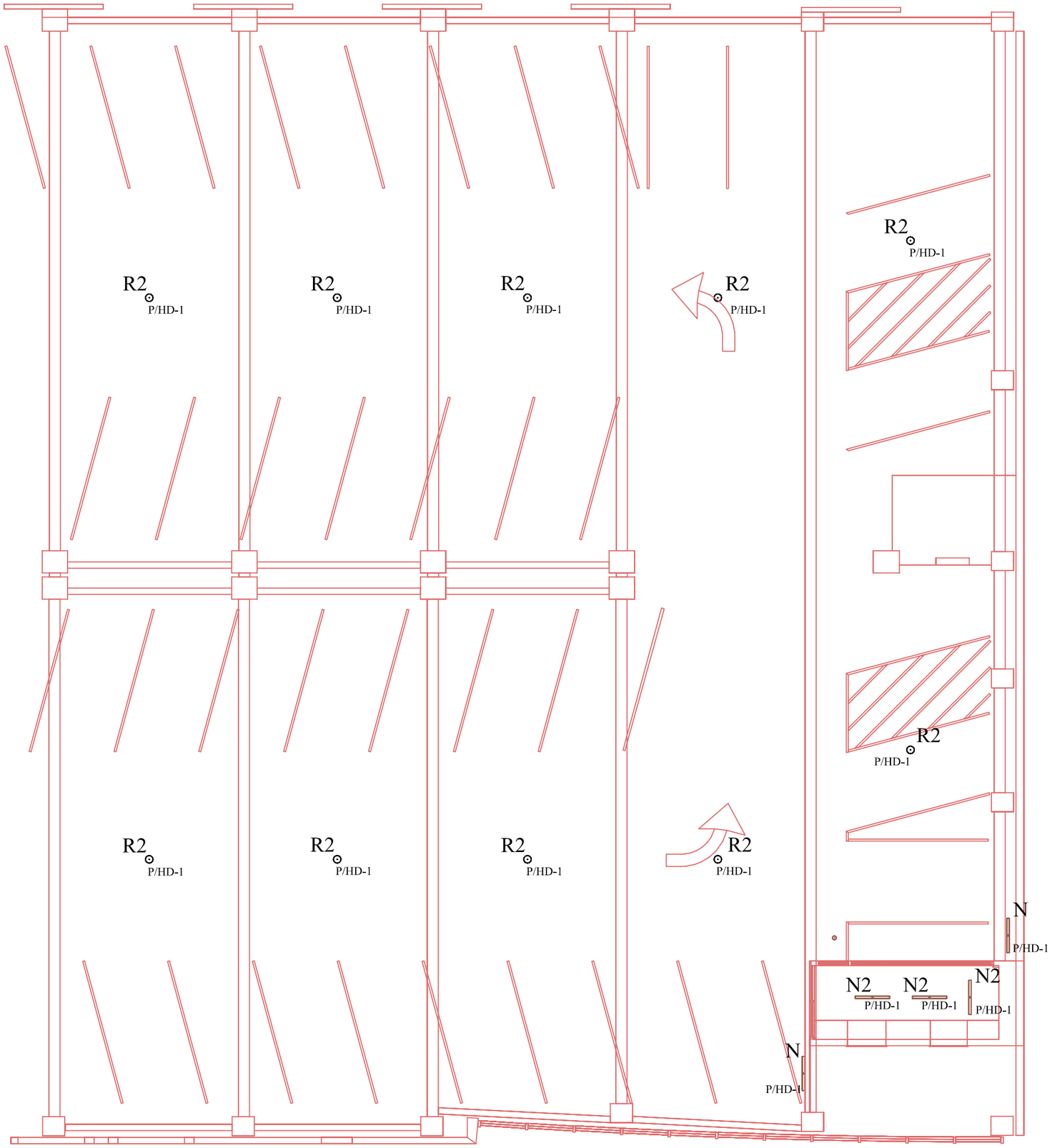
Vertical Illuminance – Rating: 6

The vertical illuminance varies for points within the parking structure. As noted in chapter 22 of the IESNA Handbook, they should follow this schedule:

	Day	Night
Basic	5 lux	5 lux
Ramps	10 lux	5 lux
Stairs	10 lux	10 lux
Entrance	250 lux (incl. daylight)	5 lux

Layout and Circuiting

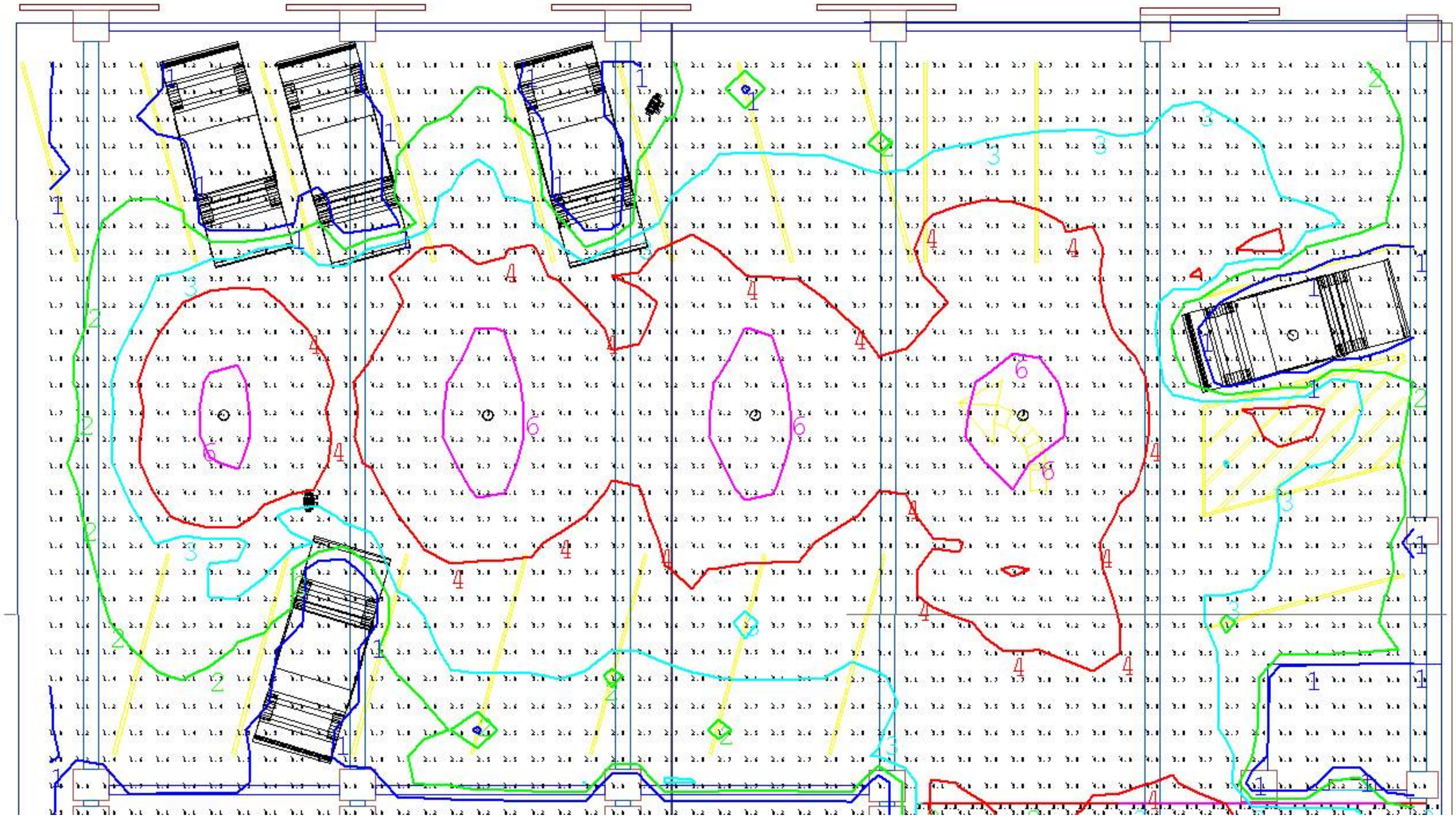
Parking Garage Floor Plan, Lighting Layout and Circuiting Diagram
All Luminaires additionally labelled with "S" are operable both manually and by Daylight ("D) or Occupancy ("O") Sensor

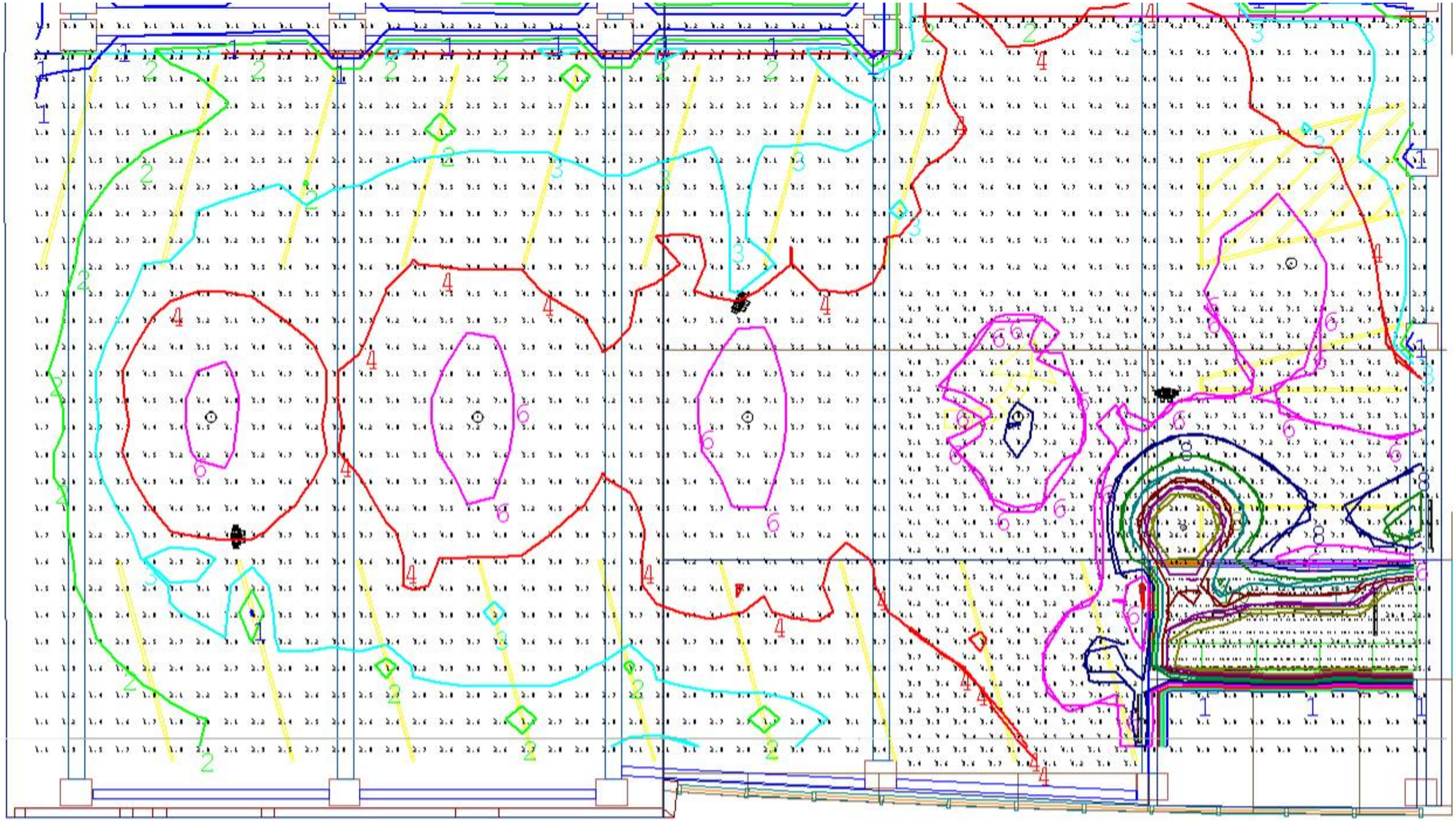


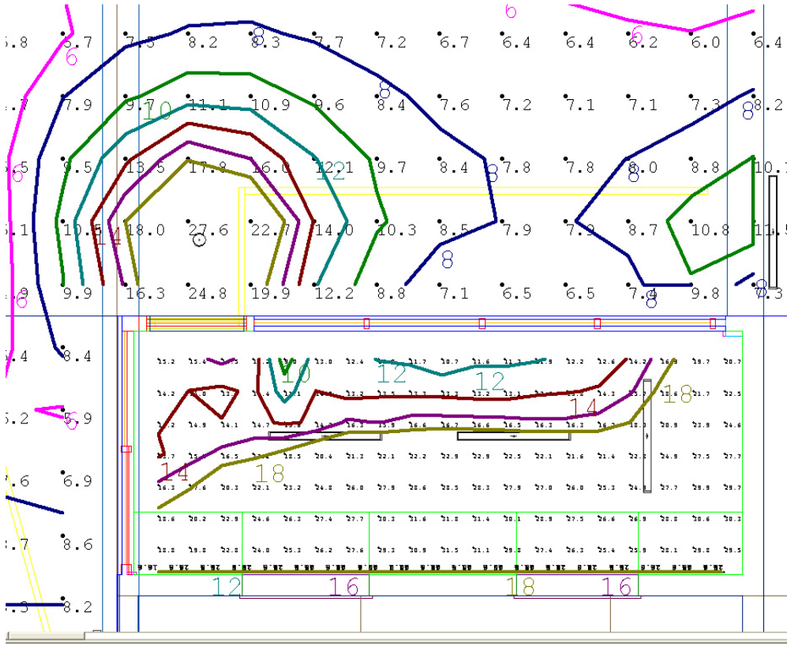
All Fixture information can be found in Appendix C or on the provided CD.

Not to Scale

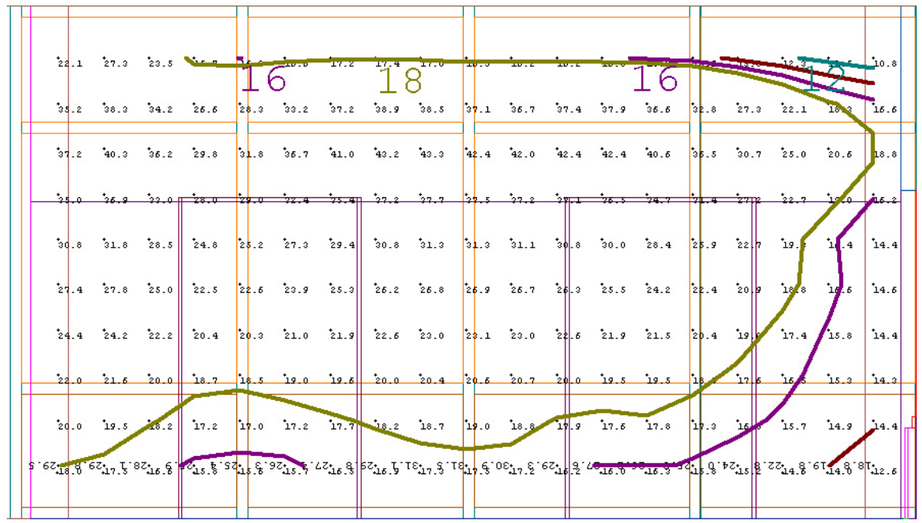
Performance



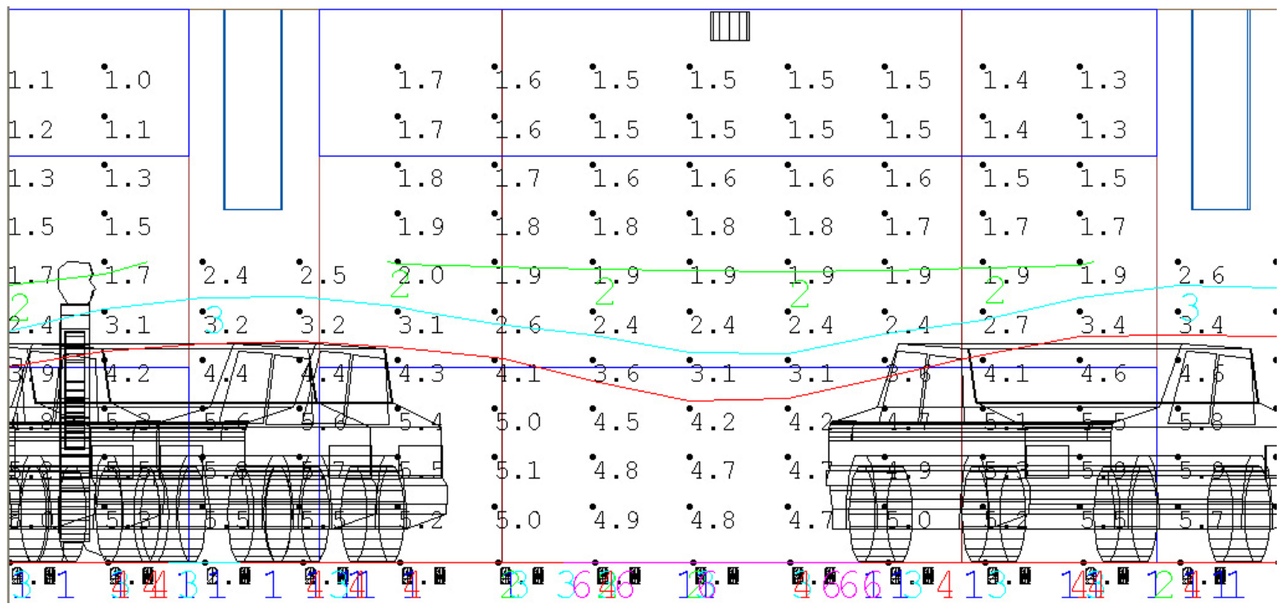




Close-up of Elevator Lobby



Elevator Wall Illuminance



Vertical Plane Illuminance

Project_1
Calc Pts

Lobby
Illuminance Values (Fc)
Average=20.91
Maximum=31.8
Minimum=9.0
Avg/Min=2.32
Max/Min=3.53

Lobby Elev Wall
Illuminance Values (Fc)
Average=24.09
Maximum=43.3
Minimum=10.8
Avg/Min=2.23
Max/Min=4.01

Outside Lobby
Illuminance Values (Fc)
Average=6.42
Maximum=27.6
Minimum=2.2
Avg/Min=2.92
Max/Min=12.55

Parking Vert Mid
Illuminance Values (Fc)
Average=2.92
Maximum=6.2
Minimum=0.1
Avg/Min=29.20
Max/Min=62.00

Parking Vert Turn
Illuminance Values (Fc)
Average=4.15
Maximum=7.8
Minimum=1.6
Avg/Min=2.59
Max/Min=4.88

Parking
Illuminance Values (Fc)
Average=3.76
Maximum=27.6
Minimum=0.0
Avg/Min=0.00
Max/Min=0.00

ASHRAE Power Density Calculation

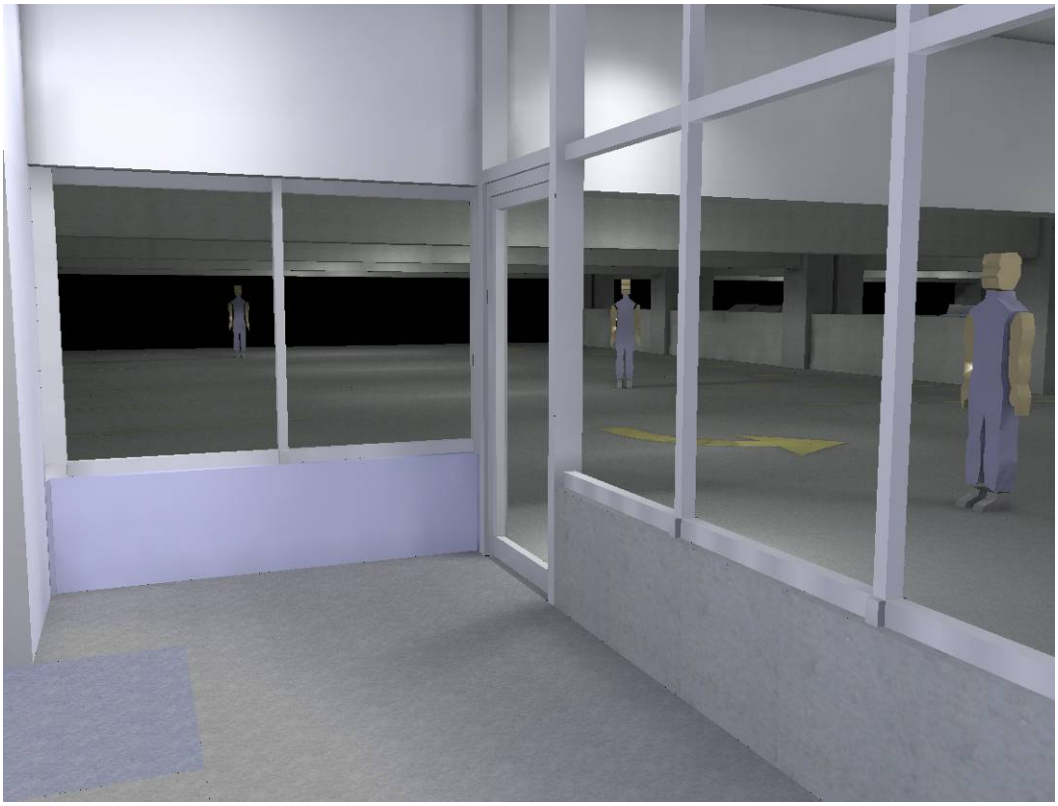
ASHRAE Power Density Allowance for Parking Garage: 0.3 W/sf

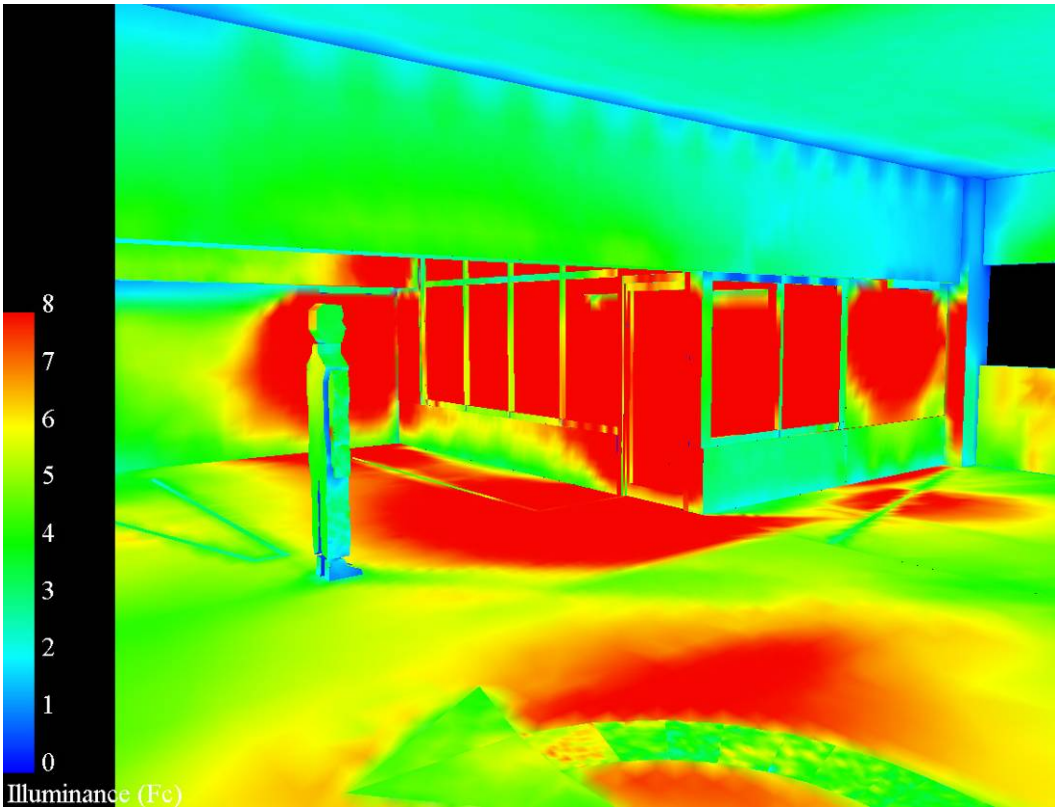
Parking square footage BA: 11600 sf
ASHRAE allowance BA: 3480 W
Existing Power Density BA: 0.255 W/sf Meets ASHRAE 90.1

