UNIVERSITY OF PENNSYLVANIA NEURAL AND BEHAVIORAL SCIENCES BUILDING

415 University Ave, Philadelphia, PA 19104

Reinhardt Swart | Lighting + Electrical
Advisor | Shawn Good

Technical Report Part I
9.16.13

Lighting calculation files can be found at Y:\Swart_Reinhardt

EXECUTIVE SUMMARY

In the following report, four spaces from the University of Pennsylvania Neural and Behavioral Sciences (NBS) Building are analyzed using a set of design criteria and considerations. Both qualitative and quantitative criteria are considered. Referencing the tenth edition of the IES Handbook, ASHRAE 90.1 – 2010, LEED v4 Draft, and general design principles, the appropriate criteria is established and evaluated.

The spaces to be studied include:

- **Special purpose space** – lecture hall
- **Circulation space** – ground floor southern lobby/lounge
- **Large work space** – ground floor classroom
- **Outdoor space** – southern façade and site

Overall, the design solution is energy efficient and compliant with major standards and recommendations. In response to the function of the university building, most of the spaces create public psychological impressions. The lighting design complements the architectural elements. As LED technology continues to advance, the NBS utilizes several LED fixtures throughout to save energy and continue to provide the appropriate amount of light. Lighting controls work well to increase energy savings and provide flexibility in spaces such as the classroom and lecture hall.

The exterior, lobby, and lecture hall could benefit from a more dramatic and expressive design. The lighting should be comprehensive and elicit emotional responses to improve the quality of the space.

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BUILDING OVERVIEW

Name | University of Pennsylvania Neural and Behavioral Sciences Building
Location | 415 University Ave, Philadelphia, PA 19104
Occupant Name | University of Pennsylvania faculty, staff and students
Occupant Type | Business (B), Assembly (A-3), and Storage (S-1)
Size | 77,100 SF total
Number of Stories | Five stories and a basement below grade
Construction Dates | January 2014 – March 2016
Estimated Building Cost | $49,300,000
Project Delivery Method | Guaranteed Maximum Price (GMP)

PROJECT TEAM

Architecture & Engineering | SmithGroupJJR, Inc.

Project Manager: Mark Potter
Architect: Sven Shockey
Structural Engineer: ZY Liu + Liliana Blackson
Mechanical Engineer: Dan Mather + Liz Kaminsky
Electrical Engineer: Joe Trusk + Andrew Verilone
Lighting Designer: Matt Alleman + Leland Curtis
Interior Designer: Lori James
Sustainability: Chris Heine

Owner | University of Pennsylvania
Construction Manager | P. Anges
Landscape Architecture | Christopher Allen
Civil Engineering | Pennoni Associates, Inc.
Audio, Visual, Telecomm, Acoustics | Shen Milsom & Wilke, LLC
Signage | InkSpot DESIGN Inc.

OVERVIEW OF EXISITING LIGHTING

Overall, the building is lit primarily by LED and fluorescent fixtures. Most of the spaces are illuminated for tasks regarding reading/writing or lab work. The existing lighting complements the architectural details and emphasizes the concept of organic growth and neural connections. Regarding lighting power densities, the building appears to meet ASHRAE 90.1 – 2010 Standards. The building is targeting a LEED silver rating.