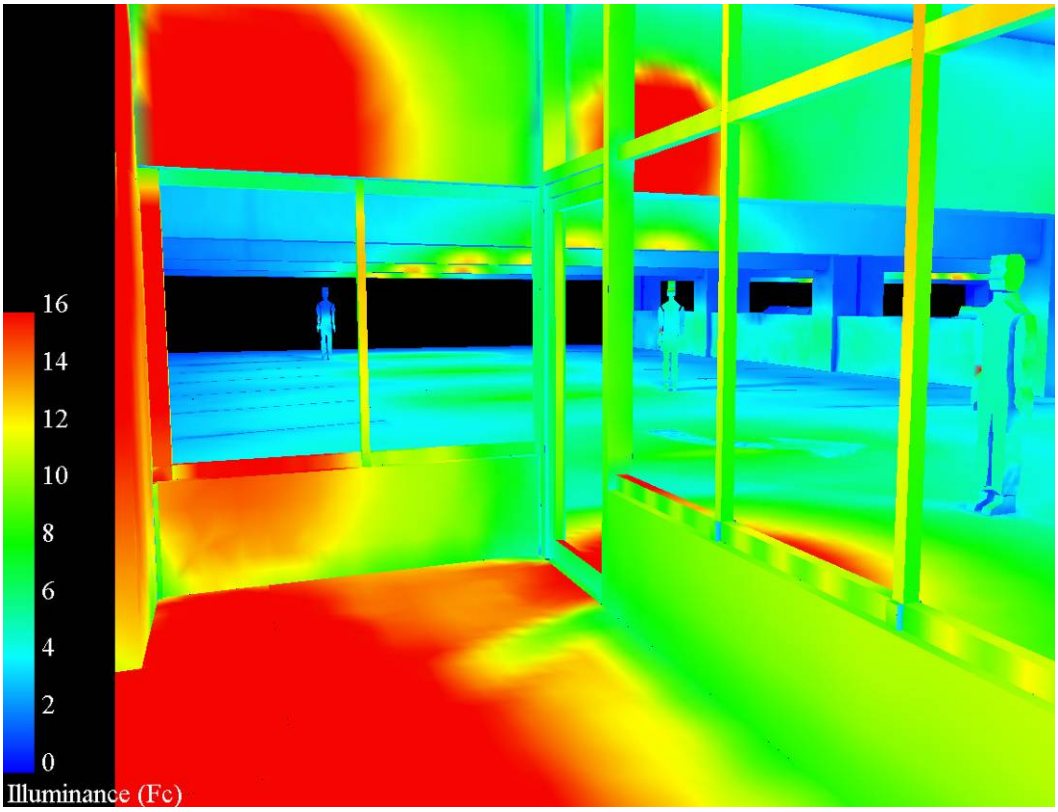
Parking Garage (Section)	N	N2	R2			
Luminaire	2	3	10			Power Density
Wattage	32	59	191	SUM (VA)	Area (sf)	
Total Power	63	176	1910	2148.5	11600	**0.185 W/sf**

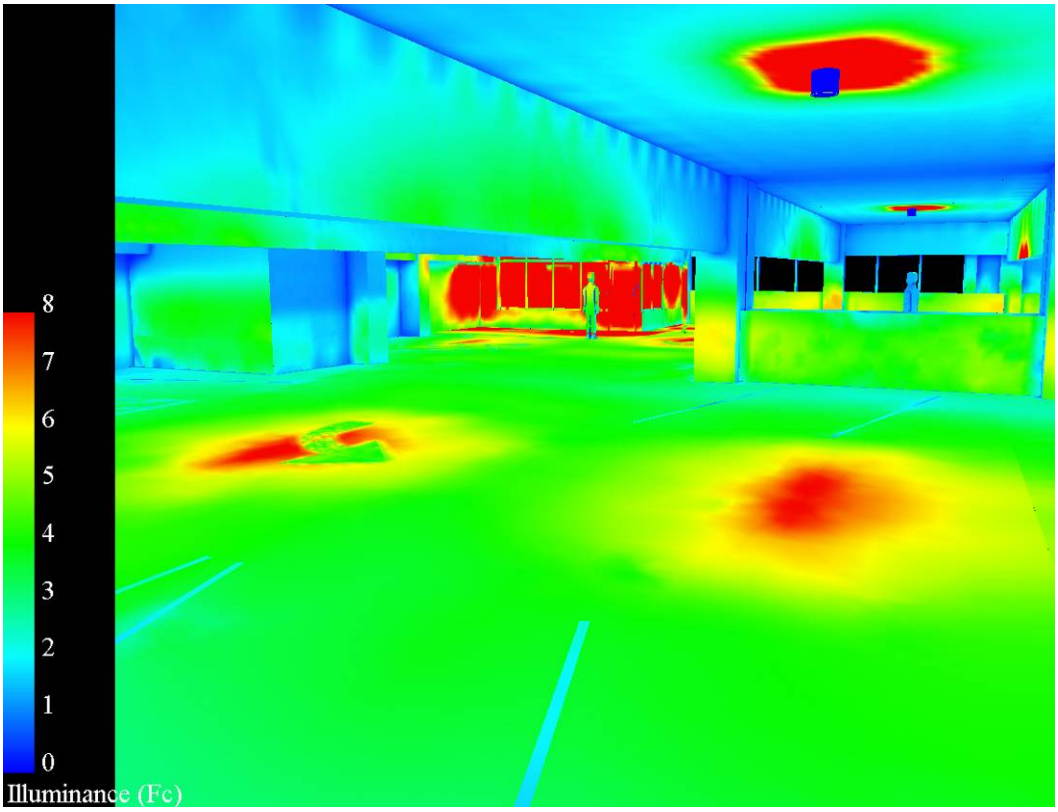
New design meets ASHRAE 90.1 Standard

Renderings

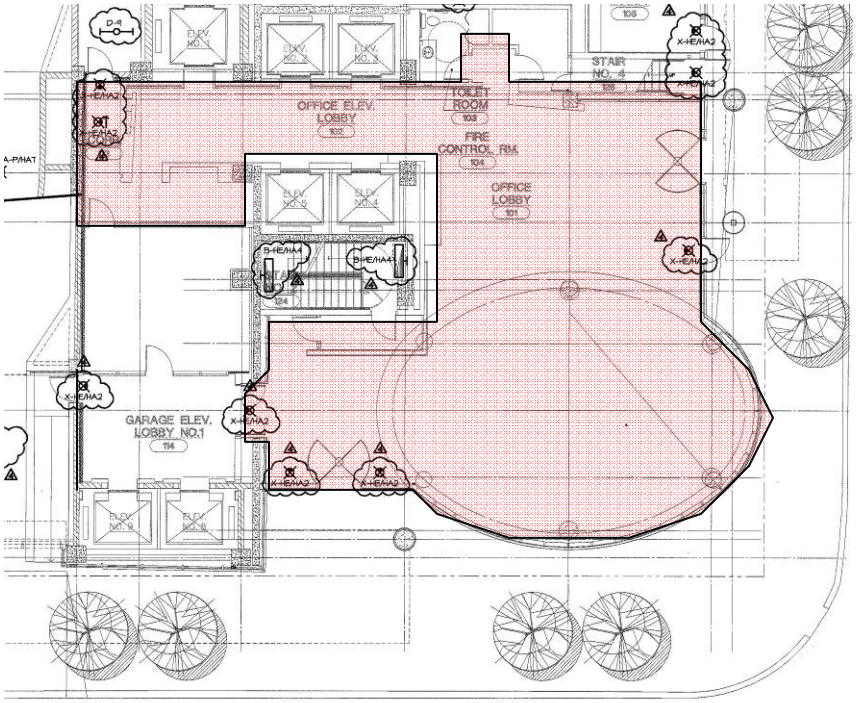



8
7
6
5
4
3
2
1
0
Illuminance (Fc)


16
14
12
10
8
6
4
2
0
Illuminance (Fc)


8
7
6
5
4
3
2
1
0
Illuminance (Fc)

Lobby



Special Luminaires

The Lobby has a few special luminaires that should be mentioned prior to viewing of the spaces. First, the same LED system used on the façade of the building is used on the aluminum mullion elements where the green translucent glass walls are located. The only difference between the façade LEDs and the Lobby LEDs is the orientation. The façade aims upward while the Lobby has the LEDs aiming upward.

The second of the special luminaires are the sculptured art pieces which were researched for the candela distribution (described above). These pieces are only located within the space and do not have any special orientation or function beyond simply existing.

The third special luminaire is the "barrel" luminaire used as an area source for the translucent "wave" pattern on the ceiling. These luminaires were also modeled as part of the lighting research and are described above as well.

All of these luminaires are detailed in Appendix C

Thematic Description

The theme of the exterior façade complimented by the vast, screened "windows" of the parking garage is exemplified, and even magnified in detail, within the Entrance Lobby. The water theme of the exterior would have to remain on the exterior and could not extend into the Lobby without logically altering the impression. Upon entering the building, one, in theory, enters the water fountain. This would put them underwater in all technicality and this idea was the basis for the lighting design within the space.

Considering the architectural elements already used, metaphors were developed for each of the materials and the lighting design appropriately adjusted. For example, the translucent walls, both white and green tinted, were underwater "bubbling" elements of the scene. The wood paneling seen on a select few of the walls, and accentuated by differing materials, implies a sunken ship, or underwater view of piers. All of the marble elements and white painted walls were considered stone, or the "bottom of the sea" where the individual would be walking. The glass and ceiling would then naturally be the limit of the water, as implied by the façade's appearance. Because the limit of the water is naturally oriented upward, the ceiling needed special significant design to achieve this impression. For this reason, a barrel-downlighting solution was applied and plastic highly translucent strips of varying width hung from the ceiling. These strips were tinted with a color gradient varying from light coral green to blue. The light output through these materials would vary, the dimensions of the strips themselves vary, and the varying color all give rise to a "wave" impression with peaks and valleys – a distinct indicator of the water's limit.

Surface Materials

Material and finish schedules could not be obtained in detail from the architects, and thus the reflectances have been determined using a small patch of the material gleaned from photographs and applied as surface materials in AGI which calculates an overall reflectance based on the materials colors and patterns.

The aluminum for the interior spaces has a higher specularity than the aluminum on the façade. The aluminum as is seen on the left side (non-daylight) is grey colored with a high sheen clear glazing giving it the specular look.

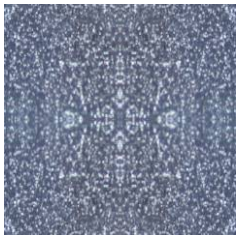
Reflectance: 0.7 (based off façade aluminum)

The blue glass interior wall is a deep panel system with the aluminum mullions extruded out 3 inches past the glass. The glass is colored blue to complement the coral green tones seen on other elements and in other glass framing.

Reflectance: 0.27 overall

The ceiling is a whitened grey tone with a high reflectance value. The soft grey was used to complement the other soft colors and not provide a stark bleak background to the otherwise colorful space.

Reflectance: 0.77



The black/blue marble shown here is the pattern seen on half of the floor in the lobby space. It is closest to the eastern façade and accounts for roughly 20% of the floor area.

Reflectance: 0.22

The white marble is the majority floor covering for the lobby space. The white marble does not sit adjacent to any façade, but is continuous through the main lobby, around the security station and into the main elevator lobby. It is similar to the black/blue marble, but obviously a different shade

Reflectance: 0.69

The red mosaic tile is the only different material used on the floor. Between the black/blue marble and the white marble is a rectangular area (oval atrium) or thin 6" strip of tile extending to each wall. The mosaic pieces are glazed over to match the specularity and smoothness of the marble floor area.

Reflectance: 0.36

The green glass wall complements the blue glass wall, and is of the same construction. While the blue glass wall is on the western side of the room, the green glass wall is on the southern wall leading to the parking elevator lobby.

Reflectance: 0.50

The wood paneling throughout the space has a very light hue with a slightly darker contrast in the "veins". The wood paneling is located on the western wall as an accent piece to the blue-glass, and at the south end of the elevator lobby. It is also featured behind the east entrance stair-wall.

Reflectance: 0.14

This metal mesh is featured on the desk area and is complimented on the walls in thin strips between light green colored glass paneling (same as the material shown, without the mullions). It is not prominent by surface area, but by location and accentuation.

Reflectance: 0.16

This wood featured mainly on the security desk as well, is a lighter version of the wood paneling seen on the walls, but complements it very well.

Reflectance: 0.56

Glazing Specifications – Transmittance and Reflectance

The glass on the exterior, shown to the left, has a slight reflectance and a high transmittance. Because of the viewing angle, a considerable amount of the street can be seen. It is a light hue of blue, but not to the contrast that the picture shows (combination of daylighting and camera quality).

Further information on the glazing is shown below.

Typical Glazing:

Type:	Insulating Glass - Surface #2 Coating – NP-61
Reflectance Outdoors:	0.21
Transmittance Visible:	0.61
Solar Heat Gain Coefficient:	0.4
U-Value:	0.31 (winter and summer)
Light to Solar Gain Ratio:	1.53
Thickness and # panes:	(2) 6mm panes with ½” airspace between

Laminated Glazing:	Insulating Glass with Lami Board – Surface #2 Coating – NP-61
Reflectance Outdoors:	0.21
Transmittance Visible:	0.59
Shading Coefficient:	0.46
Solar Heat Gain Coefficient:	0.39
U-Value:	0.30, 0.31 (winter, summer)
Light to Solar Gain Ratio:	1.51
Thickness and # panes:	(2) 3mm panes, ½” airspace, and (1) 6mm pane
PVB thickness:	0.030”

Design Concept

The design concept for the Lobby space focused on the "water" theme as described in the thematic description. It will not be further detailed here, but the fall semester concept sketches have been included.

Design Criteria

Appearance of Space and Luminaires – Rating: 10

The appearance of the main entrance lobby to the office tower is of utmost importance. Business clientele as well as the employees of the offices require a pleasant and calm, yet sophisticated and professional appearance. The space itself should not scream at the occupants what the most unique or particular aspects of its design are, but should calmly present itself and its intricacies only through the occupant's consideration. The appearance of the luminaires and overall aesthetics must conform to the activities to which this lobby will lead, and only enhance the "psychological advantage" of the office tenants.

Color Appearance and Contrast – Rating: 9

The architectural materials of the space are not to be taken for granted. The translucent glass banding, the fine metal mesh banding, the wood veneers, and aluminum accent pieces all require accurate color rendering for the space to result as the architect had intended. To forego this quality undermines the architect and causes the space to quickly lose appeal. Additionally, the colors of the lobby's terrazzo flooring must also be accented and appropriately viewed. The three differing patterns and color schemes would not seem so brilliant under a poorly color-rendered lighting system.

Daylighting Integration and Control – Rating: 9

Daylighting control within this space is absolutely necessary. The daylighting, at times, borders on "severe penetration" due to the extreme specularity of the terrazzo floor, the glare resultant from the floor at early morning hours (times of high use at the start of business day), and the direct glare due to such high ceilings. The entire east and north façades are 20'6" high, 3' wide glass paneling with diffuse aluminum mullions. During the day on clear days, and especially in the morning hours, daylight penetration is considerable. In an attempt to counteract the current system's daylight penetration, a large canopy was added as a shadowing lightshelf to around the most offensive areas of the curtainwall.

Direct Glare – Rating: 7

As a calm and comfortable atmosphere, direct glare will result in immediate discomfort and reflect poorly on the space, the building, and especially of its occupants. Due to such a vast ceiling height, current direct glare is relatively non-existent for most of the luminaires. The sculpted luminaires' lamps cannot be viewed unless the individual is within 10d of nadir. Similarly, the lamps of the recessed downlights and linear fluorescents cannot be seen easily without extending one's view angle greater than 70d from horizontal.

Light Distribution on Surfaces – Rating: 5

A differing ratio of distribution can be used as a means of leading an individual from entrance to destination or exit. Contrary, an even distribution can give the occupant a feeling of spaciousness and openness with which they have the freedom to move around. The lack of constraint may prove misleading to points of interest (entrances, exits, elevators, etc.) but would increase the overall immediate comfort level the person has upon entry or while waiting.

Luminance of Surfaces – Rating: 8

Complimentary of the appearance and color appearance, the luminance of surfaces will be important in further distribution of diffuse light, and will enhance the depth and relativity aspects of locations in the lobby. Highlighting the dark woods, and decreasing the illumination levels on the aluminums, white surfaces, and translucent glass may even out the depth appearance of some walls and an even greater contrast in brightness on these darker elements may reverse the spatiality of the space.

Modeling of Faces and Objects– Rating: 6

Facial modeling is not a distinctly important quality of the lobby. While initial face-to-face contacts may be made, and close personal conversation between individuals is typical, they do not create a great necessity for substantially well modeled faces. Likewise, the space itself has few objects that would cause confusion or be completely neglected due to poor modeling.

Points of Interest – Rating: 7

Points of interest are quite necessary in differentiating lounge and waiting areas from information and reception areas. There is no standard waiting area within the space, and the only locus of information is centered on the security desk. The three remaining points of interest are the entrances and exits, the information panel at the west wall, and the elevator area. Higher illumination in these areas is necessary for differentiation.

Surface Characteristics – Rating: 7

As has been mentioned, the surfaces used throughout this lobby vary in their reflectances, specularities, colors, and textures. To bring out the greatest aesthetic appeal in the architect's design, these characteristics should be accentuated if the design allows. At most, one wishes to make the occupant or visitor aware of the specular, and therefore smooth, slippery nature of the floor as a safety concern. All other accentuation of materials is purely aesthetic and will only be relative to the overall lighting theme.

System Control – Rating: 10

Because of the considerable daylight penetration, the vast spectrum of illuminance levels over the course of the day, and for better energy savings, system control in the lobby should be considerable. It is very important to make the most use of the natural light and to minimize the energy consumption of the lobby. This is especially true since the lobby operates over the longest time period throughout the day.

Horizontal Illuminance – Rating: 8

The horizontal illuminance suggested for the lobby space is 100 lux. Since the space has very little activity, no areas for reading or writing, and no distinct tasks are performed within the space, 100 lux is reasonable. However, as the cornerstone of the building, it would be desirable for the space to have a much higher illuminance level to 300 lux and possibly higher dependent on the illuminance levels of the adjacent spaces.

This increase in illuminance on the horizontal plane is desirable for the work and tasks of the security station as well. The illuminance should not cause the security monitoring to be compromised, so one would not go as high as 500 lux, but should be increased nonetheless.

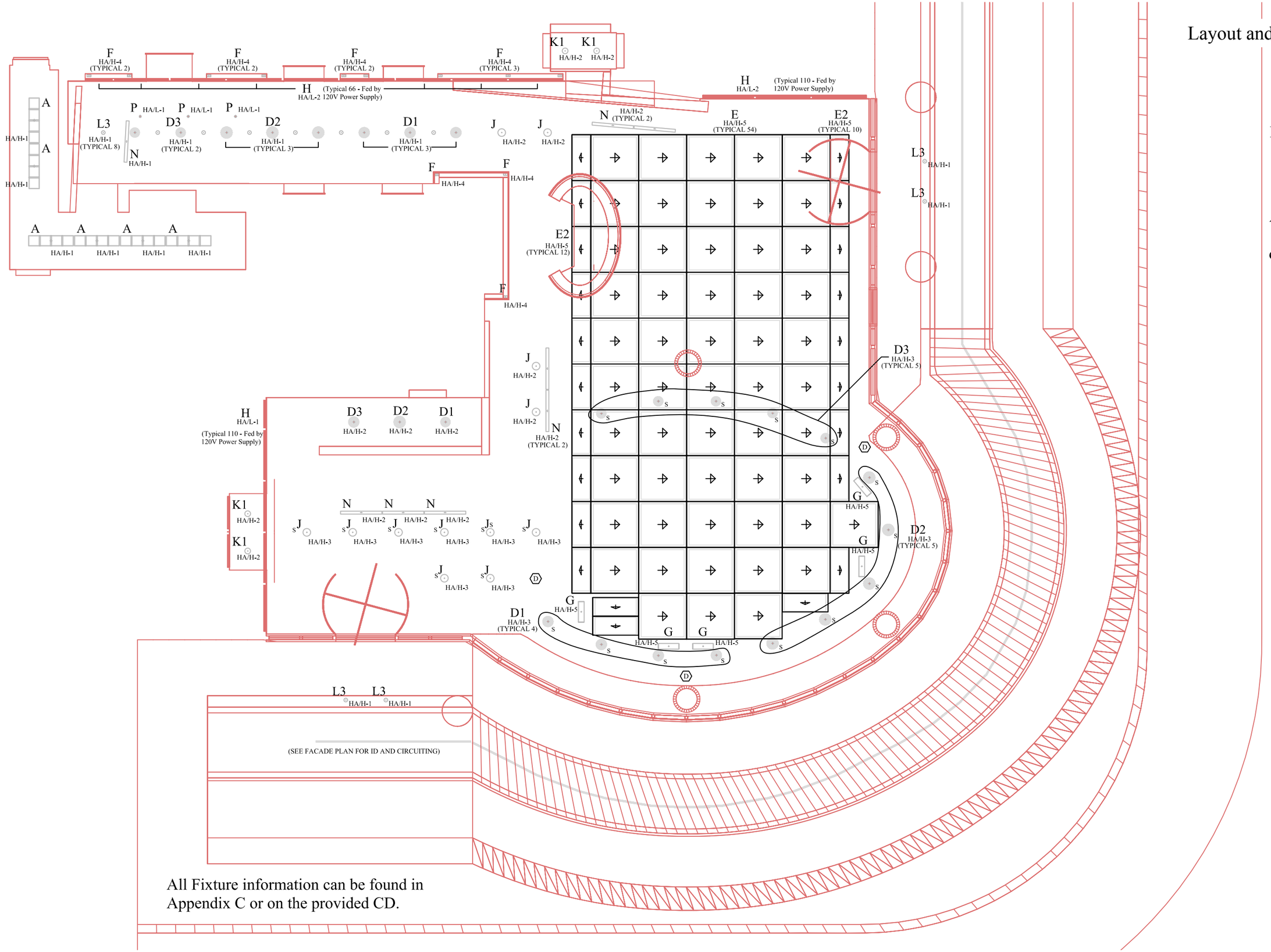
Vertical Illuminance – Rating: 6

Vertical illuminance components of the fixtures are already accounted for through basic distributions and diffuse reflections from the floor and low walls. The daylighting also acts as a vertically oriented area source for better vertical illumination. For these reasons, vertical illuminance in the range of 30 to 50 lux should not have to be distinctly accounted for in the lighting design.

Layout and Circuiting

Entrance Lobby Floor Plan, Lighting Layout and Circuiting Diagram

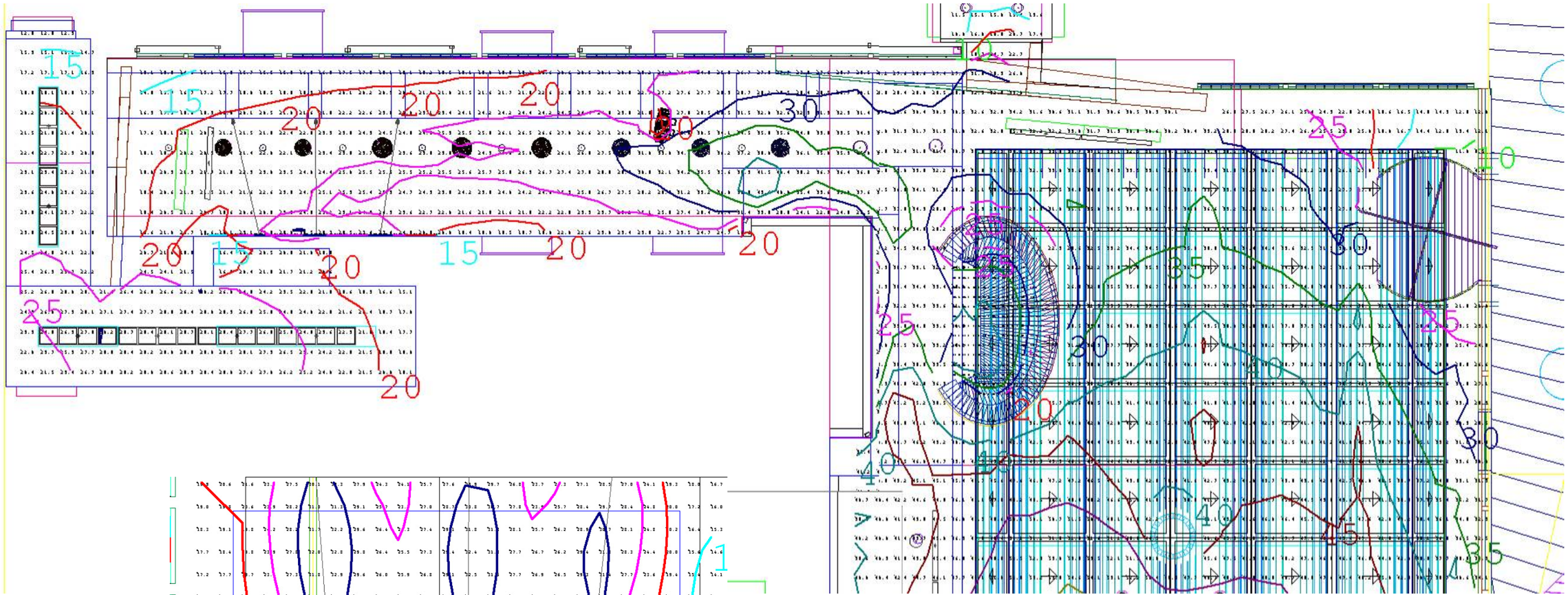
All Luminaires additionally labelled with "S" are operable both manually and by Daylight ("D") or Occupancy ("O") Sensor

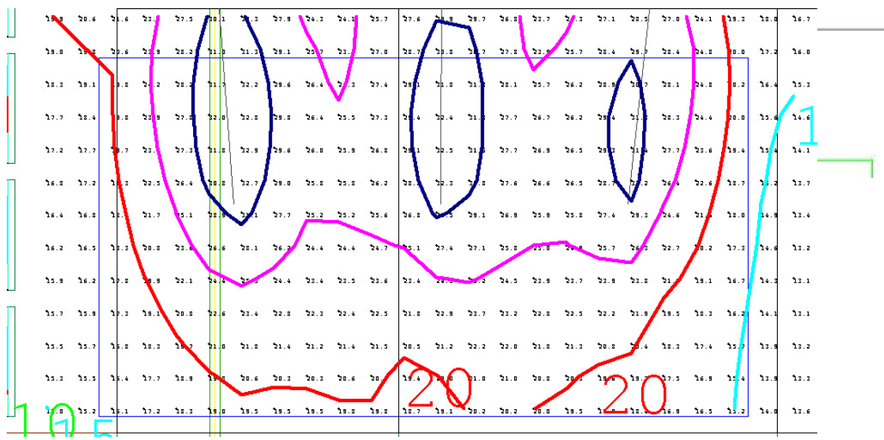


All Fixture information can be found in Appendix C or on the provided CD.