SPECIAL PURPOSE SPACE – LECTURE HALL

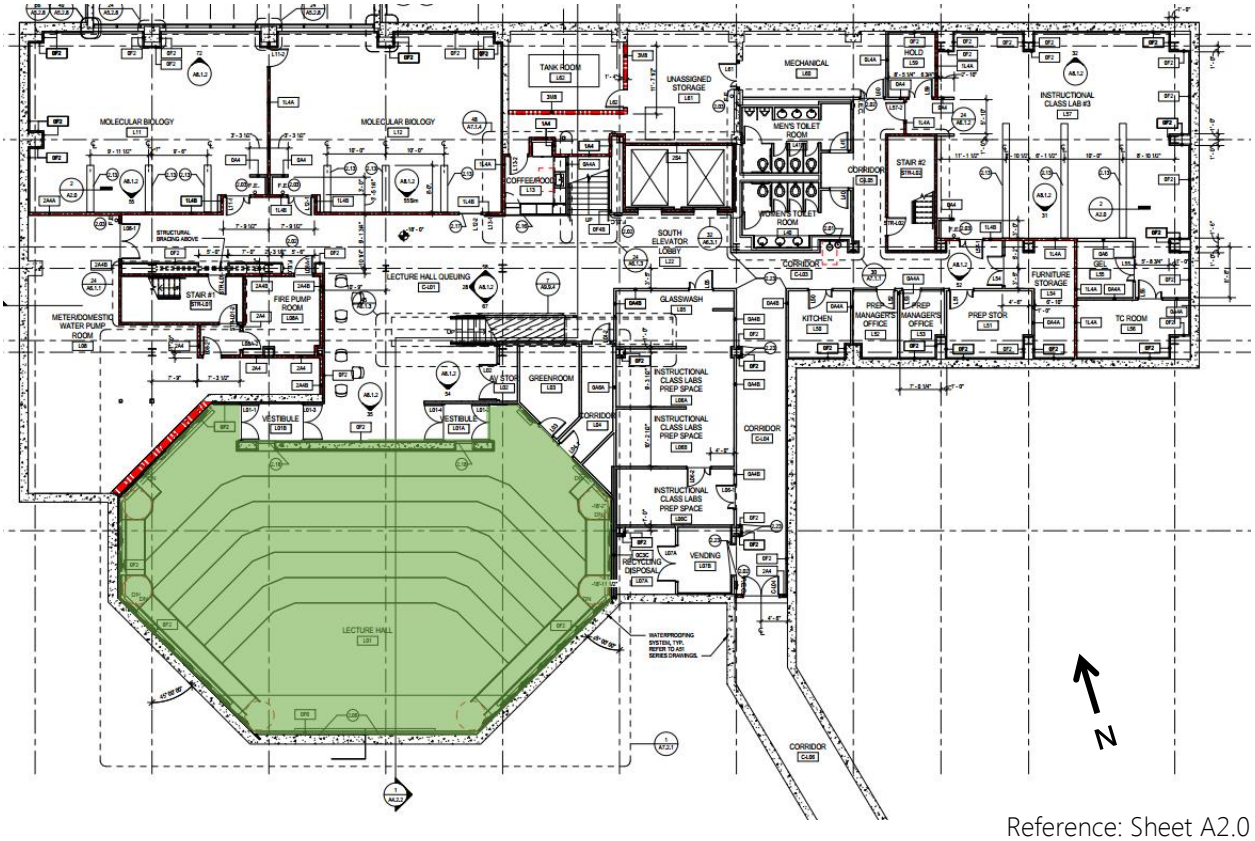
EXISITING CONDITIONS

The lecture hall is a tiered underground space that houses 174 mobile seats as well as AV equipment. The lecture hall is located on the southern side of the building, directly under the large outdoor garden and entrance. The ceiling and walls are custom-made panels that angulate throughout the space. There is appropriately no daylight present in the space as this will be used for presentations. Entrance vestibules are located to the north of the main hall; these are not included in the existing conditions study.

DIMENSIONS

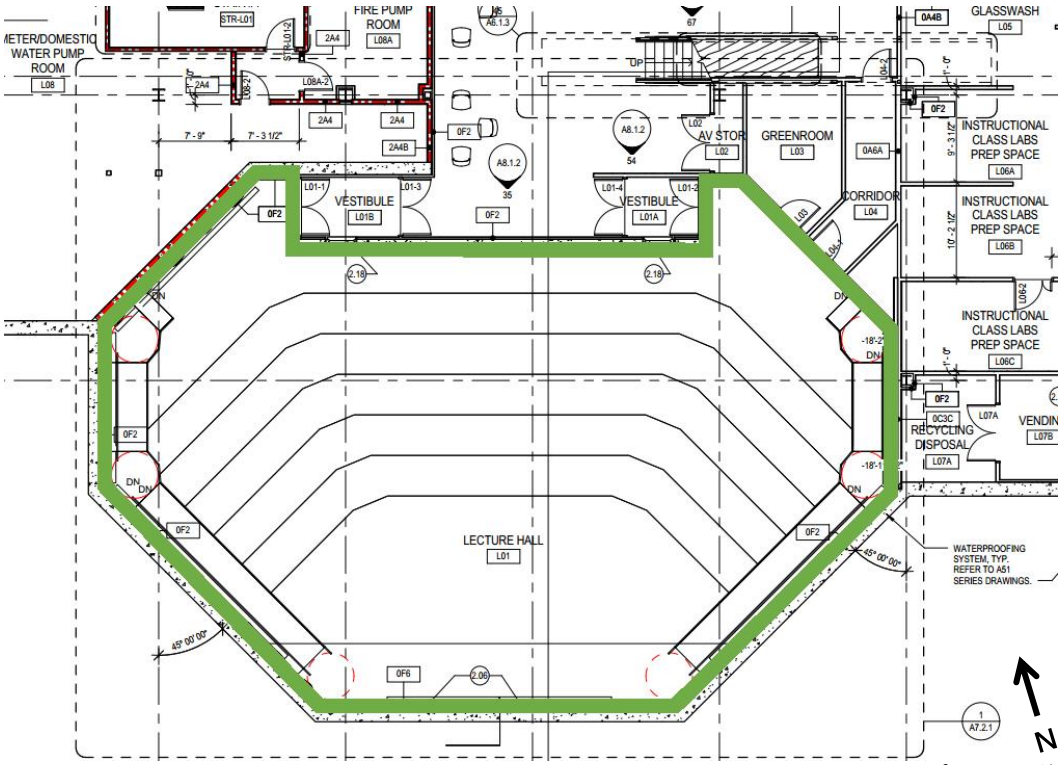
Area – 3200 ft^2.
Approximate width – 90 ft
Approximate length – 55 ft
Approximate ceiling height – 13 ft