Not to Scale

Performance





Large Artwork in Elevator Lobby

Floor
Illuminance Values (Fc)
Average=34.11
Maximum=56.3
Minimum=4.4
Avg/Min=7.75
Max/Min=12.80

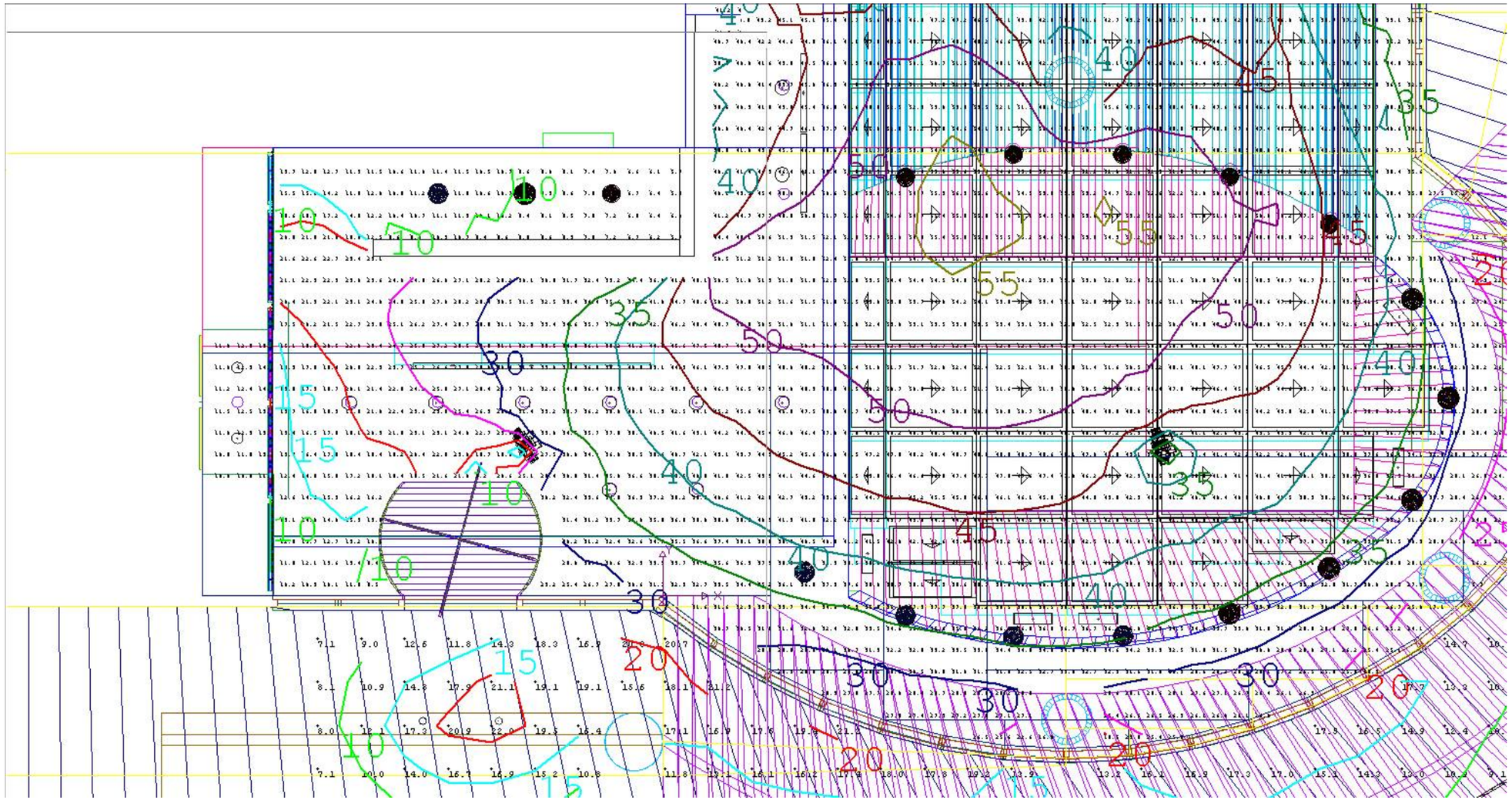
Art1
Illuminance Values (Fc)
Average=22.82
Maximum=32.9
Minimum=13.1
Avg/Min=1.74
Max/Min=2.51

Trans Wall East
Illuminance Values (Fc)
Average=15.31
Maximum=42.4
Minimum=5.9
Avg/Min=2.59
Max/Min=7.19

Desk
Illuminance Values (Fc)
Average=35.68
Maximum=43.9
Minimum=13.2
Avg/Min=2.70
Max/Min=3.33

Facade Stuff
Calc Pts

Main Canopy
Illuminance Values (Fc)
Average=8.06
Maximum=22.0
Minimum=1.3
Avg/Min=6.20
Max/Min=16.92



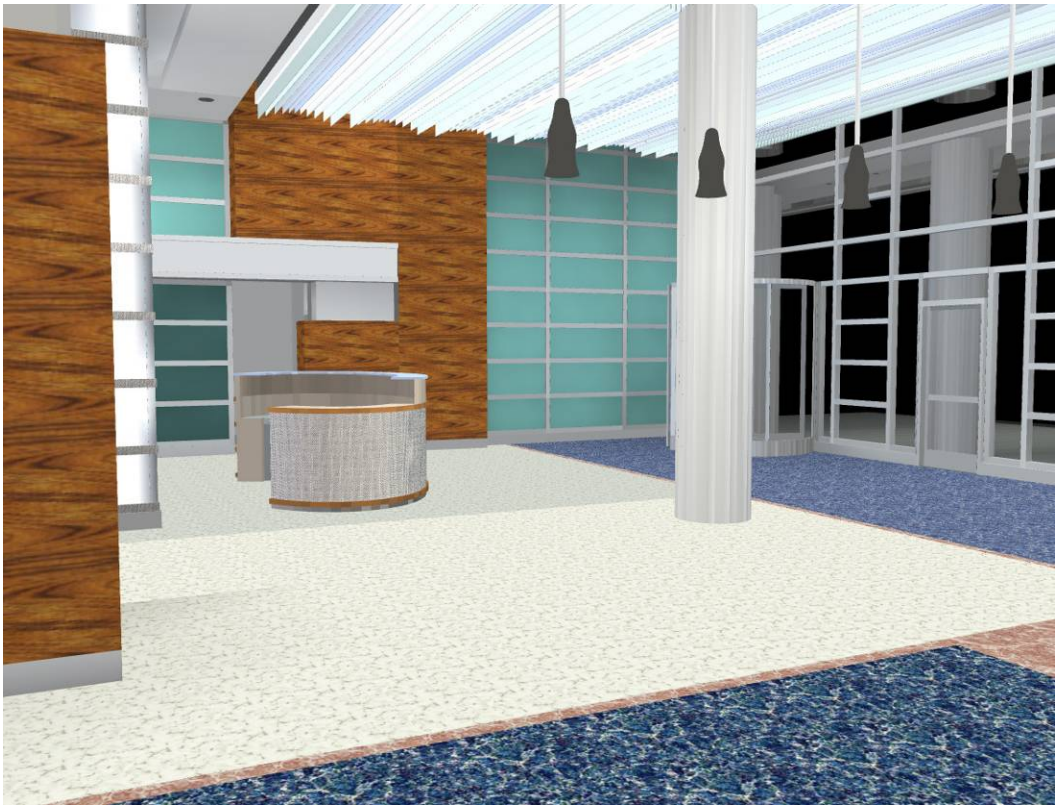
ASHRAE Power Density Calculation

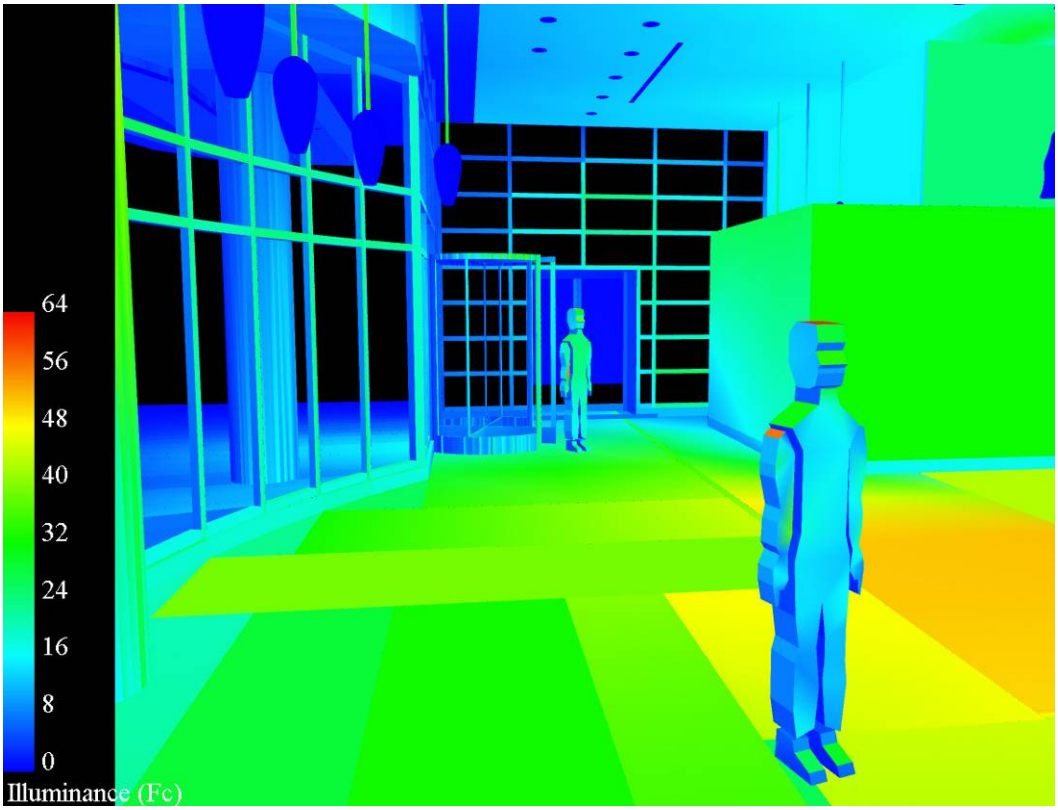
ASHRAE Power Density Allowance for Office: 1.3 W/sf
ASHRAE Power Density Adjustment for Decorative Lighting: 1.0 W/sf
Lobby square footage: 2900 sf ASHRAE allowance: 6670 W
Existing Power Density: 1.61 W/sf Meets ASHRAE 90.1 (including decorative allowance)

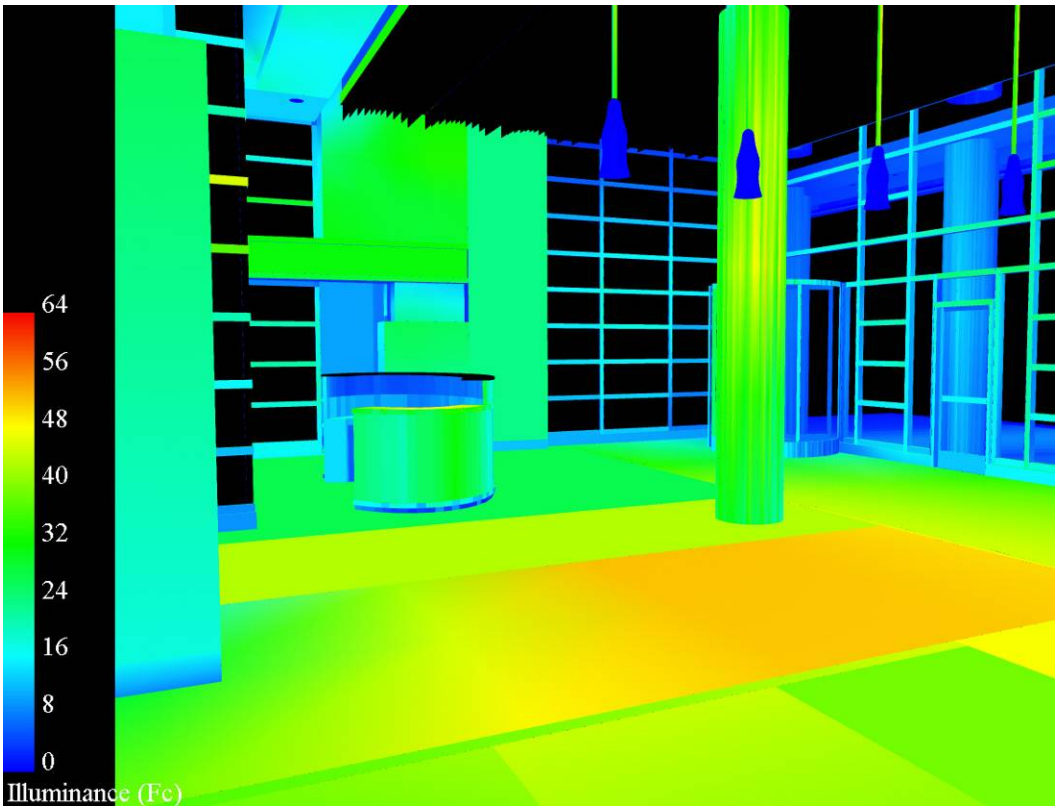
Entrance Lobby	A	D1	D2	D3	E1	E2	F	G	H	J	K1	L3	N	P			
Luminaire	6	8	9	8	54	22	15	5	210	12	4	12	8	3			Power Density
Wattage	32	35	35	35	32	32	35	17	1	58	20	50	32	37	SUM (VA)	Area (sf)	
Total Power	189	276	311	276	1701	693	525	85	210	696	78	600	252	111	6002.5	2900	**2.070 W/sf**

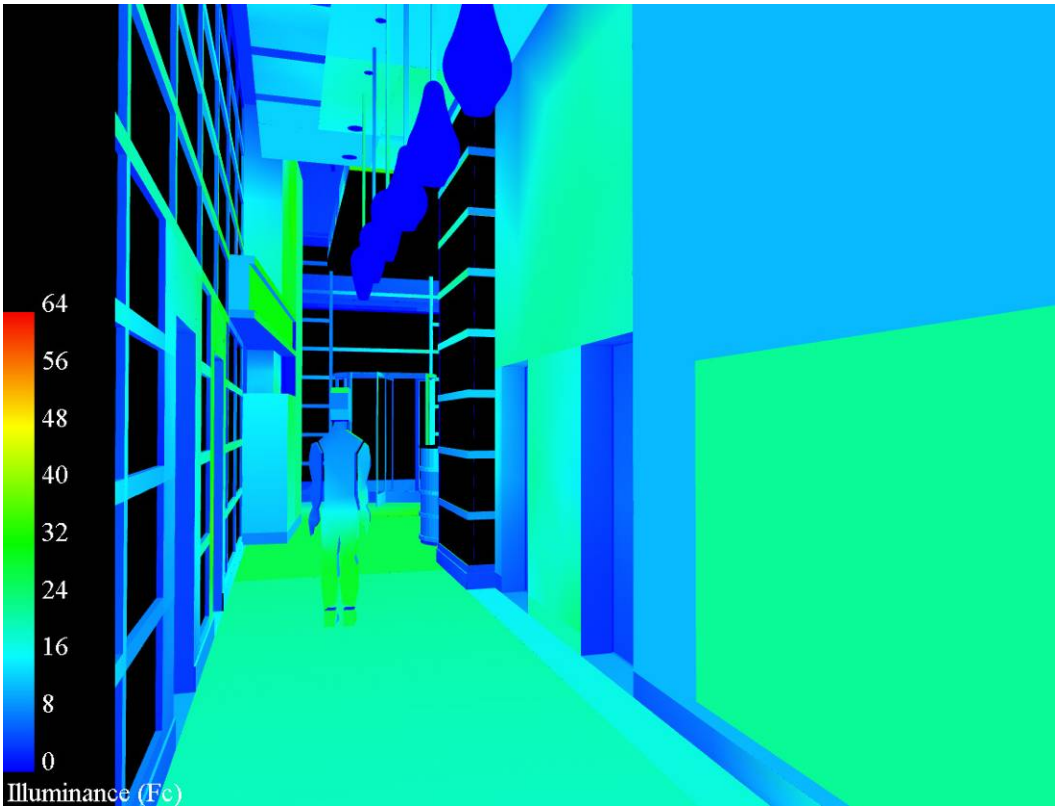
New design meets ASHRAE 90.1 Standard

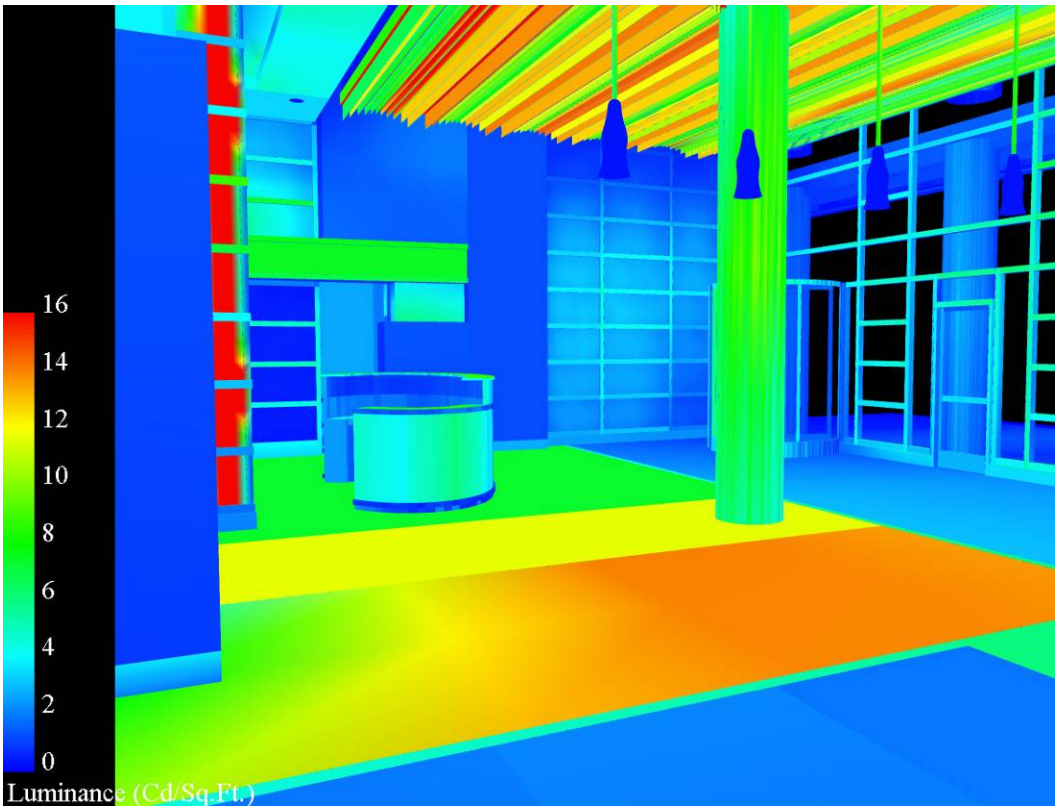
Renderings



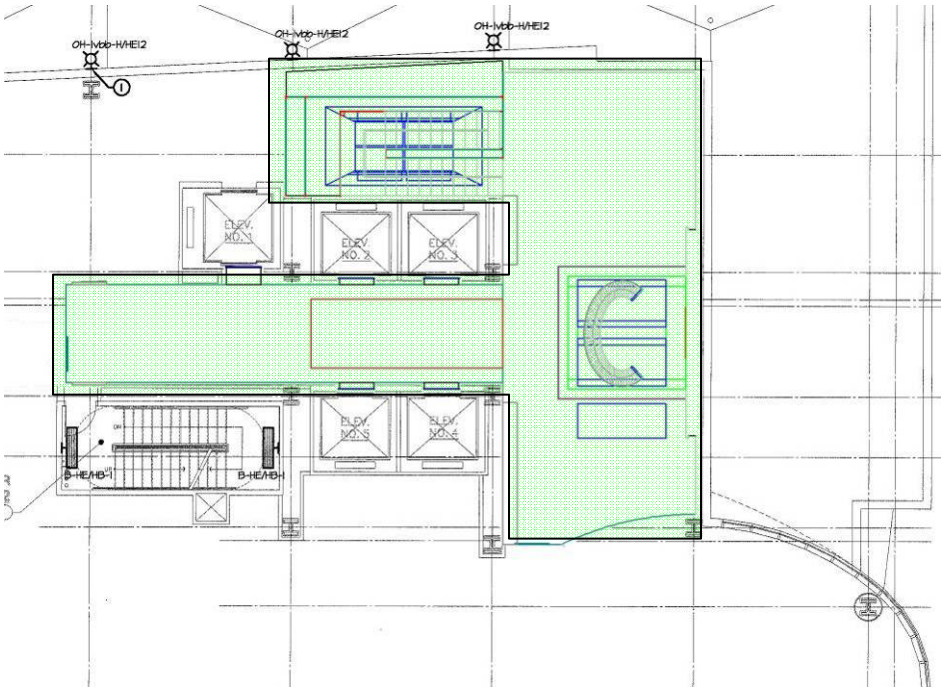

64
56
48
40
32
24
16
8
0
Illuminance (Fc)


64
56
48
40
32
24
16
8
0
Illuminance (Fc)


64
56
48
40
32
24
16
8
0
Illuminance (Fc)


16
14
12
10
8
6
4
2
0
Luminance (Cd/Sq.Ft.)

Reception



Special Luminaires

The Reception has a single "specially created" luminaire system, as opposed to the special luminaires created for other spaces (listed in the research). The skylights in the Reception space serve as "skylights" all day, and all night long if the occupants so desire. Just below the skylight itself, two recessed 8" deep bays were cut into the ceiling plenum. Within these spaces were place linear fluorescents with wallwash characteristics. Each wallwash was aimed at the opposite wall "facing" downward to keep as much downlight as possible on the walls.

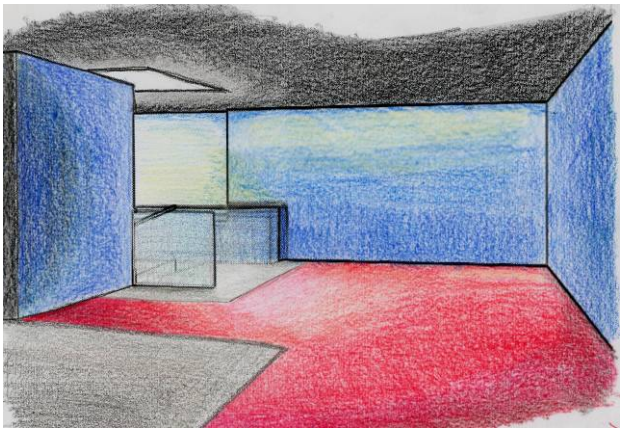
To account for the vast light loss through the skylights during hours of operation when the sun was already down, or the sky was considered too dark for any adequate light penetration, the system has an integrated shade-on-rails system with a small motor mounted in another recessed space. These systems are only located above the stairwell skylight and the two reception desk skylights. While the depths of the "bays" vary between the two skylight types, they operate in the same manner and are constructed in nearly identical detail.