FLOOR PLAN



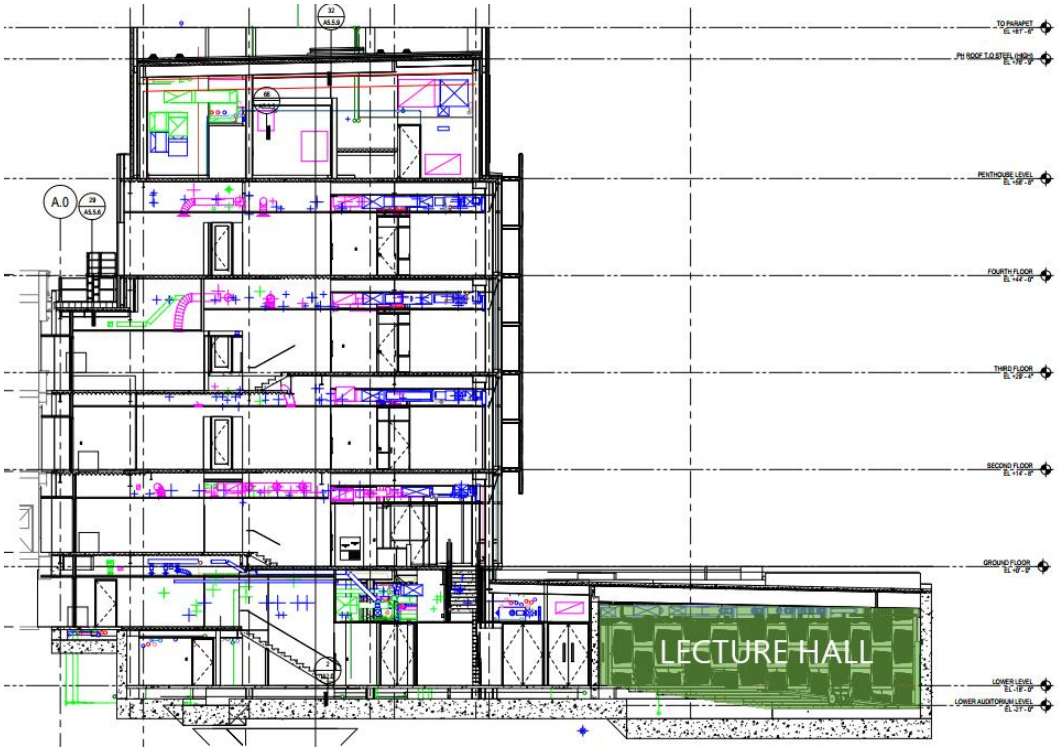
Reference: Sheet A2.0

ENLARGED FLOOR PLAN



Reference: Sheet A2.0

NORTH-SOUTH SECTION



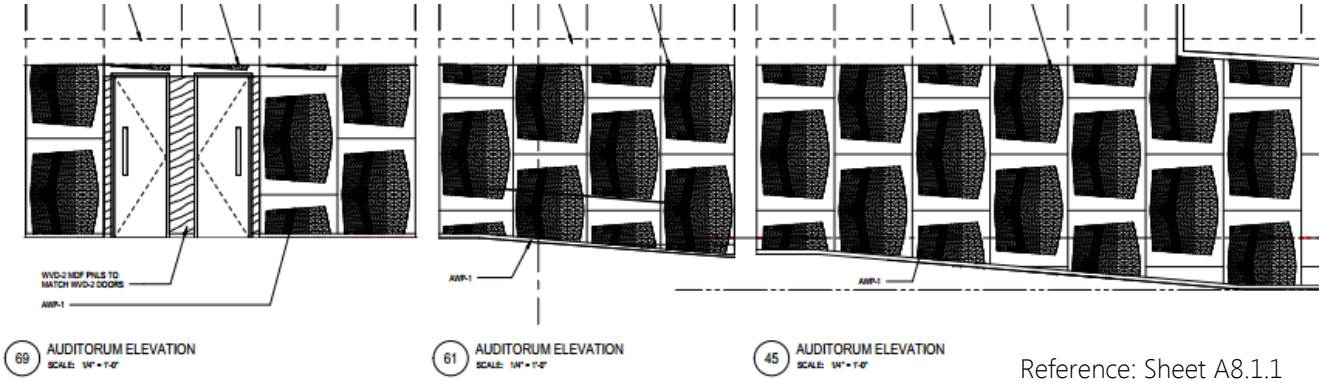
Reference: Sheet A4.2.2

FINISHES

The ceiling and walls are constructed of custom-made acoustic ceiling panels which have unique curved shapes to reinforce the architectural concept of organic and biogenetic. The panels are lightly colored—they have high reflectance values ideal for lighting a public space. The back wall is constructed of yellow wood veneer. The floor is a resilient sheet flooring material, somewhat darker with a lower reflectance value. Overall, the space is relatively reflective which aids in facilitating a public psychological impression.

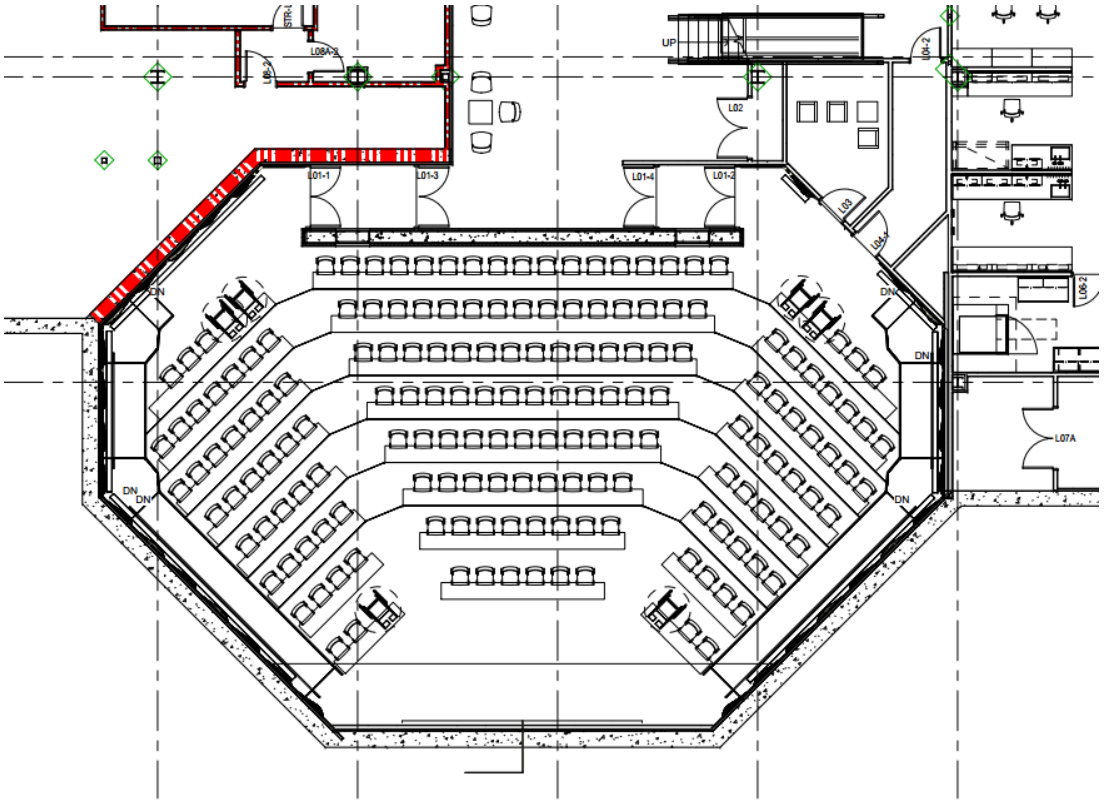
Lecture Hall Materials				
Surface	Material	Description	Style/Color	Reflectance (ρ)
Ceiling	ACP-1/PNT-8	Arktura custom white fiberglass ceiling panel system with specular finish, paint behind	Light yellow, iron ore SW7069 paint	0.75
Walls	AWP-1/WDV-3	Arktura custom white feiberglass wall panel system with specular finish, back wall yellow wood veneer	Light yellow panel/medium finish wood	0.75/0.50
Floor	RSF-3	Optima Series 1/8" homogeneous vinyl sheet	Cool Beige	0.30