The details for the two skylight systems are located in Appendix C.

Surface Materials

The Reception area did not exist architecturally prior to the lighting design. For this reason, all of the materials used were relative to the available textures and colors present in AGI32. For all textures and painted surfaces, please view the actual renderings (as they appear in greater bulk) for these spaces. For the most part, architectural materials closely coincide with the materials already listed for the façade, lobby, and parking structure. For detailed surface illustrations and reflectances, reference the previous sections.

Design Concept



The concept for the reception area is specific to a high-profile business entrance with the intention of impressing their business clients. The concept developed for the fall semester was completed based on a limited three-dimensional development of the space. The further design concept was developed as the three office spaces came into being. The space concept for the fall semester is illustrated below.

The concept focuses on the availability of daylight at the reception desk and the development of daylight penetration in the newly-created stairwell. The concept of the space, architecturally, was to lead the individual along a given path and the lighting design paralleled this concept by highlighting points of interest and creating an even illuminance across the waiting area.

Design Criteria

Appearance of Space and Luminaires – Rating: 9

The appearance of the reception area is of utmost importance to the office tenant. As this is the first impression a visitor will receive, it is very important that the space exude sophistication and prestige. The luminaires need to be high-profile and stylish, and the space needs to have rich color and significant emphasis on the most important areas of the space. All of the dead zones, while not so dark that they seem cavernous, should be significantly lower than the travel paths, points of ingress and egress, and areas of congregation.

Color Appearance and Contrast – Rating: 8

The colors of the space, since they should be rich and visually stimulating, need to come through accurately and cannot become skewed by lower CRI lamps. Since the combination of colors was designed to work together within the space, altering them, graying them out, or causing them to seem too bright and washed out all should be eliminated. The advantage of this space is that daylighting will be used for the majority of the emphasized spaces, which will bring out all of the true colors of the space.

Daylighting Integration and Control – Rating: 9

Daylighting integration and control in this space is of utmost importance. Not only because 3 main skylights illuminate the area around the reception area and the transition space toward the elliptical conference room, but also because of the integration of the stairwell skylight at the western corner of the space. Daylighting control should be implemented in an on/off manner to reduce the consumed load in the space when daylight levels are more than adequate to illuminate the space.

Direct Glare – Rating: 5

The direct glare within the space is not a major concern given the types of luminaires used throughout the space. Additionally, the skylight wells with diffuse walls will not contribute to a glare condition, and the depth of the skylights prevents the major components of direct glare resulting from the sun to become a factor.

Light Distribution on Surfaces – Rating: 6

Light distribution on surfaces is a mediocre criterion that should be met relative to "hot spots" or points of interest (as described below). The light distribution uniformity on surfaces is not a concern and gradients exist on almost every wall in the space. Light distribution should have a gradient at the hot-spot areas, and should maintain a fairly uniform illuminance level in the gathering areas.

Luminance of Surfaces – Rating: 6

Luminances of surfaces are particularly important for only two areas. First, the walls behind the artwork located at the south walls needs to have a distinct visual contrast so the artwork seems to pop out of the wall and the borders of the artwork are well defined. At the West wall, with the larger piece of artwork, luminance of the wall was intended to melt into the artwork given the piece. Since the building has a theme revolving around water, and the picture is of water, the intention was to "extend" the picture into the walls and illuminate the actual work fairly well to emphasize the painting. Luminances of other surfaces only lend emphasis to the delineation of space and architectural direction of visitors and occupants.

Modeling of Faces and Objects– Rating: 7

Modeling of faces within the space is limited to the receptionist and the entering visitor. For this reason, specific downlight were provided at the countertop so reflected light would highlight the shadows created on the faces by the skylights and other downlighting components. The ambient uplighting and small contribution of wall reflectances also aids in the modeling of faces. Objects throughout the space are few, and modeling is limited to the grain and texture of the paintings. For this small design criterion, the accenting lights were placed at higher grazing angles to induce very slight shadows from the texturing.

Points of Interest – Rating: 10

Points of interest in a space that was specifically designed to lead individuals through the space through materiality and lighting, is of utmost importance. The points of interest are the employee entrance to the east, the reception desk at the elevator lobby, the waiting area at the northwest, and the stairwell to the west.

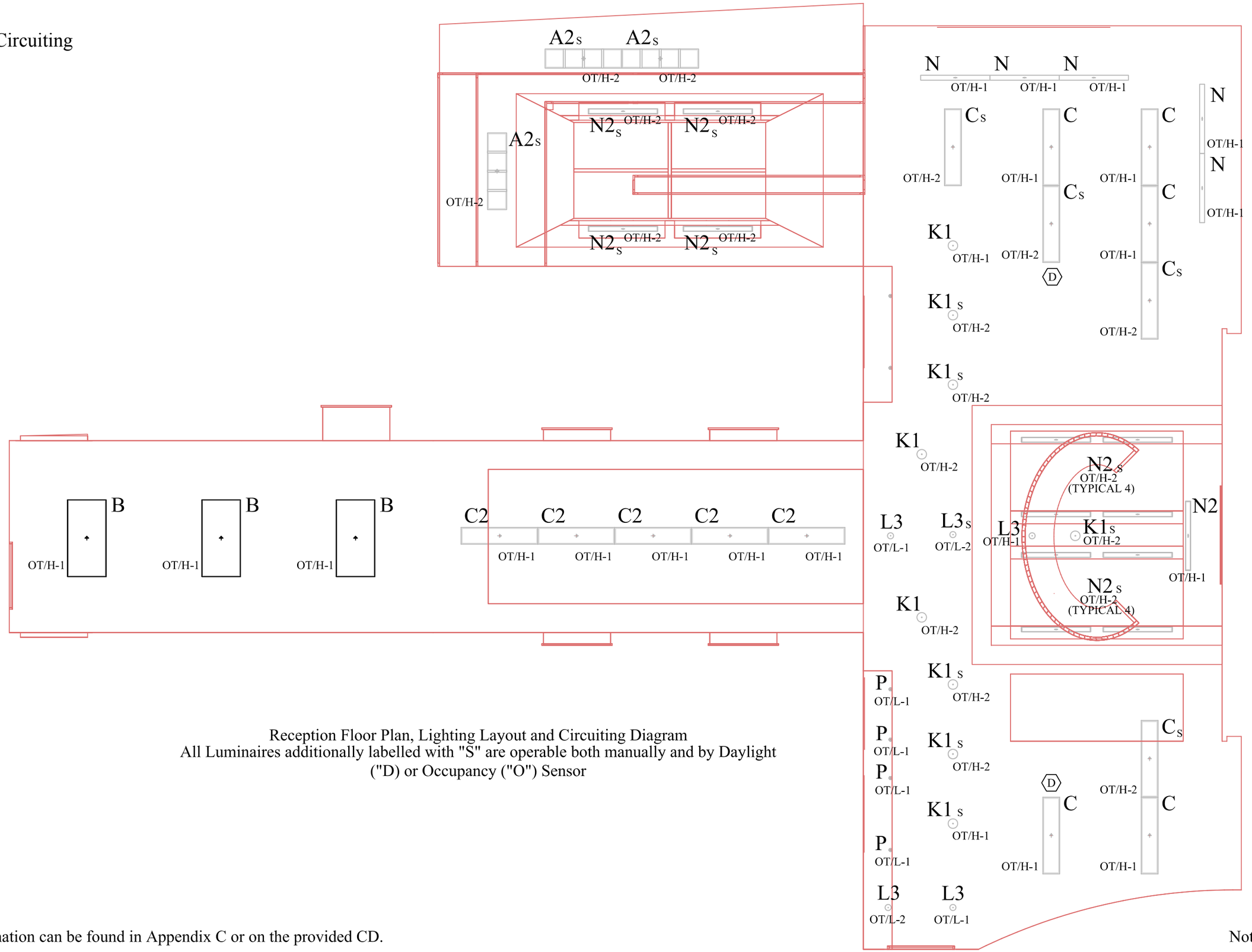
Horizontal Illuminance – Rating: 7

Horizontal Illuminance is relative to the floor for the most part, with specific attention paid to the desktop workplane of the reception desk. Horizontal illuminance should be maintained between 200 lux and 400 lux with exceptions occurring for clear-sky daylight penetration (where the illuminances will significantly exceed these values).

Vertical Illuminance – Rating: 5

The only vertical illuminance requirements in the space have been covered in the facial and object modeling of the space. This level should not exceed the horizontal illuminance, but still should be above 100lux.

Layout and Circuiting

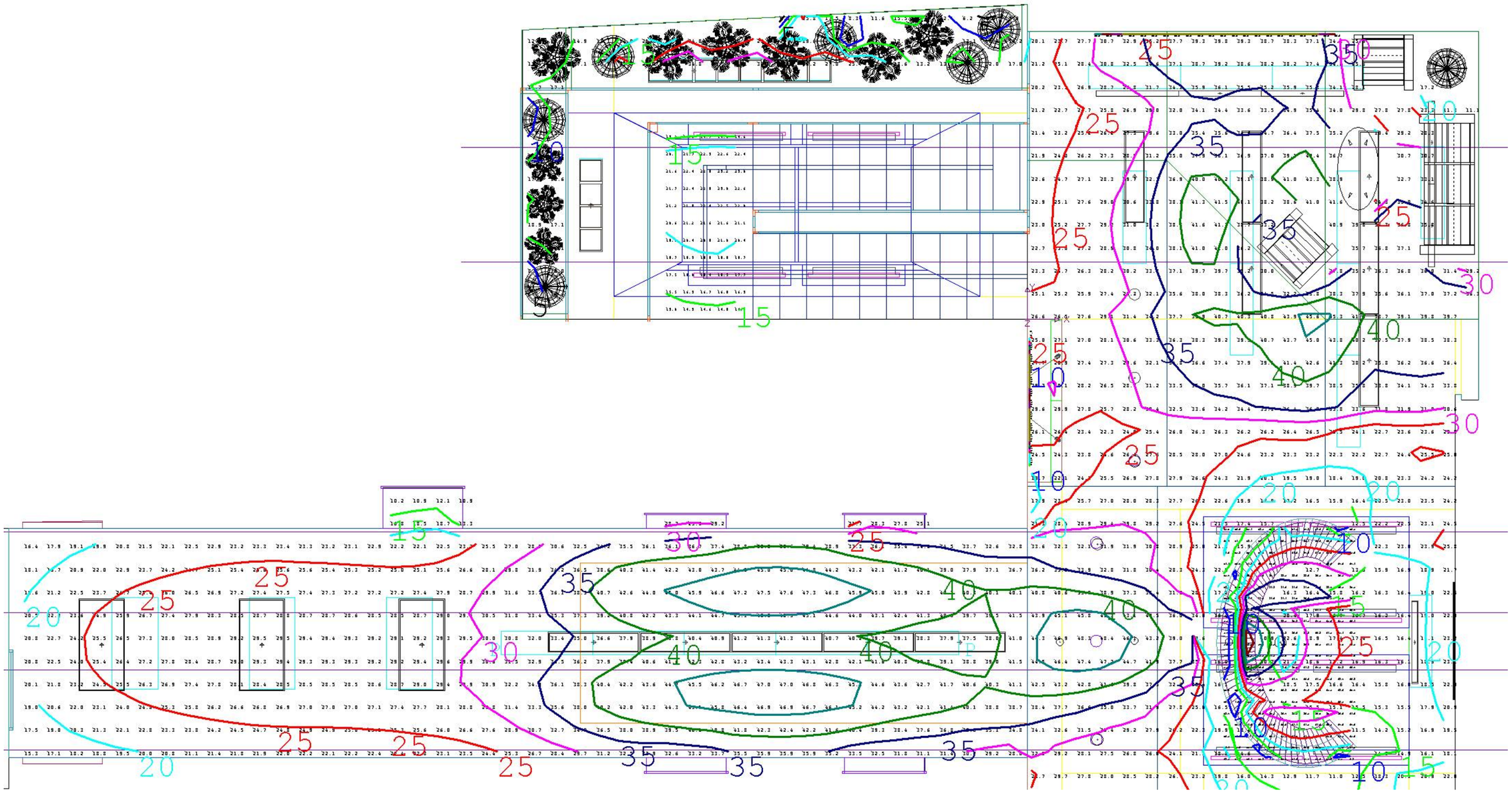


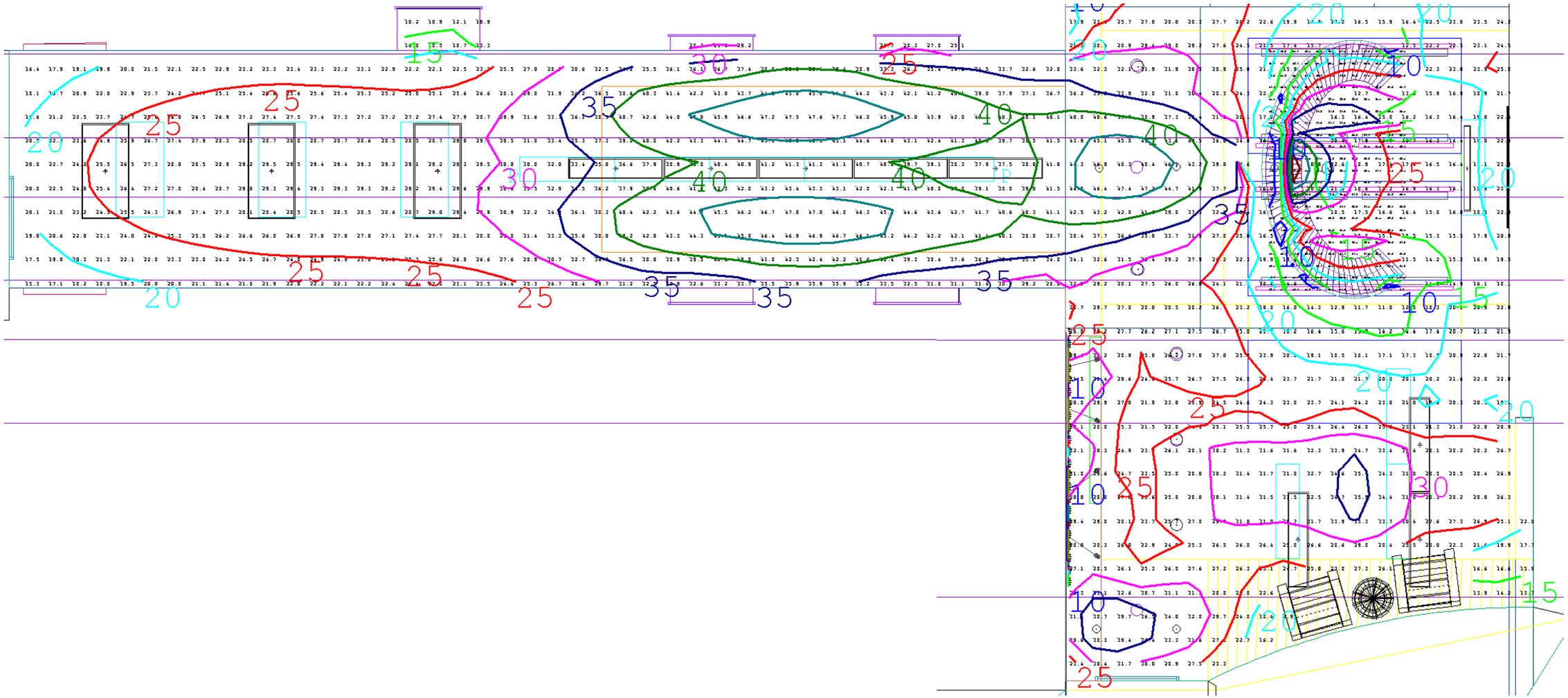
Reception Floor Plan, Lighting Layout and Circuiting Diagram
All Luminaires additionally labelled with "S" are operable both manually and by Daylight ("D) or Occupancy ("O") Sensor

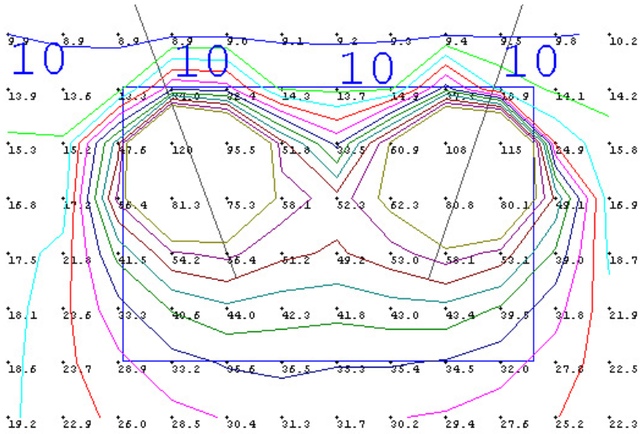
All Fixture information can be found in Appendix C or on the provided CD.

Not to Scale

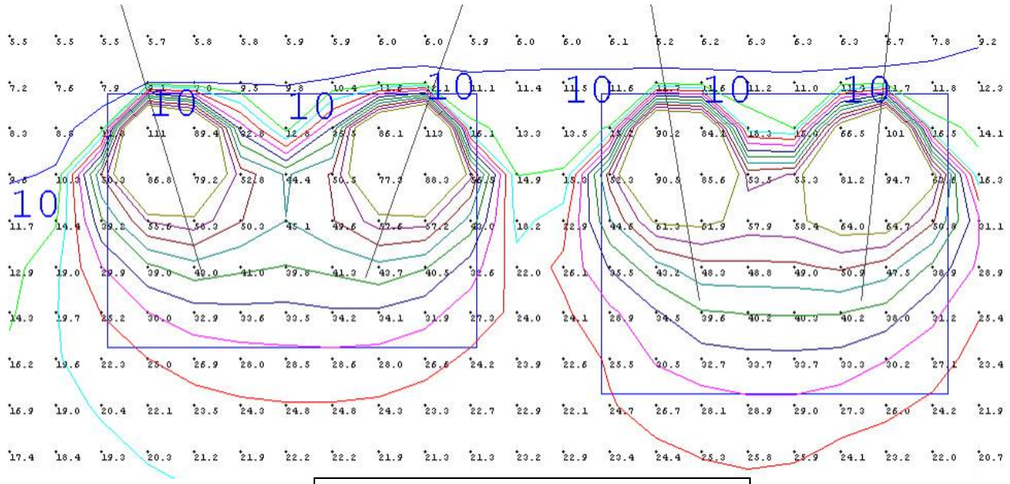
Performance







Artwork on Slower South Wall



Artwork on Upper South Wall

Art
Illuminance Values (Fc)
Average=29.59
Maximum=113
Minimum=5.5
Avg/Min=5.38
Max/Min=20.67

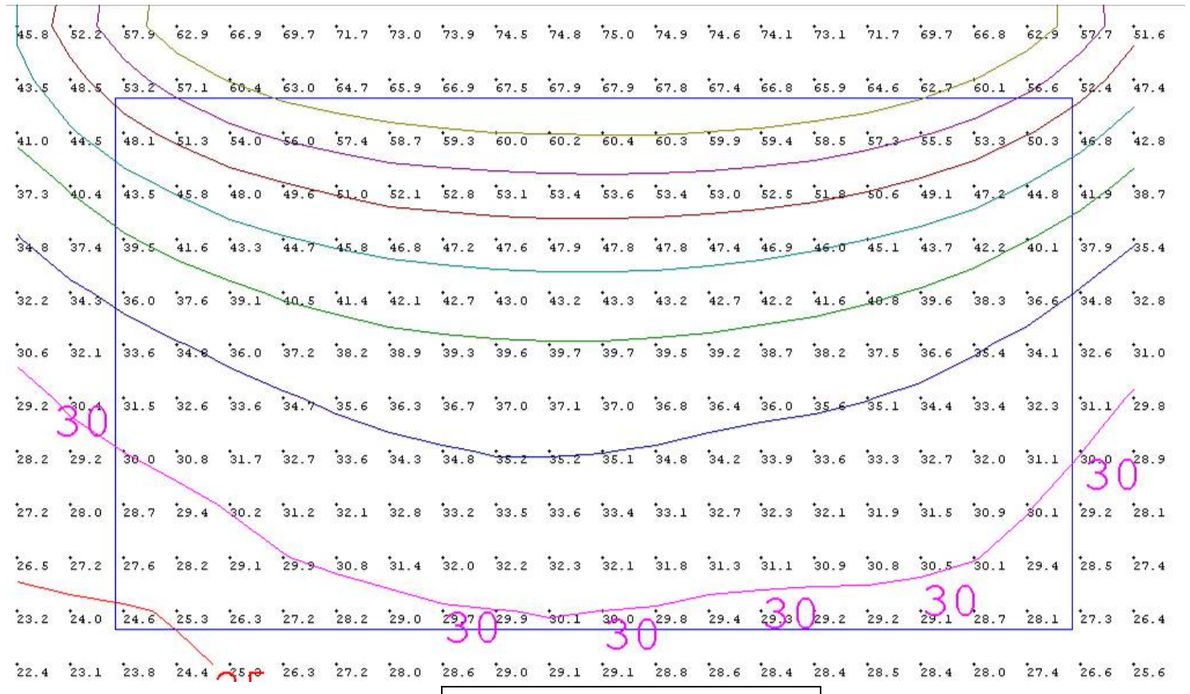
Art_1
Illuminance Values (Fc)
Average=34.62
Maximum=120
Minimum=8.9
Avg/Min=3.89
Max/Min=13.53

Art_2
Illuminance Values (Fc)
Average=42.79
Maximum=75.0
Minimum=22.4
Avg/Min=1.91
Max/Min=3.35

Floor
Illuminance Values (Fc)
Average=29.04
Maximum=48.4
Minimum=0.0
Avg/Min=0.00
Max/Min=0.00

Stair Landing
Illuminance Values (Fc)
Average=19.36
Maximum=23.2
Minimum=13.0
Avg/Min=1.49
Max/Min=1.78

Front Desk
Illuminance Values (Fc)
Average=24.75
Maximum=53.1
Minimum=5.4
Avg/Min=4.58
Max/Min=9.83



“Large” Artwork on North Wall

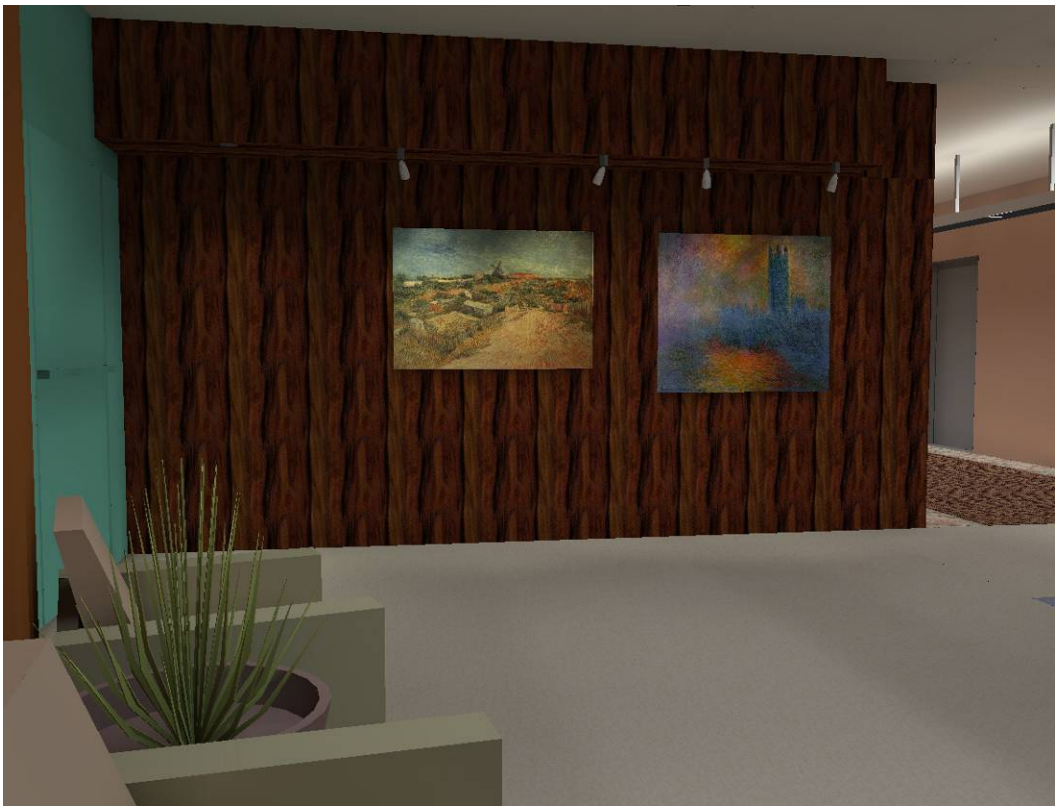
ASHRAE Power Density Calculation

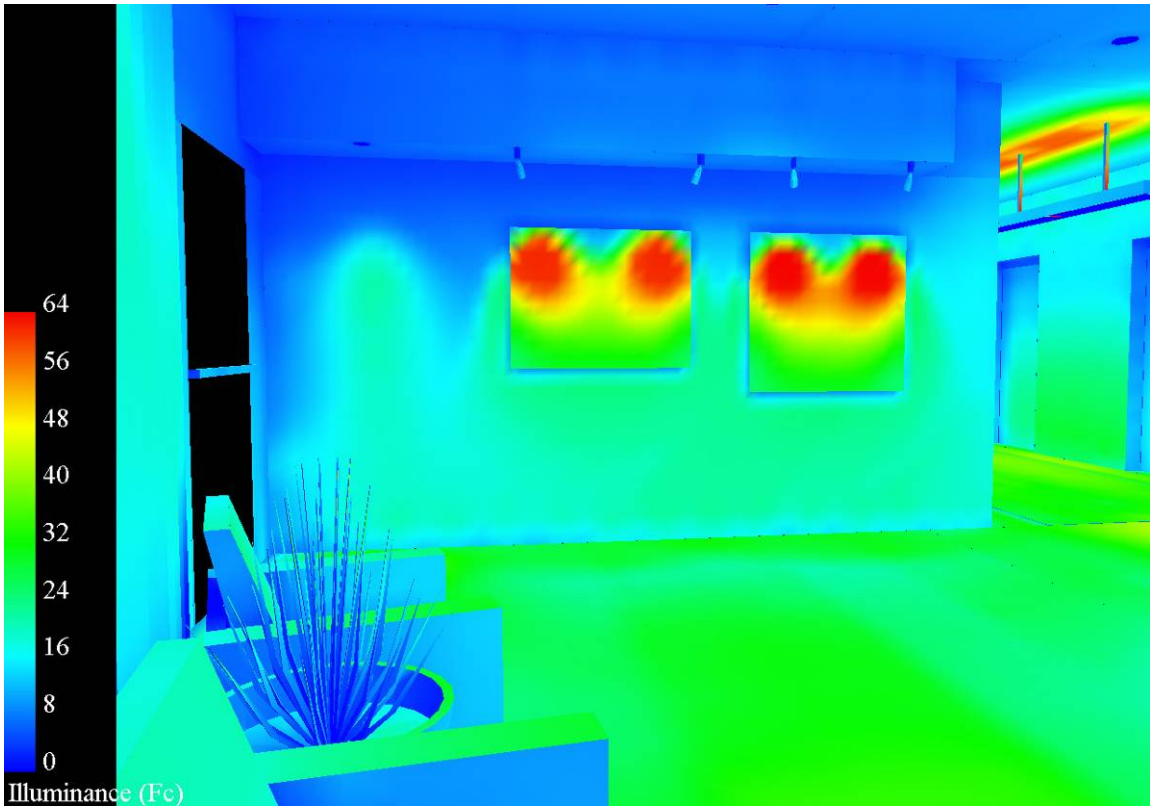
ASHRAE Power Density Allowance for Office/Lobby: 1.1 W/sf
ASHRAE Power Density Adjustment for Decorative Lighting: 0.5 W/sf

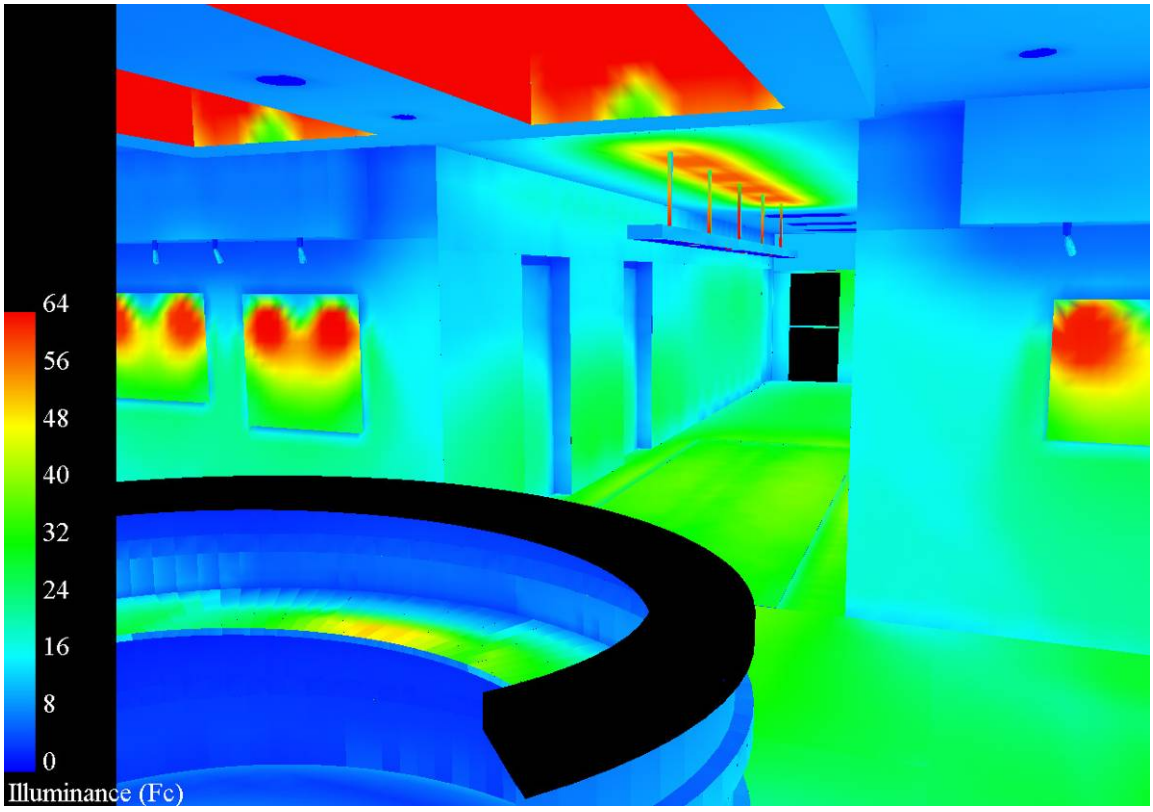
Reception square footage: 1540 sf ASHRAE allowance: 2772 W

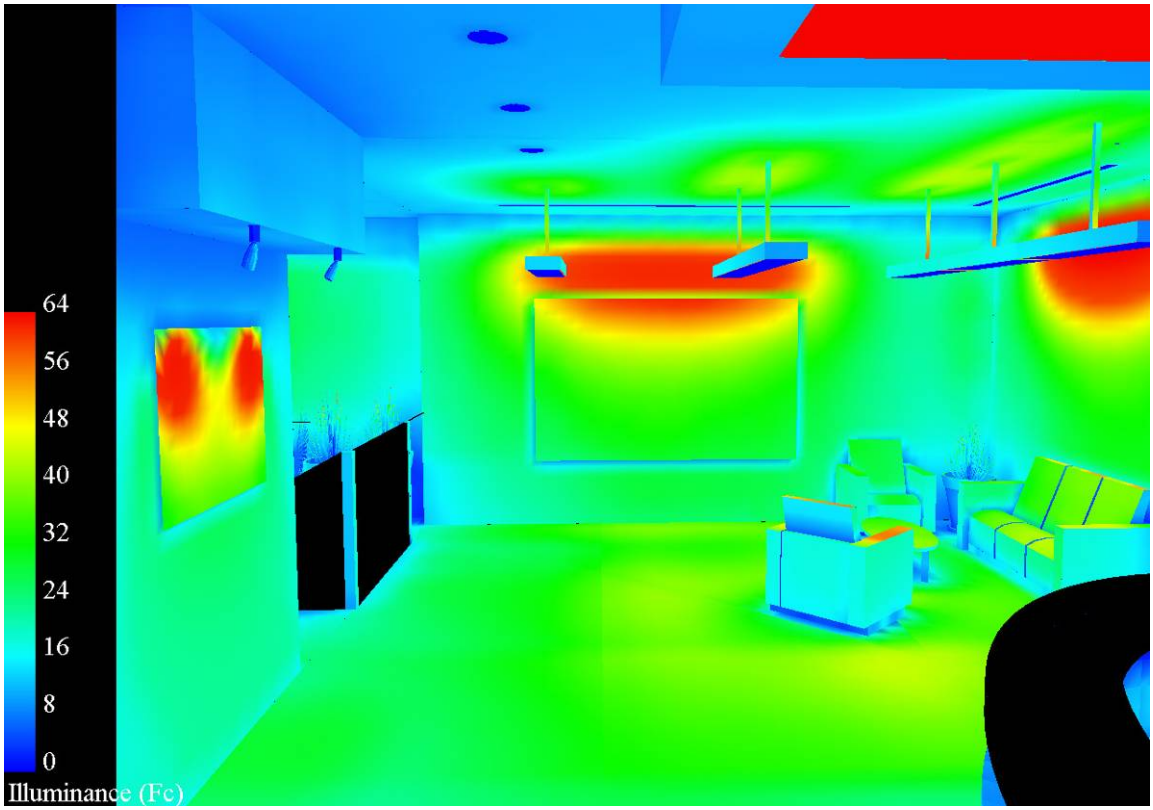
Reception	A2	B	C	C2	K1	L3	N	N2			
Luminaire	3	3	9	5	8	5	5	13			Power Density
Wattage	59	63	32	59	20	50	32	59	SUM (VA)	Area (sf)	
Total Power	176	189	284	293	156	250	158	761	2264.5	1540	**1.470 W/sf**

Renderings




64
56
48
40
32
24
16
8
0
Illuminance (Fc)


64
56
48
40
32
24
16
8
0
Illuminance (Fc)


64
56
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40
32
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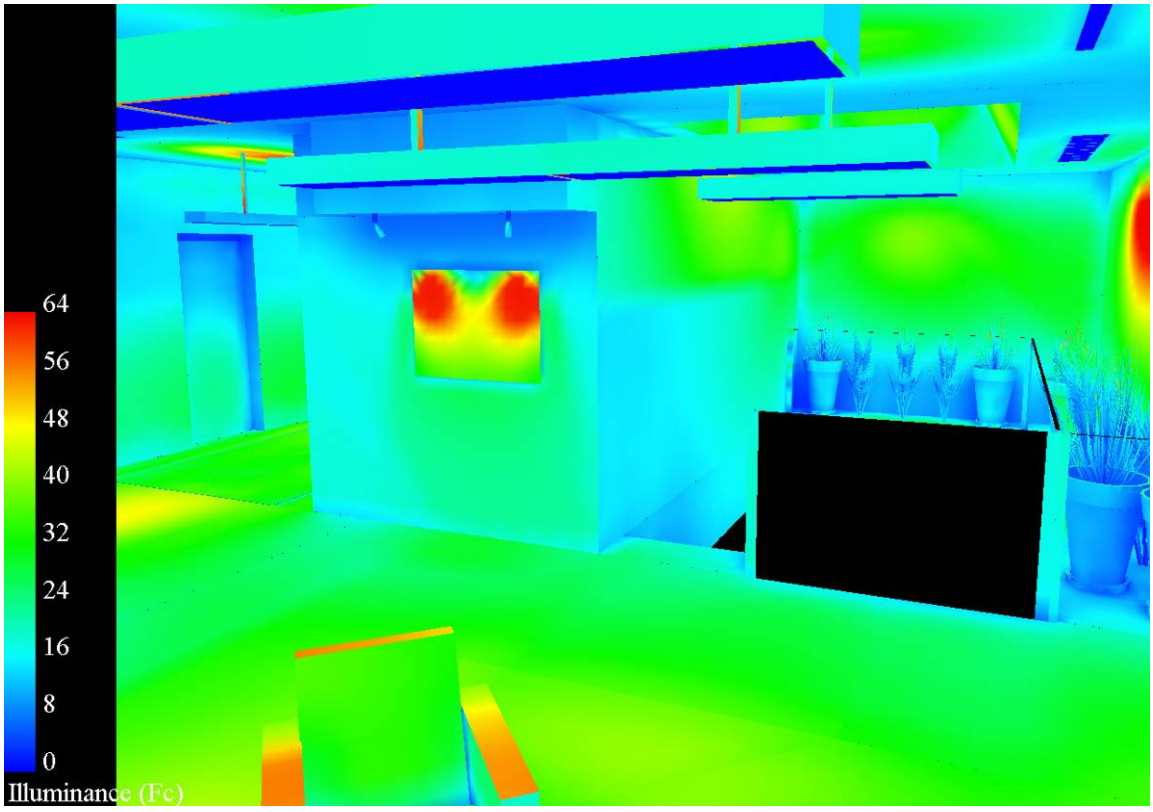
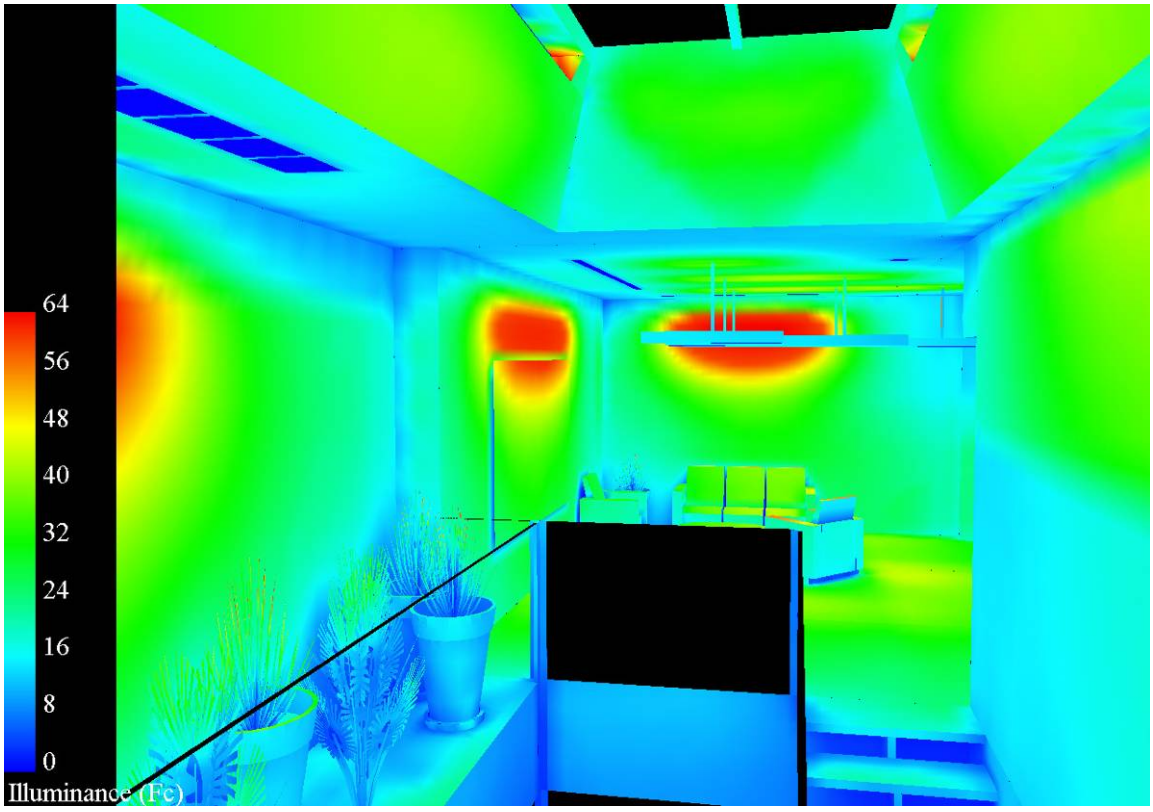
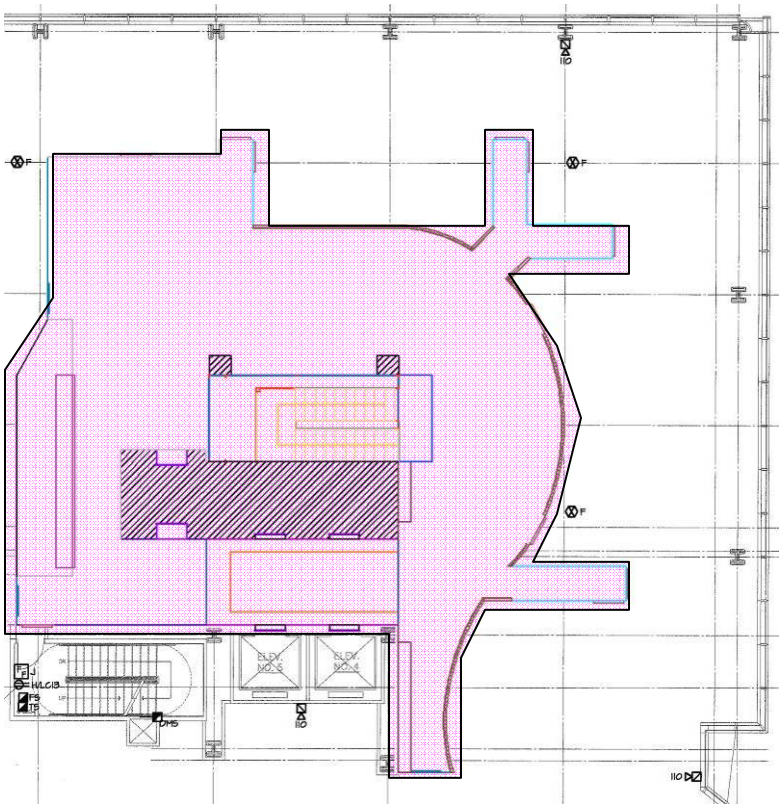
16
8
0
Illuminance (Fc)


64
56
48
40
32
24
16
8
0
Illuminance (Fc)


64
56
48
40
32
24
16
8
0
Illuminance (Fc)

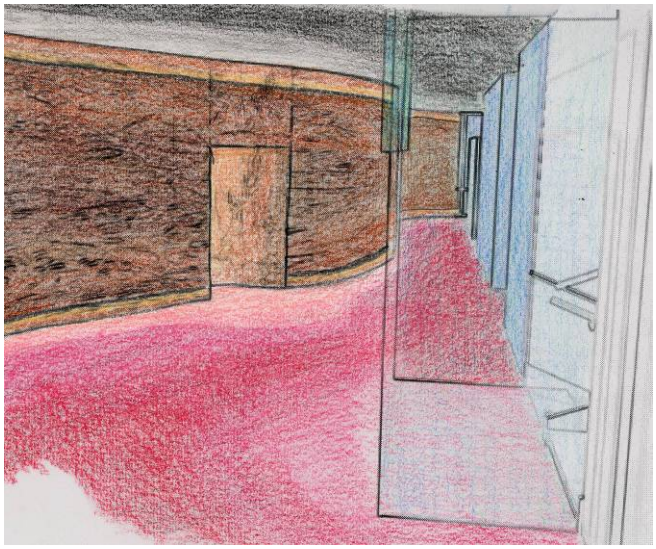
Conference Lobby



Surface Materials

The Reception area did not exist architecturally prior to the lighting design. For this reason, all of the materials used were relative to the available textures and colors present in AGI32. For all textures and painted surfaces, please view the actual renderings (as they appear in greater bulk) for these spaces. For the most part, architectural materials closely coincide with the materials already listed for the façade, lobby, and parking structure. For detailed surface illustrations and reflectances, reference the previous sections.

Design Concept



The design concept for the Conference Lobby focuses on maintaining waiting-room patience, focusing the congregation of visitors, and creating a warm comfortable atmosphere. The materials and color choices exemplify these design choices, and the illumination levels psychologically prevent individuals from wandering about the space – especially to service areas and employee entrances.

The secondary design concept was to maximize the penetration of the daylight from the stairwell skylight into the space. This penetration would further focus any visitor's attention on the stairwell, and keep them in the specific waiting area the architecture intended for them. This assumes, with some psychological significance, that visitors who are foreign to the space and unaware of its detailed layout will be drawn like moths – a valid assumption for the space in question.

Design Criteria

Appearance of Space and Luminaires – Rating: 6

Appearance of the luminaires in the Conference Lobby is not of dire concern as it was in other spaces. Because this space is located on the second-tier level of the office building, it is understood subconsciously that luminaires exist, and therefore are ignored by the typical visitor. Once the visitor is well into the space (think – typical client), they are there to do their business and leave in the shortest amount of time possible. Their impression of the area has been solidified and need not be improved.

Color Appearance and Contrast – Rating: 5

Color appearance in this space is of medium concern since the overall color theme is to be warm and inviting, which implies that the colors are all brown and wood tone with the occasional "flash of brilliance". Contrast in the space is also of less concern, save the transition area to the "rear" conference rooms. These corridors should be darker, but not so dark that they are quite uninviting.

Daylighting Integration and Control – Rating: 7

Daylight integration was completed through the stairwell skylight and the transparent windows located above the conference rooms for slight daylight penetration from all surrounding curtainwall openings. Daylighting control for the main and secondary waiting areas will be important, since excessive uplighting will not provide any additional illuminance under just about any sky condition.

Direct Glare – Rating: 5

Direct Glare is not a concern within the space except in one particular location. All of the luminaires throughout the space have diffusing lenses or deep louvers to avoid all of these direct glare problems. The sole area of concern is the stairwell. On the descent, direct glare into suspended luminaires of the main waiting area should be carefully considered. An appropriate distance should be maintained such that the visitor cannot see the lamp in the suspended fixture.

Light Distribution on Surfaces – Rating: 6

Light distribution on surfaces is relative only to the floor. Light distribution on the floor of the main waiting area should be fairly uniform with a decrease at the westernmost pillar. The light level should again increase at the secondary waiting area and remain uniform in that area. The light level at the entrance door to the employee offices should peak and the service elevator rear door should have the lowest illuminance so emphasis is not placed on the "dirtiest" area.

Luminance of Surfaces – Rating: 4

Luminance of surfaces is not a major concern in this space. The space is pretty much just a large, well-lit room with varying surfaces. The luminance of the wood walls will be considerably less in the main waiting area, but more so in the transition areas to the rear corridors. This reduced luminance will give a better depth to the wood veneer. The only other specific luminance with any significant contribution to the look and atmosphere of the space will be the translucent glass walls and doors leading to the employee offices.

Modeling of Faces and Objects– Rating: 6

The modeling of faces and objects within this space is also of medium concern. Faces are of medium importance because of the initial face-to-face meetings between clients and directors. Objects in the space are few, and their modeling has little impact on the space.

Points of Interest – Rating: 5

Points of interest in the space are less important than in prior spaces because of the lack of movement through the space. Points of interest for the employees are focused at the south end of the space on the support areas. Beyond this, points of interest are limited to the stairwell which will receive either a large amount of daylight or a focused amount of faux daylight via the skylight well.