AUDITORIAM INTERIOR ELEVATION



Reference: Sheet A8.1.1

FURNITURE PLAN



Reference: Sheet AI2.0

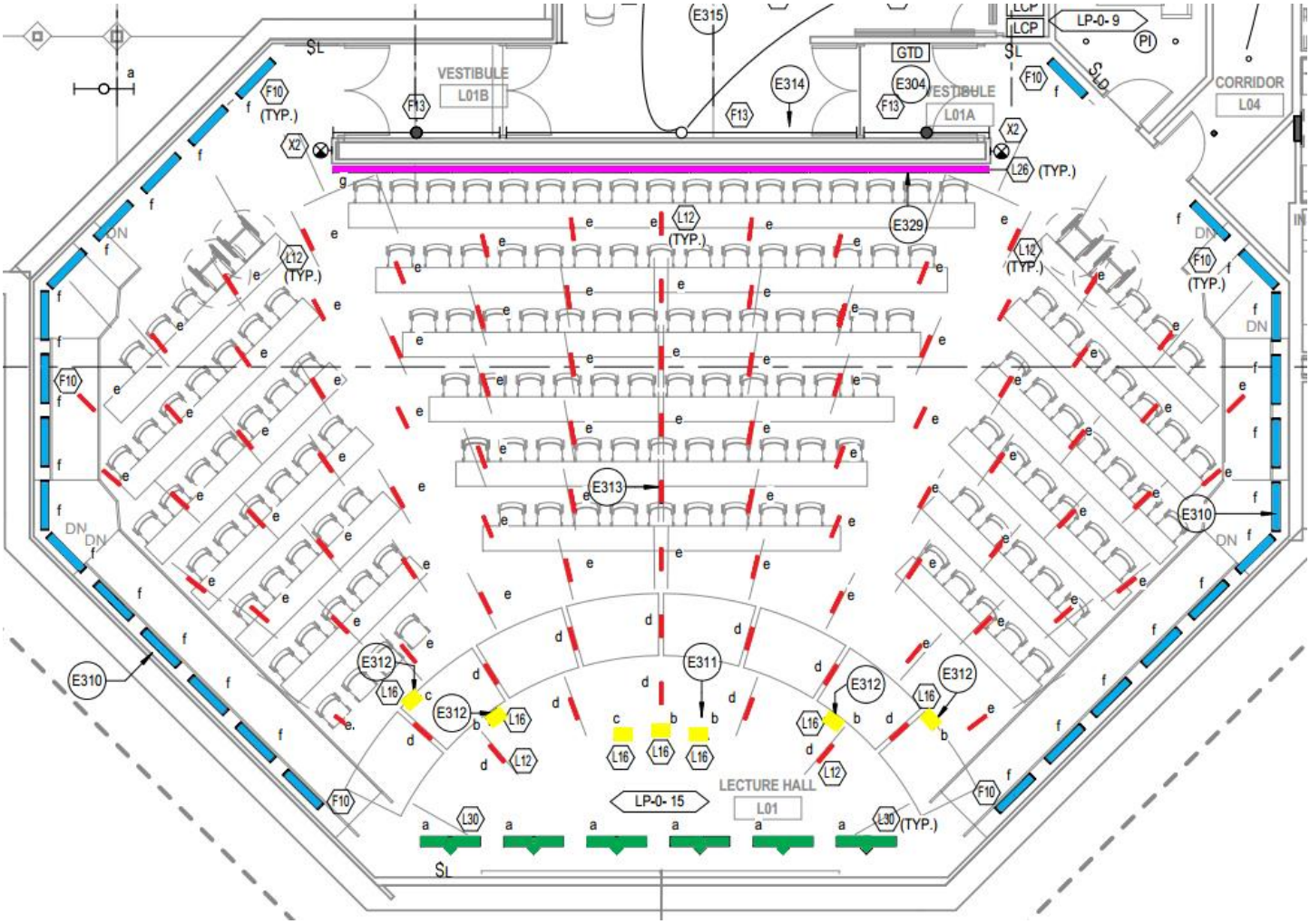
FURNITURE/EQUIPMENT

The lecture hall houses 174 rolling chairs including space for six handicap accessible spots. Medium reflective tables are used for writing; these architecturally mimic a wood finish. There is a single projection screen at the front of the lecture hall with one corresponding ceiling-mounted projector in the center of the room. Sliding chalkboards will be used for presenting material.

TASKS

Important tasks in this space consist primarily of reading and writing. Laptop and computer use are viable design considerations and will be accounted for in the redesigned lighting solution. Projector presentations require the use of audio/visual equipment and thus, appropriate light settings through the use of lighting controls. The screen must be able to be seen clearly from the back of the room; keeping the surroundings relatively dimmer than the screen will resolve viewing issues.

EXISTING LIGHTING | REFLECTED CEILING PLAN



Reference: Sheet E3.0

Lecture Hall Existing Lighting								
Color	Type	Description	Manufac.	Model	Lamp	Mount	Input Watts	Voltage
	F10	Linear fluorescent in-grade wall wash	WE-EF	ETR 140	(1) 21W, T5, 4100K	In-grade	25W	277 V
	L12	Low profile linear LED downlight	Kreon	Nuit	LED, 630 lm, 3000K	Pendant	7.1W	277 V
	L16	Track-mounted LED spot	LSI	Lumlex 2044	LED, 860 lm, 4000K	Track	25W	277 V
	L26	4" x 4" continuous lensed linear LED	A-Light	D3 Series	LED, 500 lm/ft, 3000K	Wall	7W/FT	277 V
	L30	Linear LED asymmetric wall wash	A-Light	D7 Series	LED, 1000 lm/ft, 4000K	Recessed	56W	277 V

The lecture hall currently utilizes a predominantly LED lighting system with the exception of in-grade linear fluorescent asymmetric wall washers. Low-profile linear LED fixtures (L12) provide the general illumination on the work plane. Wall-mounted continuous linear LED fixtures are installed on the back wood veneer wall.

Finally, for lectures and presentations, linear LED wall washers wash the front wall and chalkboard. Track-lights are installed along the ceiling for presentation settings. For the various uses of the space, all installed lighting—with the exception of the track lights—are dimmable, most down to 1% output.

CONTROLS/BALLASTS/DRIVERS

Most of the lighting in the lecture hall are LED fixtures; dimmable compatible drivers are specified. The linear fluorescent fixture (F30) is to be installed with an integral dimming ballast dimmable to 1% light output. The wall washers at the front of the lecture hall (southern end) are dimmable to 5% while the LED fixtures used for general illumination are dimmable to 1%.