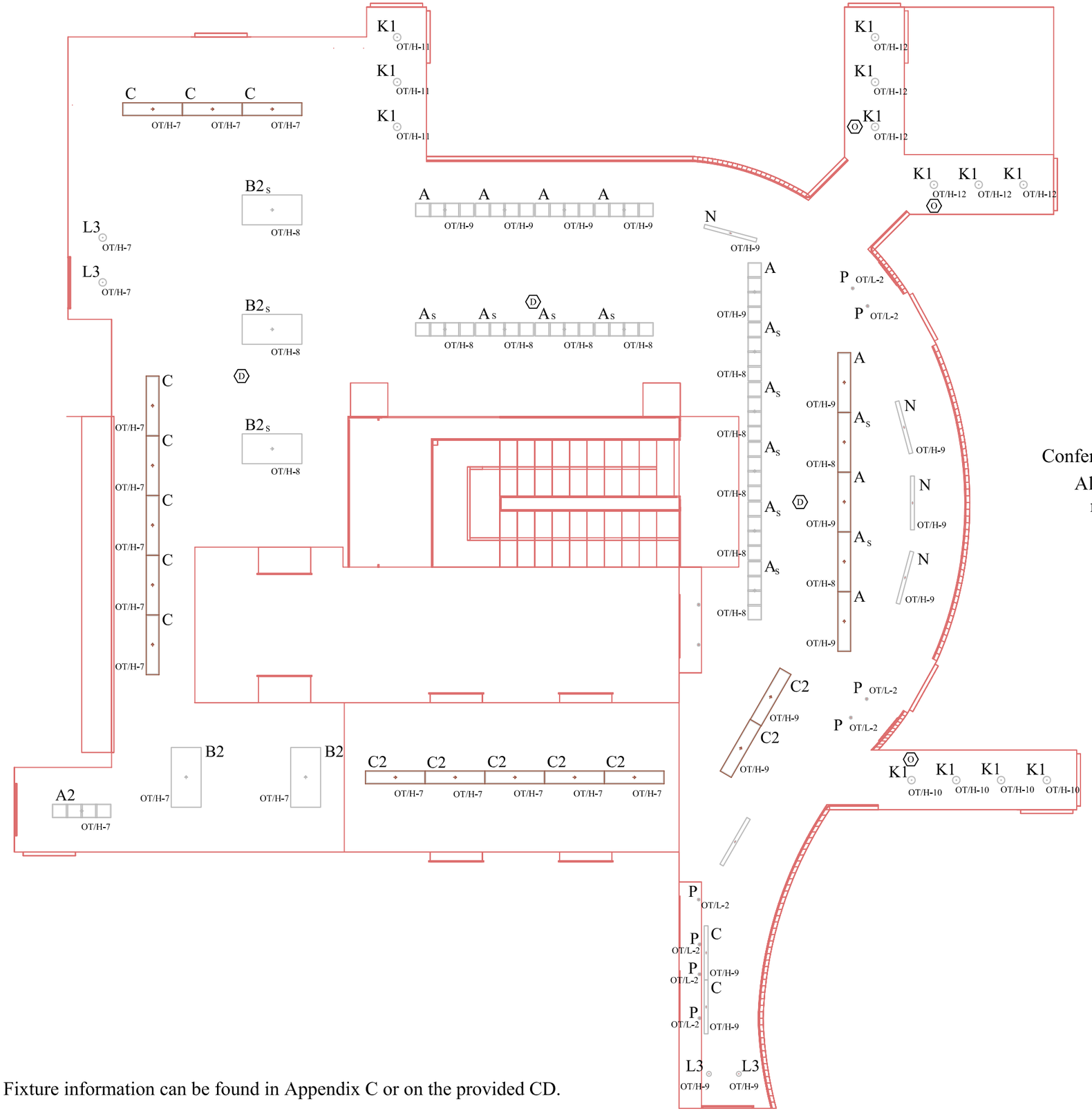
Horizontal Illuminance – Rating: 7

Horizontal illuminance in this space should be similar to the illuminance in the entrance lobby. The illuminance level need not be very high because no specific task is being completed in this area. The horizontal illuminance on the floor should be between 200 lux and 400 lux except in the areas immediately bordering the skylight well where the value will be much higher.

Vertical Illuminance – Rating: 5

Vertical illuminance is limited mostly to the walls and the artwork. Facial modeling vertical illuminances need not be much higher than the reflected values will dictate. The uplighting and diffused light from the luminaires will be enough to produce the requisite 50 lux up to 200 lux on any vertical surface (excluding the artwork which is much higher).

Layout and Circuiting



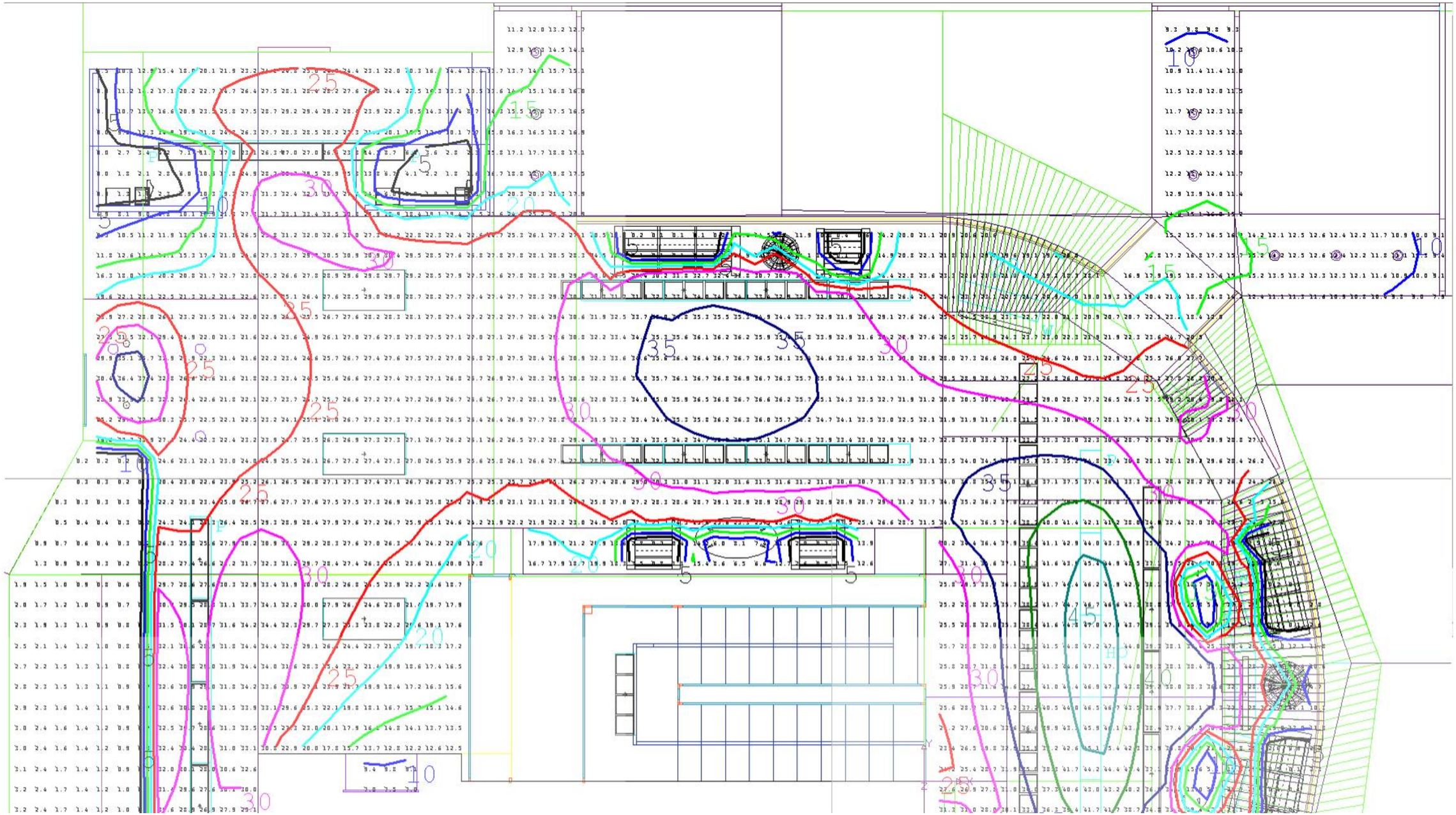
Conference Lobby Floor Plan, Lighting Layout and Circuiting Diagram

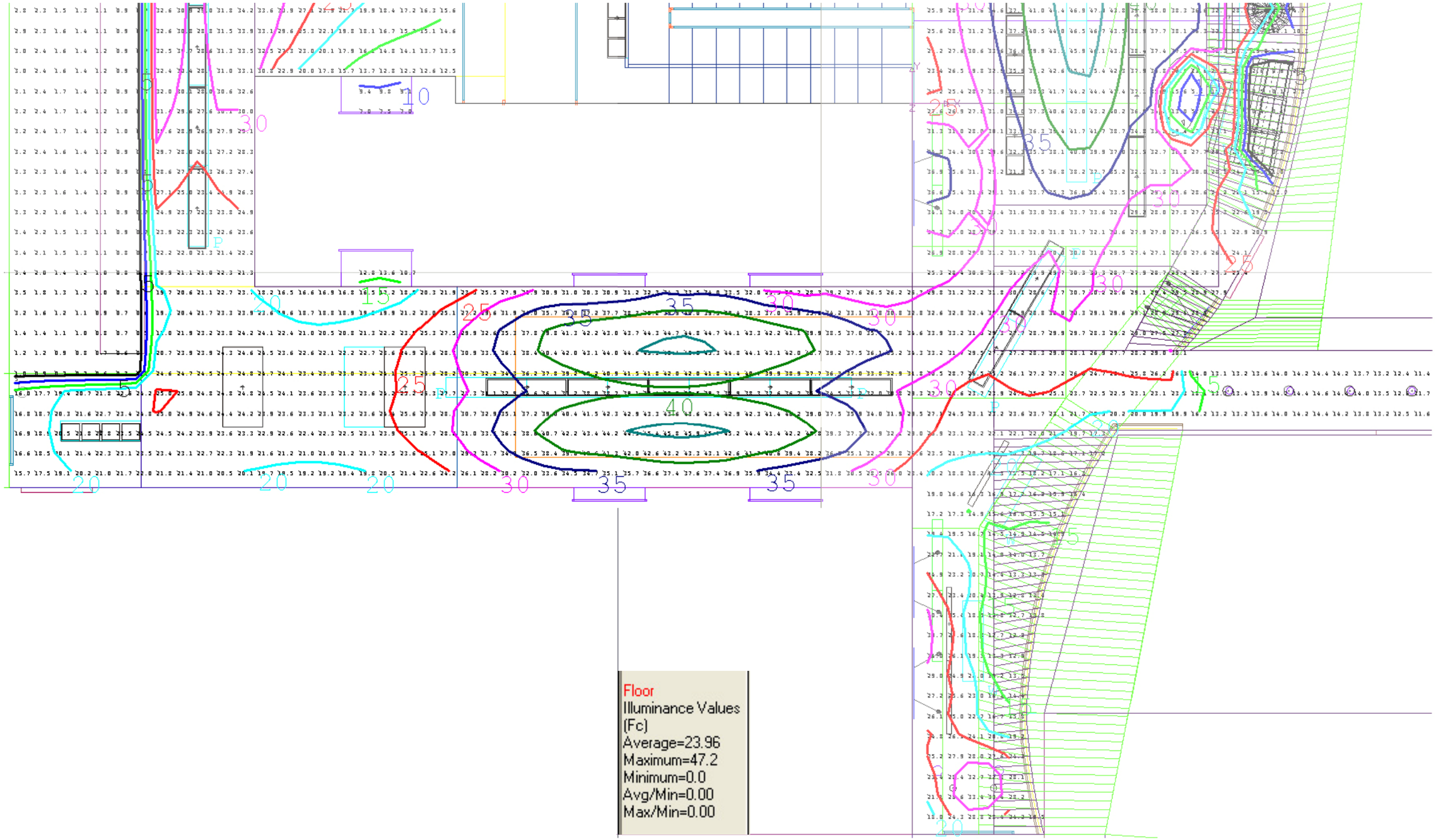
All Luminaires additionally labelled with "S" are operable both manually and by Daylight ("D") or Occupancy ("O") Sensor

All Fixture information can be found in Appendix C or on the provided CD.

Not to Scale

Performance




Floor
Illuminance Values
(Fc)
Average=23.96
Maximum=47.2
Minimum=0.0
Avg/Min=0.00
Max/Min=0.00

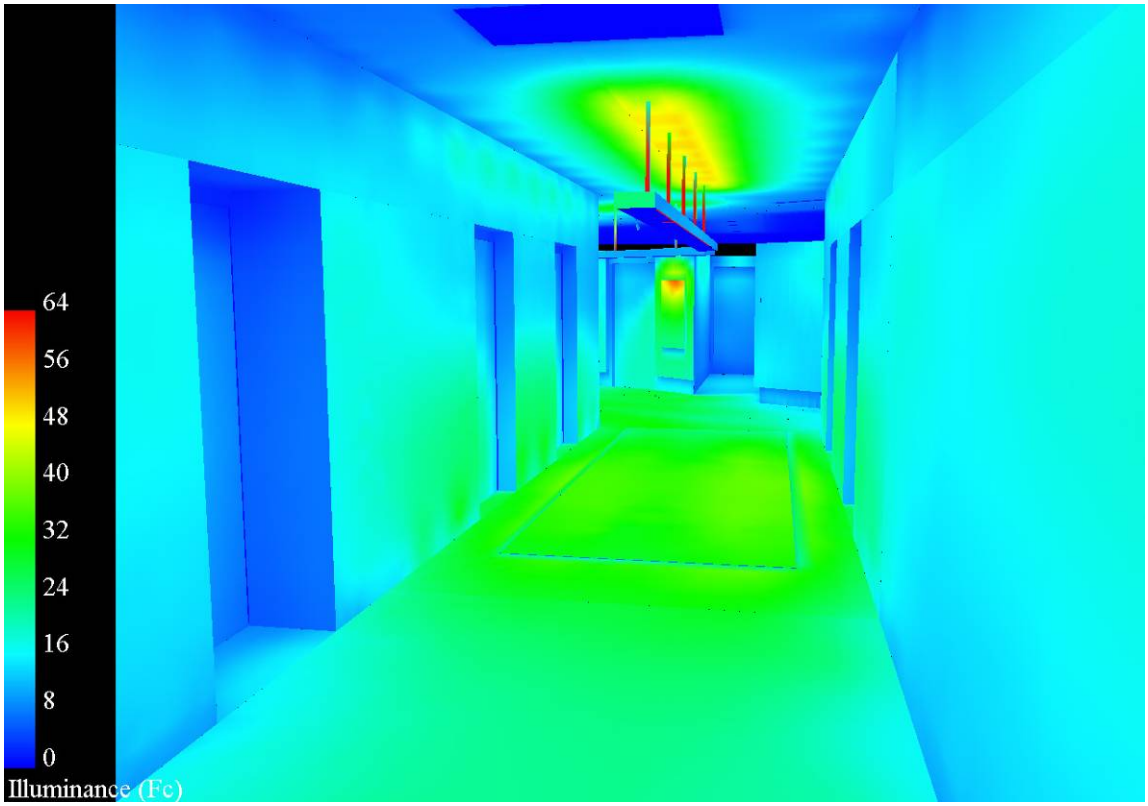
ASHRAE Power Density Calculation

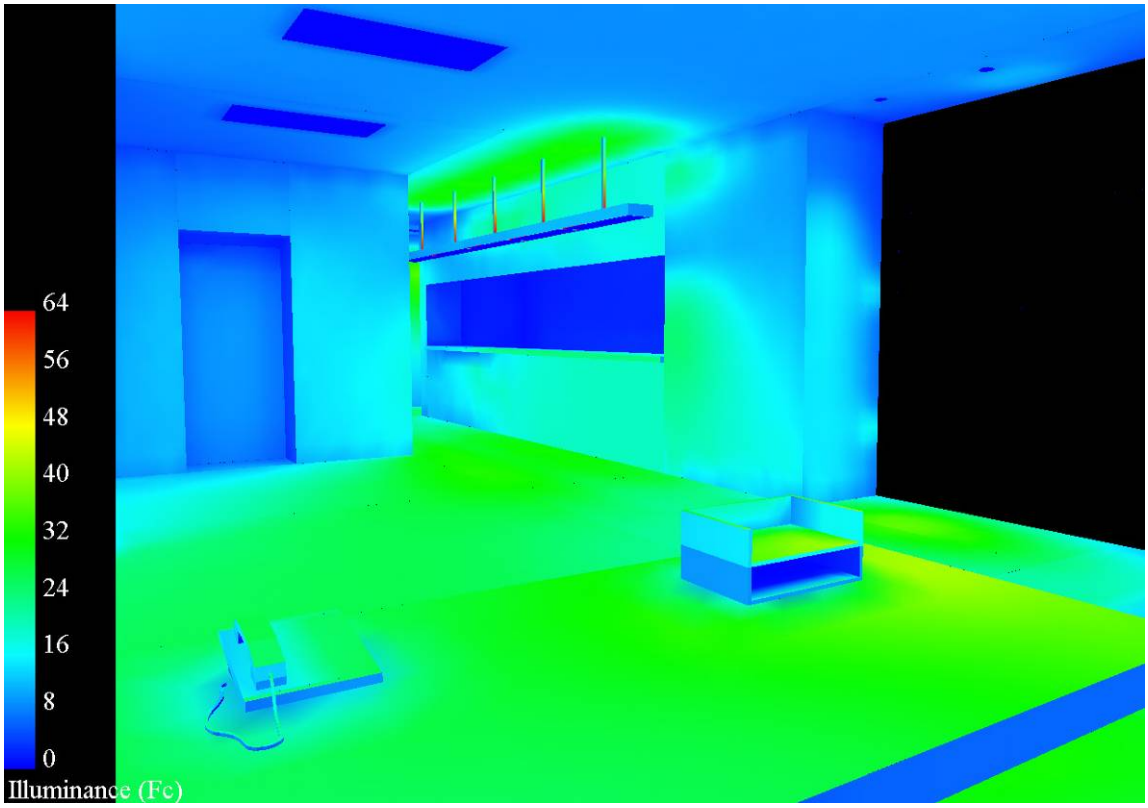
ASHRAE Power Density Allowance for Office: 1.1 W/sf

Conference Lobby square footage: 2770 sf ASHRAE allowance: 3601 W

Conference Lobby	A	A2	B2	C	C2	K1	K1	L3	N	P2			
Luminaire	14	1	5	10	5	13	13	4	7	10			
Wattage	32	59	117	32	59	20	20	50	32	37	SUM (VA)	Area (sf)	Power D
Total Power	441	59	585	315	293	254	254	200	221	370	2736	2770	**0.988**

Renderings


64
56
48
40
32
24
16
8
0
Illuminance (Fc)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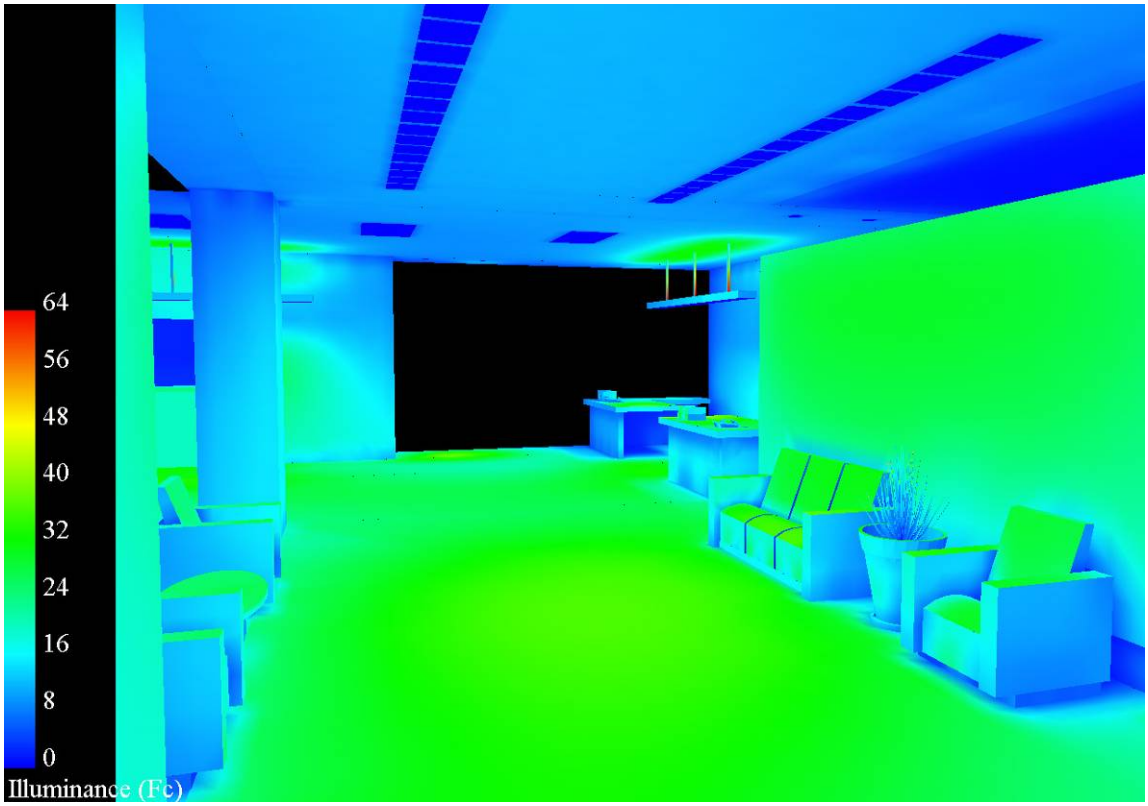
0
Illuminance (Fc)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16
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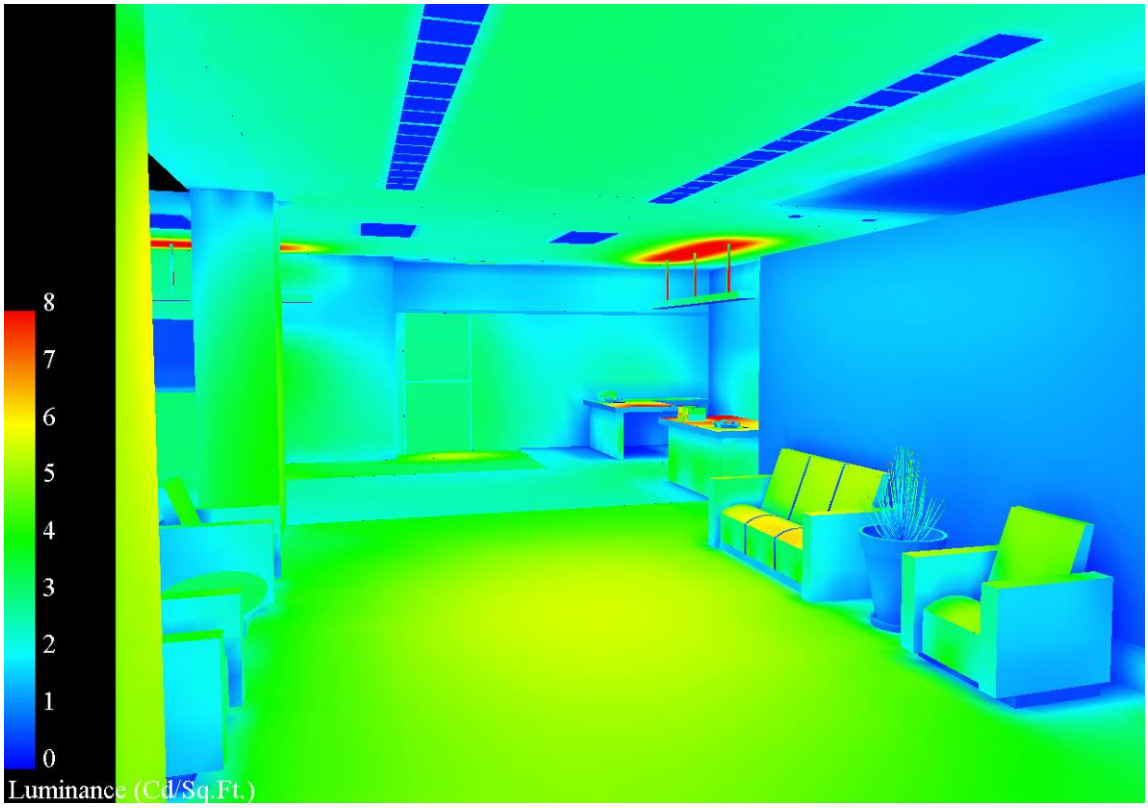
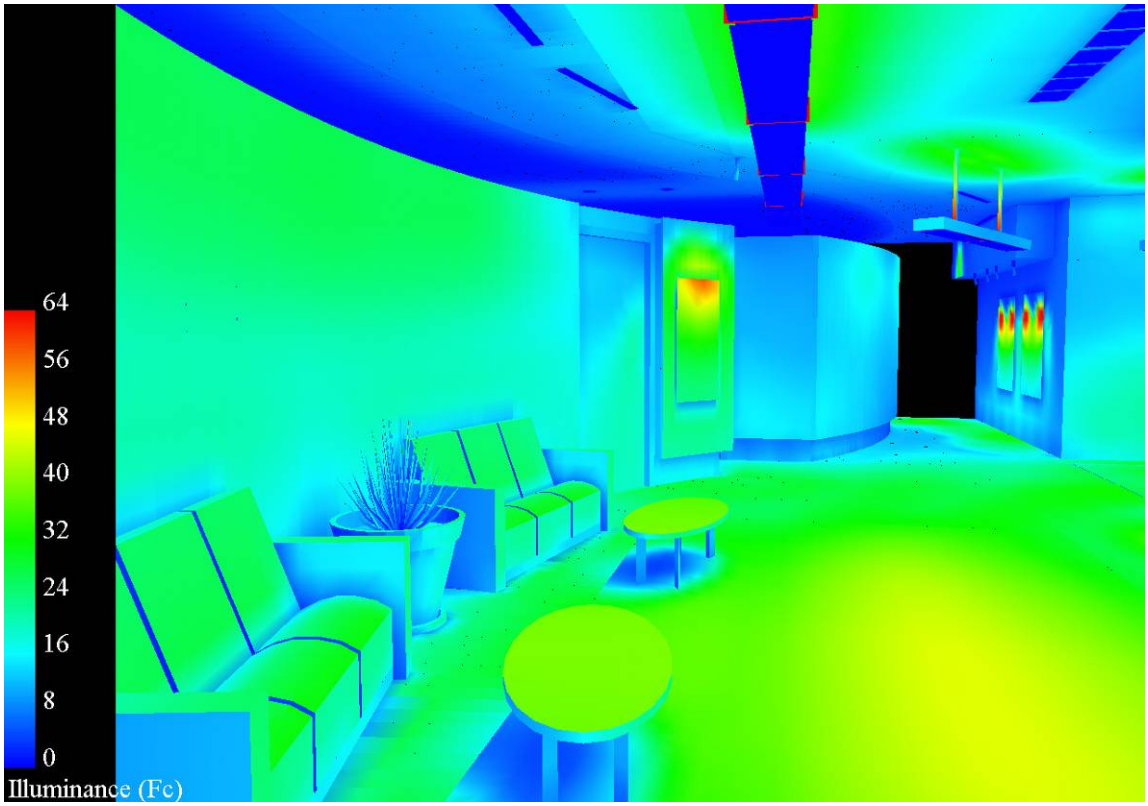
0
Illuminance (Fc)


8
7
6
5
4
3
2
1
0
Luminance (Cd/Sq.Ft.)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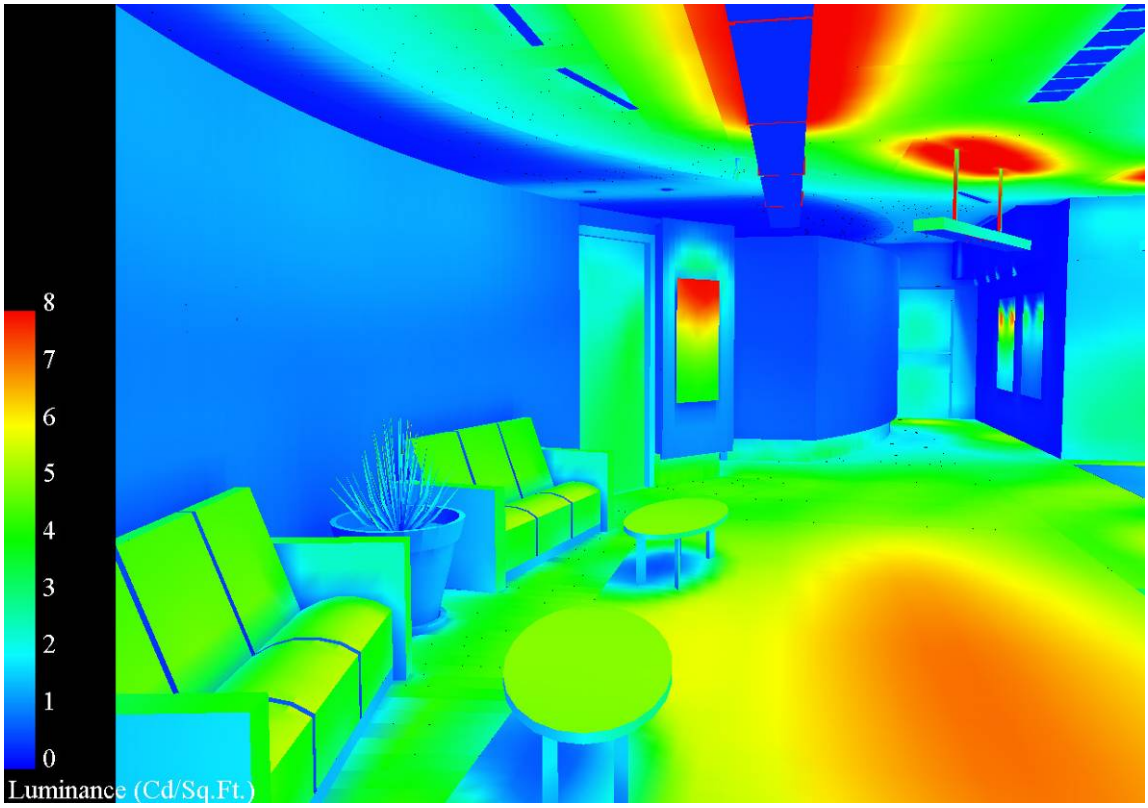
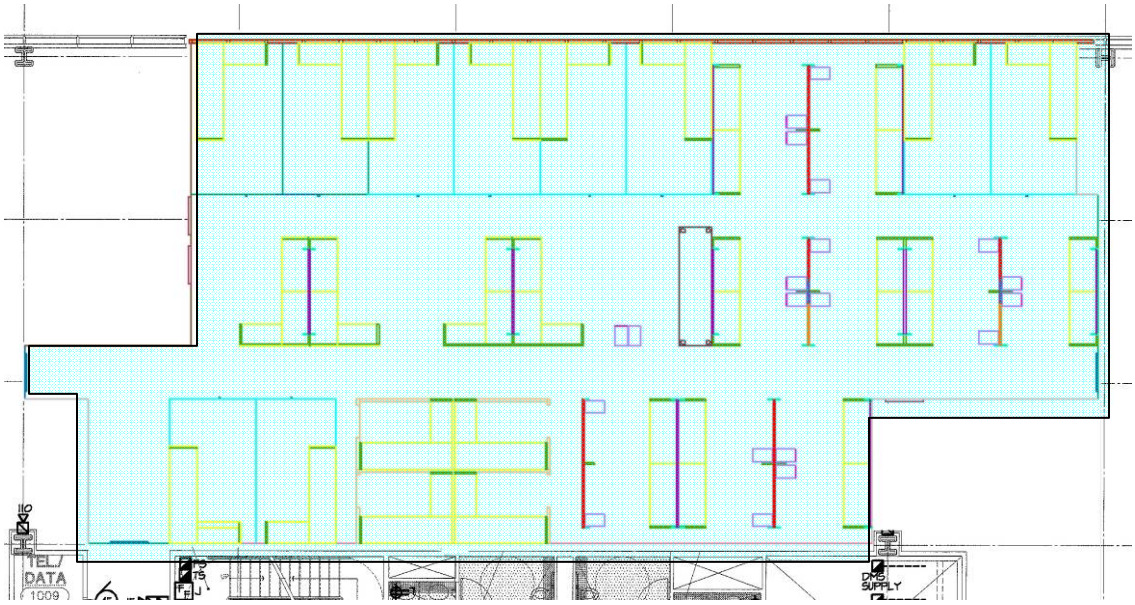
40
32
24
16
8
0
Illuminance (Fc)


8
7
6
5
4
3
2
1
0
Luminance (Cd/Sq.Ft.)

Open Office



Special Luminaires

The special luminaire systems in this space make up the vast majority of the lighting for the space. As was partially detailed in the research description, the desk-system luminaire is based at a height of 5'. The uplighting component spreads across the ceiling in much the same manner as any suspended indirect fixture would, but the downlight component is "funneled" into the translucent glass and reflector space immediately below the lamp. This allows the majority of the lamp lumens to be spread in an indirect manner, but also creates a glowing effect on the glass to illuminate the workplane from the front of the individual, in much the same manner a task light would. The difference being that the "new system" is an area source and has a less-steep falloff gradient across the desk.

The major design issue is one of glare. The lamp was placed low enough in the bay that glare from any angle perpendicular to the lamp orientation is impossible. The glare possibility from viewing angles in the direction of lamp orientation was eliminated by the use of 1' high reflective barriers. The most extreme angle was calculated and the lamp depth adjusted accordingly. No person with an eye level less than 6' would be able to view the lamp unless they crawled up on top of the desk and looked directly in.

The details and dimensions for the design can be found in Appendix C.

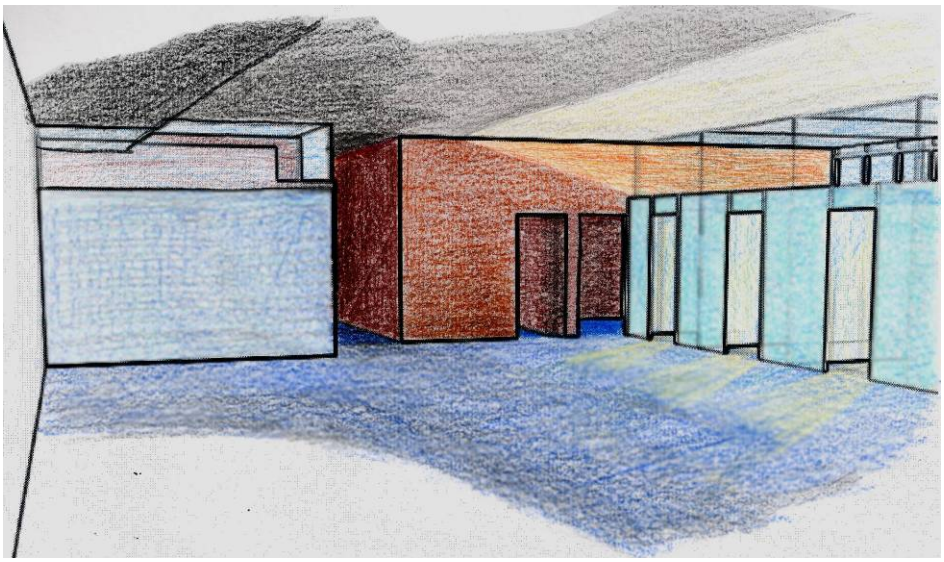
Surface Materials

The Reception area did not exist architecturally prior to the lighting design. For this reason, all of the materials used were relative to the available textures and colors present in AGI32. For all textures and painted surfaces, please view the actual renderings (as they appear in greater bulk) for these spaces. For the most part, architectural materials closely coincide with the materials already listed for the façade, lobby, and parking structure. For detailed surface illustrations and reflectances, reference the previous sections.

Design Concept

The design concept for the Open Office space focused on a single element, from which the remainder of the design was developed. Within the open office, the main task area is the desk in front of each individual. While this does not come as a surprise to any lighting designer, the attempt in this space was to create a "luminaire" that focused all of its output to the task plane. Combining this idea with the contrast limits of the computer screen with near and far geometry, it was decided that a luminous wall in front of the task plane would best illuminate the desk surfaces. This led to a few significant advantages. First, no veiling reflections from high luminance ceiling sections or luminaires would be present. Second, no shadowing would occur on the workplane if the individual was bent over their desk writing. And third, the contrast from looking at the computer screen compared with the "cubicle" wall would be significantly reduced, as would the contrast from workspace to open office corridors.

Further, the design concept was developed in relation to the architectural concept developed in the architectural breadth. With the division of space, and the intention of the design to keep the ceiling open, there needed to be a significant replacement of suspended luminaires in the space. Beyond this, suspended luminaires were eliminated from the private offices to better illuminate the walls for the "area" source impact intended in the architectural design.



Design Criteria

Appearance of Space and Luminaires – Rating: 8

Appearance of the Open Office is of major concern in relation to the architecture of the space. The luminaire appearance is of major concern since the architecture dictates that it be as invisible as possible. The remainder of the luminaires should be as hidden as possible unless it is specifically calls out a particular architectural element.

Color Appearance and Contrast – Rating: 7

Color appearance in the space is important, but not as much so as the contrast between surfaces and areas within the space. Given the major uplighting component proposed, the ceiling contrast should be minimized, and the difference between the workplane and surrounding areas should not be excessive. Color variation throughout the space is significant when considering the floor color, the translucent private office glass color, and the ceiling and wall paints. These colors should all appear vibrant and accurate to their hues. The daylighting component in the space should help brighten up these colors and minimize the shift toward blue-grays.

Daylighting Integration and Control – Rating: 9

Daylighting integration in the space is a given for the glass curtainwall bordering the eastern façade (for this particular space – east and south facades in other spaces). Daylighting integration is not a major concern, but the control is. Each of the private offices, acting as a large glowing light source because of the transmitted light helps decrease the daylighting component and actually diffuses the daylight better than any other method would achieve. The daylight penetration into the private offices would require absolute control of the luminaires in these areas.

Direct Glare – Rating: 10

Because of the location and orientation of the luminaires, the direct glare component could be one of two options – either very minimal, or unbelievably excessive. The construction and implementation of the desk luminaire design needs to account for this issue and its distinct importance

Light Distribution on Surfaces – Rating: 7

The light distribution on surfaces was discussed previously. Light distribution for these areas only needs to be located in two areas, the workplane or desktop at which every employee works, and the floor in the corridors that every occupant uses to traverse the space. The distribution should be as uniform as possible on the desktop and should be continuous in the corridors.

Luminance of Surfaces – Rating: 7

The only surfaces with major luminance concerns are the translucent glass walls and doors again, but also the translucent cubicle walls that will serve as luminaires for the desktops. These luminances should not be very high as they will blind the employee at their workstation, and the glow from the rows of private offices would seem to overbearing as a soft light source.

Modeling of Faces and Objects– Rating: 5

Again, modeling of faces and objects did not take on any vast importance in the space. Of course faces and objects should be well illuminated from all directions which would be accomplished by diffuse light spread throughout the space, but there needn't be any special consideration given to ensuring high illuminances on faces. As long as the appearance of the face is not overwhelmed by facial shadows, the modeling should be sufficient with any office design.

Points of Interest – Rating: 7

There are four distinct points of interest in the space, two located at the ends of each major axis corridor. For the corridor next to the row of private offices (nearest the curtainwall), a light at the end of the corridor should illuminate the wall forcing the wall to seem closer than it actually is. At the opposite end of this corridor is the dark wood-panel wall of the office conference room. The end of this corridor should have higher illuminance to bring attention to the location of the conference room and the physical end of the hallway.

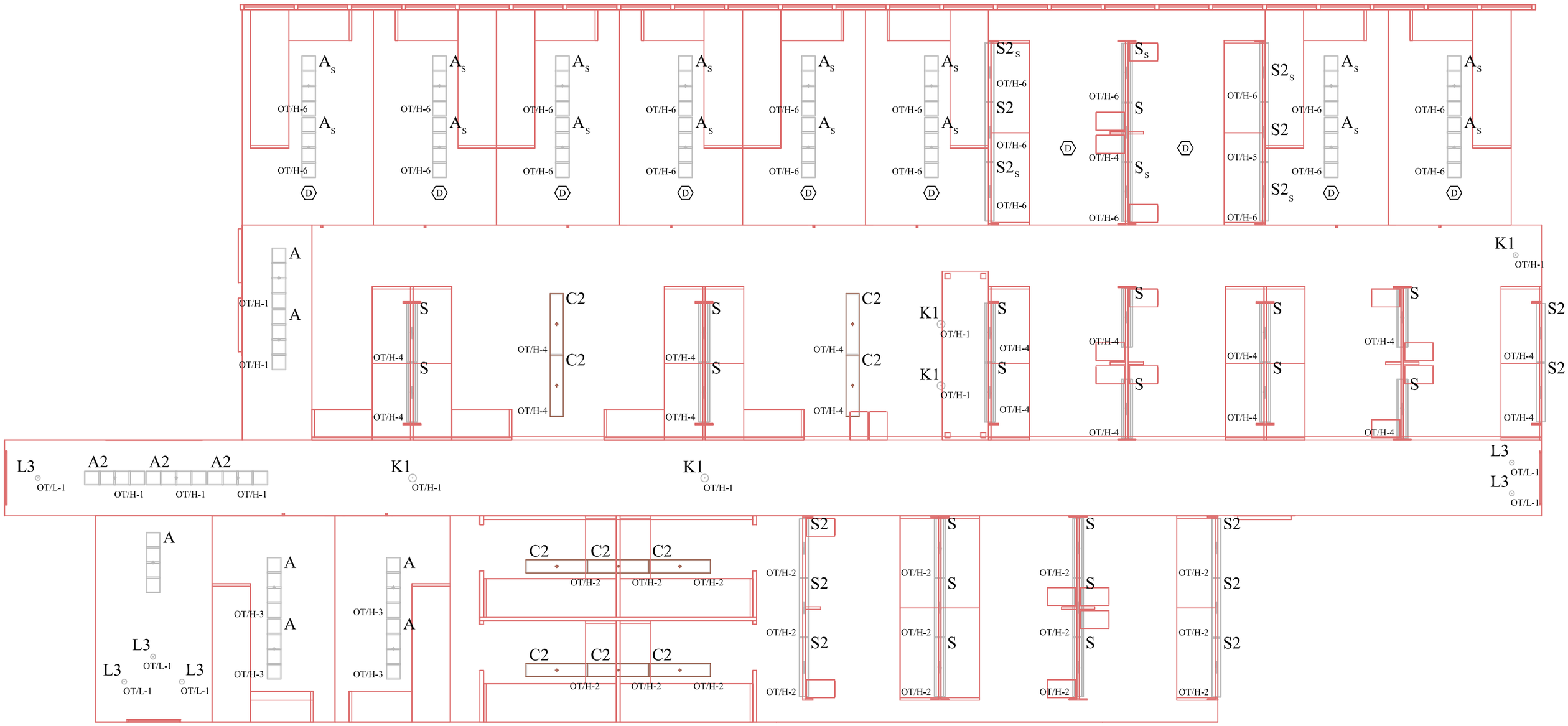
For the main corridor through the space (nearest the core), the entrance and exit glass door should be illuminated as a point of interest for entering the Conference Lobby or exiting the Open Office. At the other end, the intersection of the minor exit hallway and the end of the Open Office corridor should be accented as well.

Horizontal Illuminance – Rating: 9

The horizontal illuminance is of greater importance in this space than it has been in any other space. The desk tasks involve small print, number-crunching, etc. requiring the space to have a higher horizontal illuminance than any of the other space. For this reason, the desk illuminance should be upward of 400 lux, preferably around 500 lux or more. Horizontal illuminance in the corridors should be consistent with the other spaces averaging near 200 lux or more.

Vertical Illuminance – Rating: 5

As was stated for the modeling of faces and objects, vertical illuminance is not of great concern in this space. The only areas that would benefit from vertical illuminance are the private offices where diffuse reflected light from the glass would better illuminate the space. Additionally the more the walls of the private office are lit, the more light will transmit through a larger area source to the interior space.

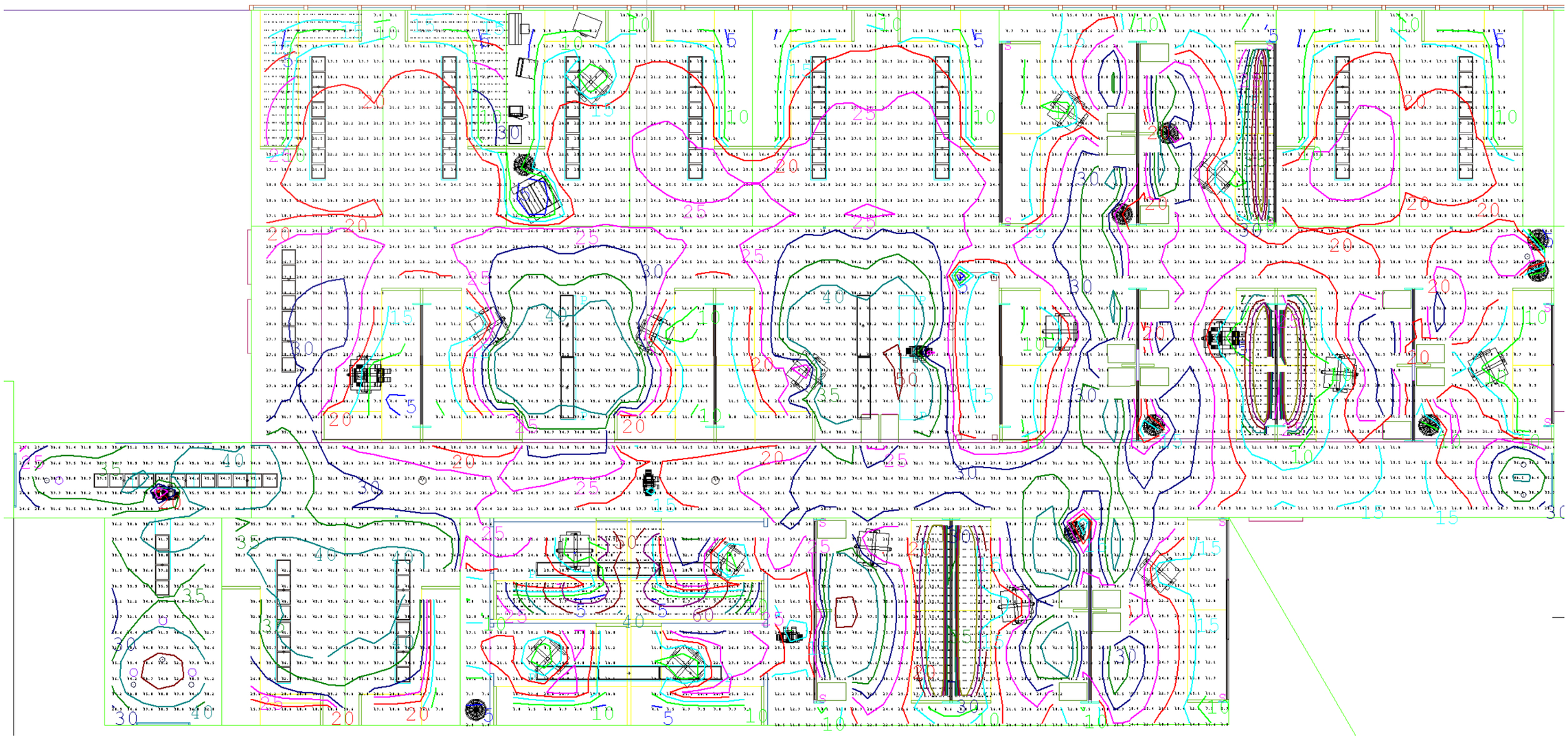


Open Office Floor Plan, Lighting Layout and Circuiting Diagram
All Luminaires additionally labelled with "S" are operable both manually and by Daylight
("D) or Occupancy ("O") Sensor

All Fixture information can be found in Appendix C or on the provided CD.

Not to Scale

Performance



Floor
Illuminance
Values(Fc)
Average=24.59
Maximum=54.0
Minimum=0.1
Avg/Min=
245.90
Max/Min=
540.00

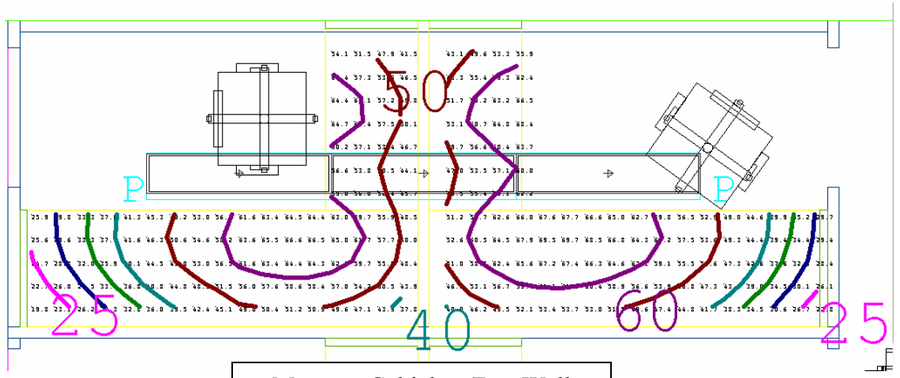
Private Desk
Illuminance
Values(Fc)
Average=21.57
Maximum=33.0
Minimum=11.0
Avg/Min=1.96
Max/Min=3.00

Cubicle Desk
Illuminance
Values(Fc)
Average=50.89
Maximum=69.7
Minimum=19.8
Avg/Min=2.57
Max/Min=3.52

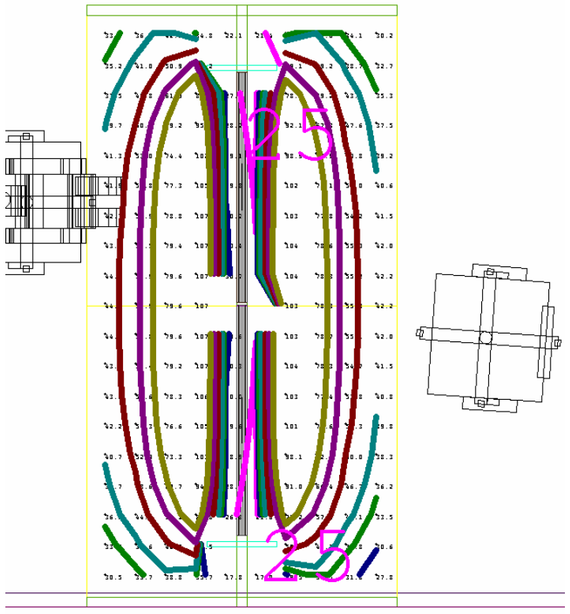
5ft Desk
Illuminance
Values(Fc)
Average=54.71
Maximum=107
Minimum=17.0
Avg/Min=3.22
Max/Min=6.34

6ft Desk
Illuminance
Values(Fc)
Average=67.61
Maximum=116
Minimum=27.8
Avg/Min=2.43
Max/Min=4.19

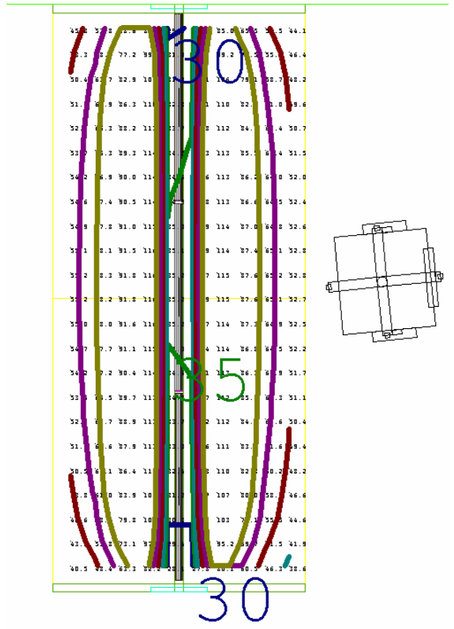
6ft Half Desk
Illuminance
Values(Fc)
Average=46.09
Maximum=83.5
Minimum=20.9
Avg/Min=2.21
Max/Min=4.00



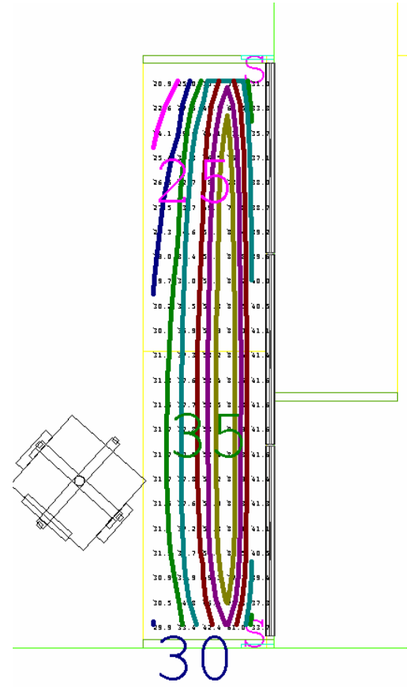
Manager Cubicle – East Wall



5ft “Full Desk”



6ft – “Full Desk”



6ft – “Half Desk”

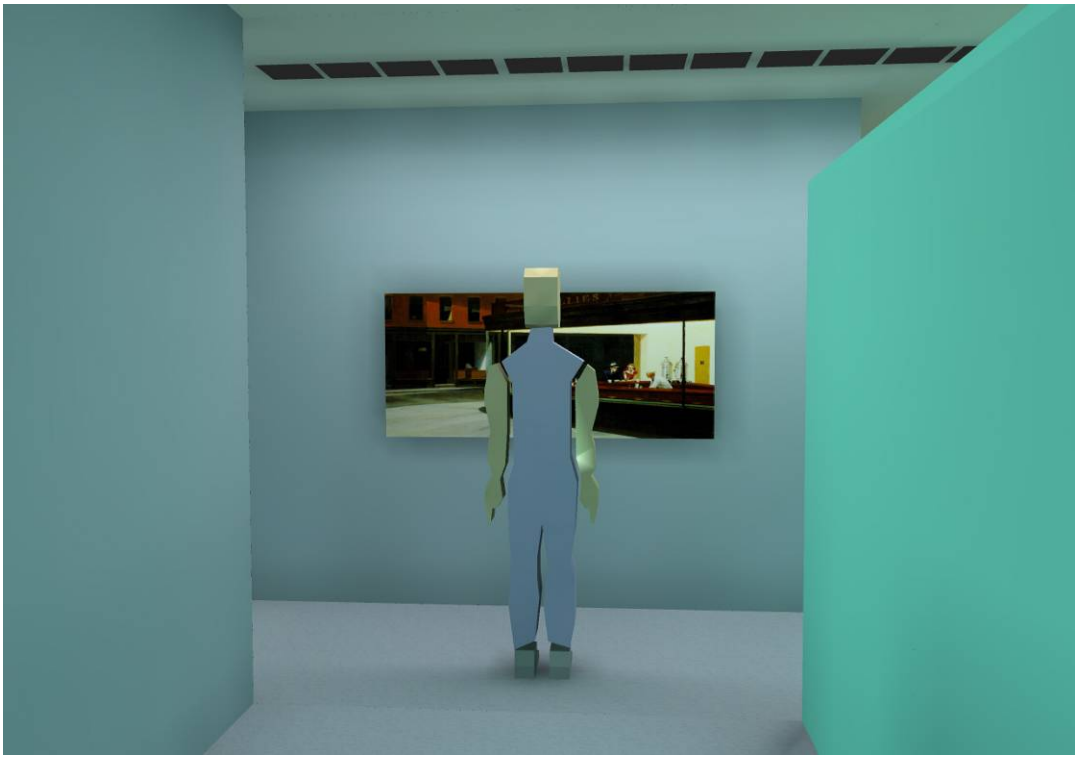
ASHRAE Power Density Calculation

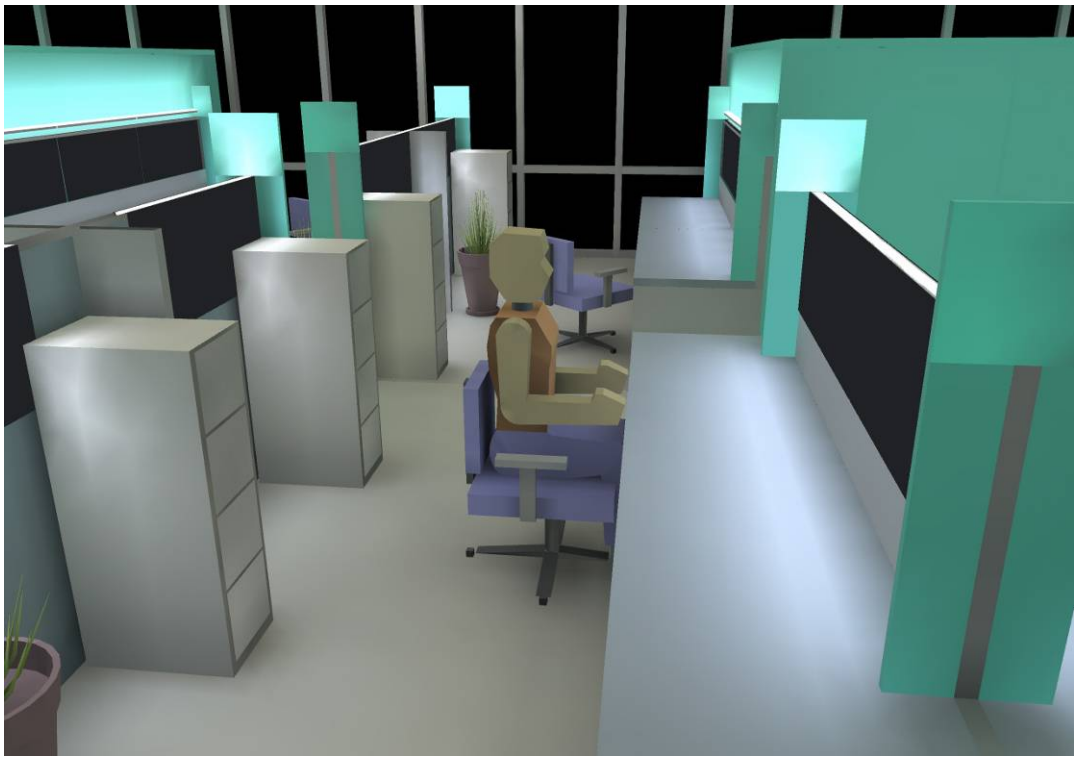
ASHRAE Power Density Allowance for Office: 1.1 W/sf

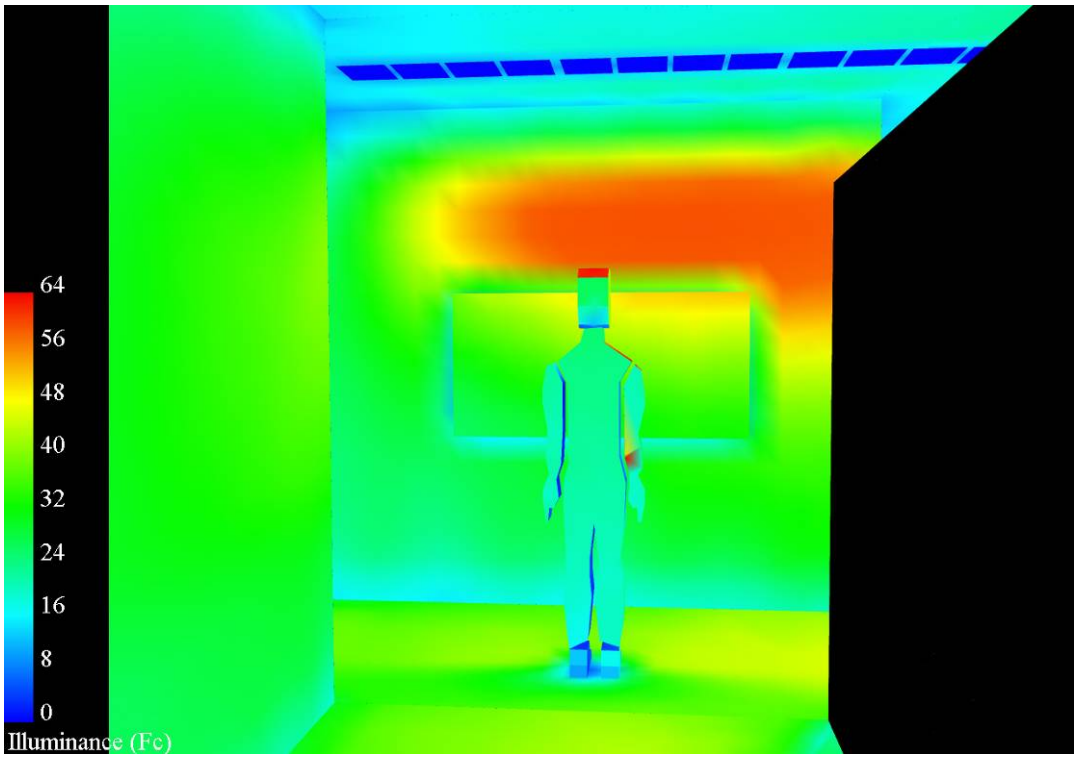
Conference Lobby square footage: 3800 sf ASHRAE allowance: 4180 W

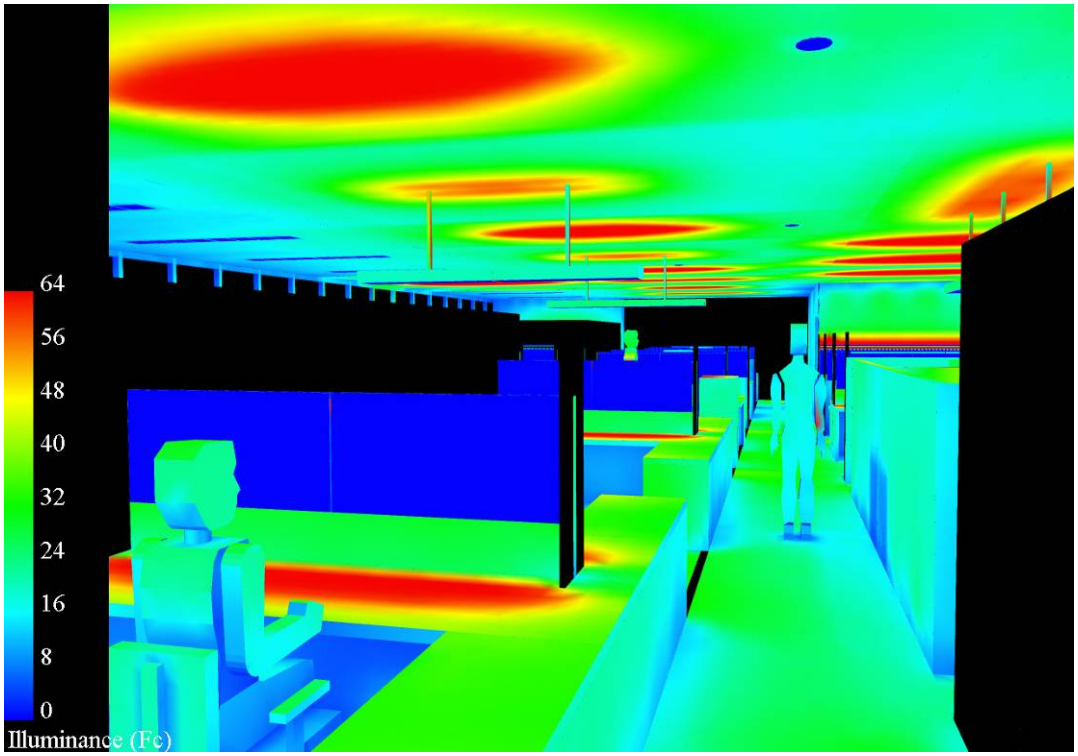
Open Office	A	A2	C2	K1	L3	S	S2			
Luminaire	23	3	10	5	6	21	14			Power Density
Wattage	32	59	59	20	50	59	32	SUM (VA)	Area (sf)	
Total Power	725	176	585	98	300	1229	441	3552	3800	**0.935 W/sf**

Renderings






64
56
48
40
32
24
16
8
0
Illuminance (Fc)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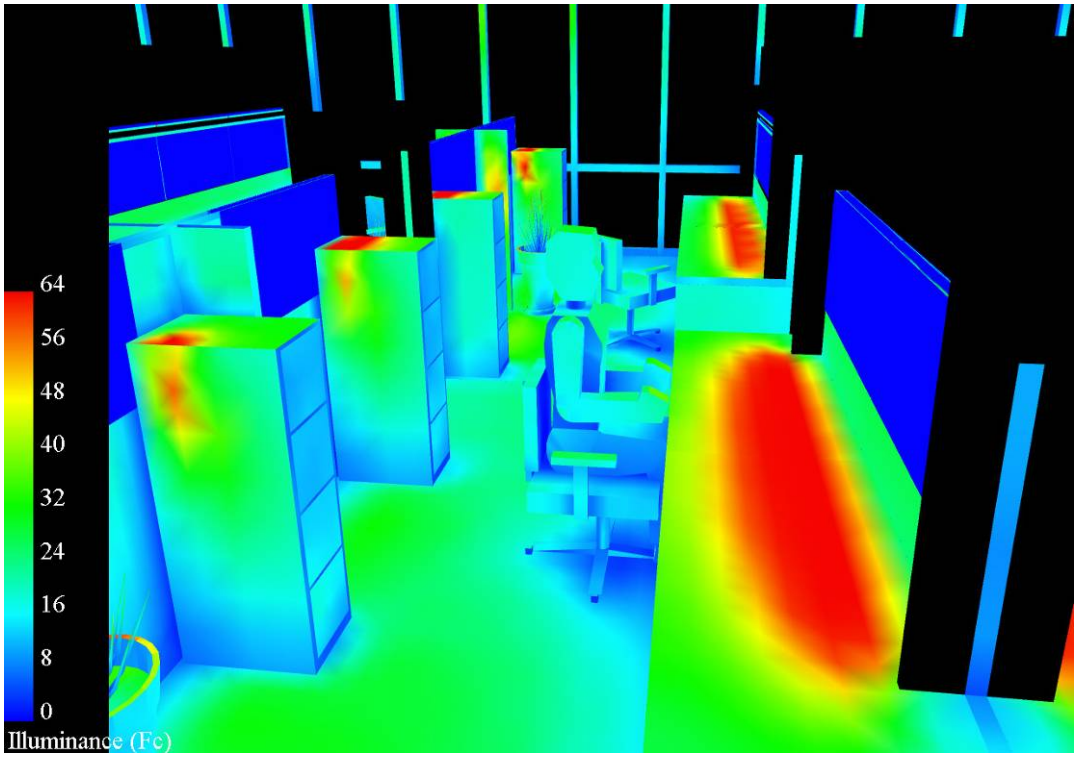
48
40
32
24
16
8
0
Illuminance (Fc)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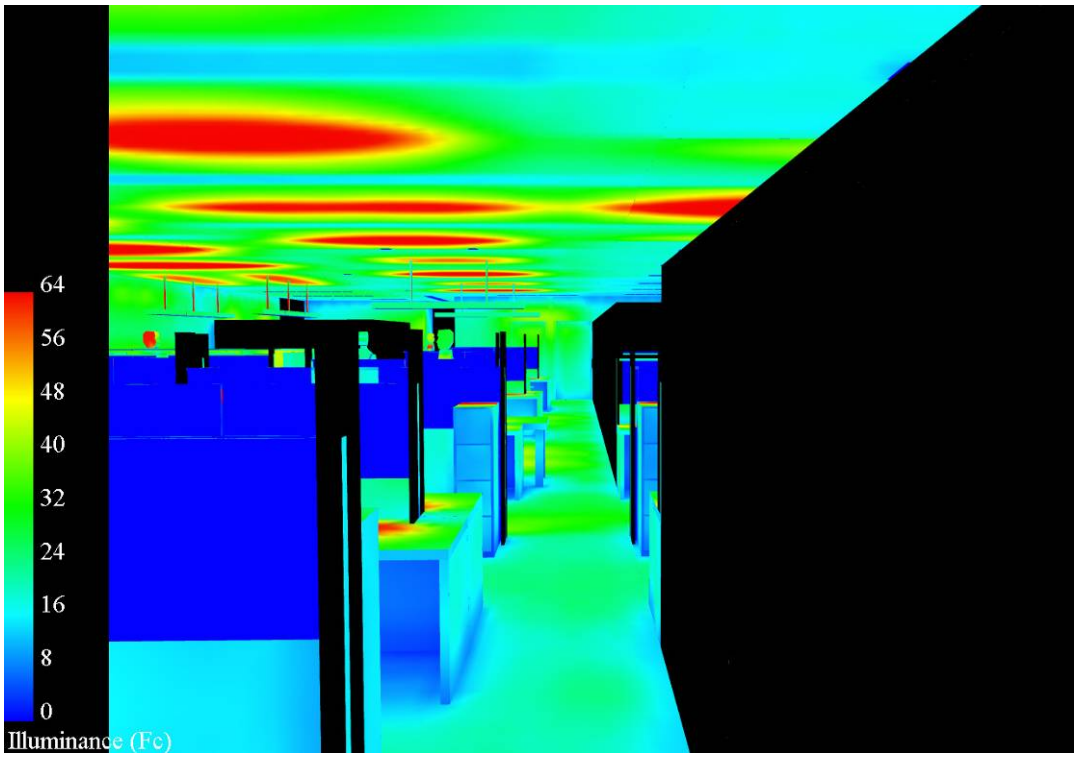
56
48
40
32
24
16
8
0
Illuminance (Fc)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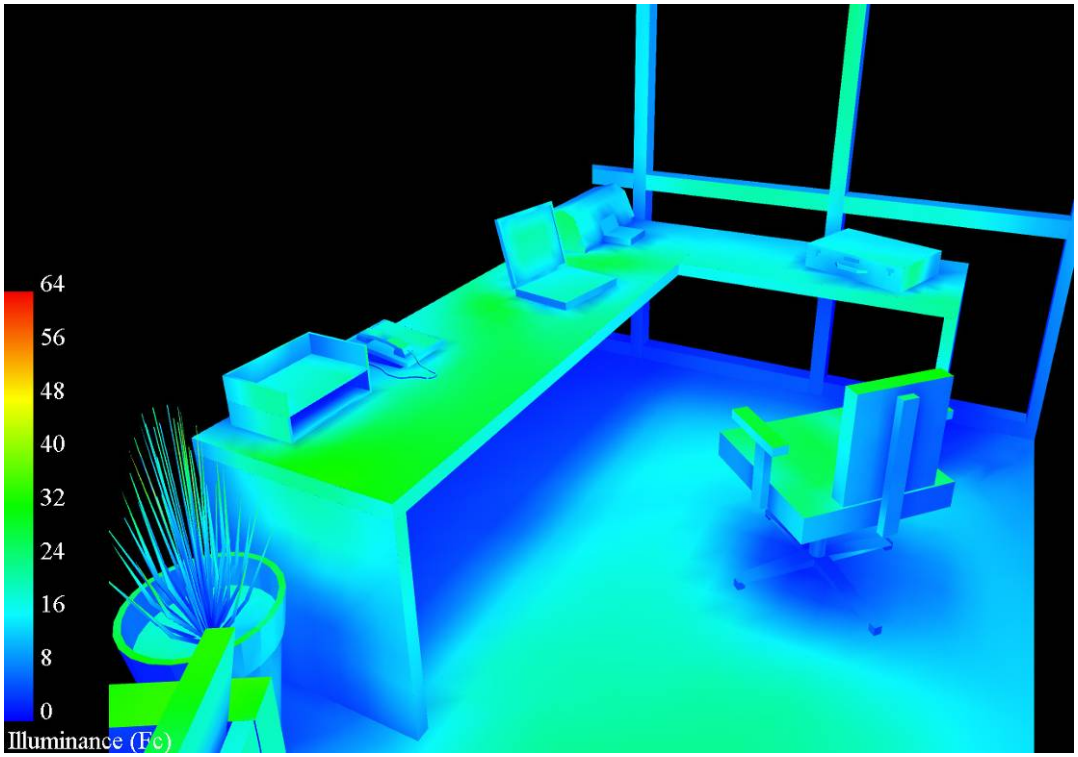
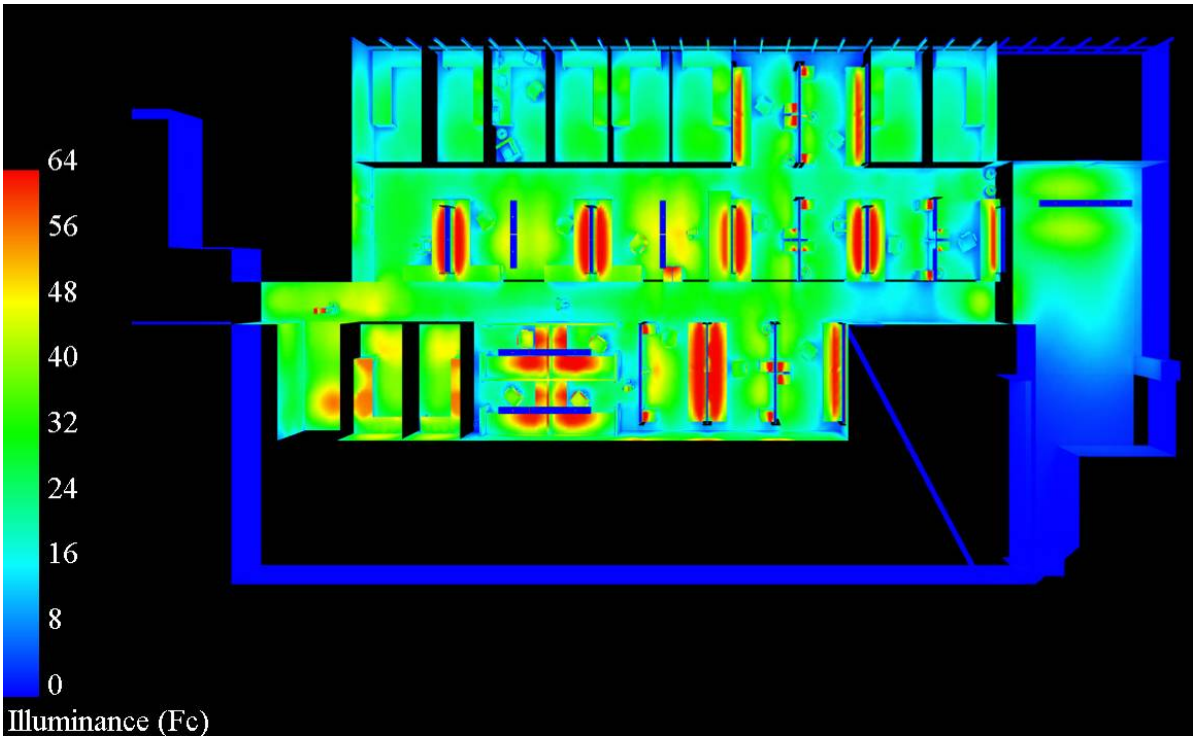
56
48
40
32
24
16
8
0
Illuminance (Fc)


64
56
48
40
32
24
16
8
0
Illuminance (Fc)


64
56
48
40
32
24
16
8
0
Illuminance (Fc)