A Crestron iLUX Master Control is indicated in the space. This controller will allow for 0-10V and ELV dimming. There are six lighting zones in the room. At the entrance the lecture hall, a wall-mounted six scene controller will control the lighting in the space—lecture, A/V, exam, recording, recording with A/V, and lights off. Near the front of the room, there is a similar three-gang switch and additional controls for the track lights and front wall washers.

EMERGENCY LIGHTING

On the reflected ceiling plan, Kreon LED fixtures are shaded. It is inferred that a large underground lecture hall will need emergency lighting to let people easily move about the aisles; it is warranted that the overhead lights are unswitched light fixtures connected to the emergency power system.

DESIGN CRITERIA/CONSIDERATIONS

QUALITATIVE CRITERIA

Very Important

- **Light Distribution on Task Plane**
  - Meeting the IES Handbook recommendations for illuminance and uniformity will ensure that there are sufficient light levels to comfortably read and write
  - Vertical surfaces (for writing) at the front of the space should be lit to sufficient levels, referencing the IES Handbook, as to help the eye maintain focus and user maintain attention
  - Render lecturer's face well so that occupants can easily identify speaker's emotions and expressions

- **Appearance of Space and Lighting Fixtures**
  - The custom curved ceiling and wall panels are prominent architectural features; the lighting design should respond and complement the space

- **Direct glare**
  - Users of the space should not experience direct glare as this will be irritating and distracting especially since the direction of viewing is in one direction

- **Lighting Controls**
  - It is critical that the space be controlled well so that different lighting modes will respond to the purpose of the space at the time; this is related to relative brightness levels experienced in the space

Important

- **Veiling Reflections**
  - Veiling reflections on specular computer and Ipad screens should be minimized by controlling the overall amount and direction of light with respect to the location and orientation of the task

- **Flicker**
  - Flicker could potentially be distracting to the occupants which would inherently effect their efficiency and retentiveness

- **Group Relamping and Cleaning**
  - A taller ceiling in the hall and quantity of fixtures require careful consideration when specifying product, as to allow for efficient and easy cleaning and relamping post-occupancy

Not applicable

- **Daylighting Integration and Controls**
  - No daylighting apertures present in space

DESIRED PYSHCOLOGICAL IMPRESSION

As outlined by John Flynn and discussed by Gary Steffy, the redesigned lighting in the lecture hall will enable public impressions on the occupants. This will be done by illuminating the peripheral surfaces and introducing uniform and relatively brighter light levels.

QUANTITATIVE CRITERIA

Recommended Horizontal Illuminance – Very Important

- IES Classification | Education
  - Reading and Writing, Print media, 12-pt font
    - Category O: 200 lux (20.0 fc), at desk height
    - Avg/Min: 2:1
  - Auditoria, Lecture Hall, Audience, A/V and notes
    - Category K: 50 lux (5.0 fc), at desk height
    - Avg/Min: 2:1

Recommended horizontal illuminance levels are driven by two critical tasks. One is a recommendation corresponding to general lighting for reading and writing. The other recommendation relates to a projector screen presentation (A/V equipment) when note-taking is expected.

Recommended Vertical Illuminance – Important

- IES Classification | Education
    - Reading and Writing, Print media, 12-pt font
        - Category O: 50 lux (5.0 fc), at desk height
    - General Classroom, Learning/teaching, Chalkboard
        - 400 lux (40 fc)
    - Auditoria, Lecture Hall, Speaker/Panel, no A/V, Faces
        - 200 lux (20 fc)
    - Auditoria, Lecture Hall, Audience, A/V and notes
        - Category K: 15 lux (1.5 fc), at desk height
    - Auditoria, Lecture Hall, Screen, Feature Presentation
        - 10 lux (1.0 fc)

Correlating to the above horizontal light levels, the vertical recommended values correspond to a general lighting scene where note-taking is expected. In this general lighting setting, recommended light levels are noted for modeling the face of the speaker at the front of the room with no A/V equipment in use. Another lighting scene accounts for projector presentations at the front screen.

LEED-NC v4 Draft

EAp2: Minimum Energy Performance

- Comply with the mandatory and prescriptive provisions of ANSI/ASHRAE/IESNA Standard 90.01-2010.

EAc2: Optimize Energy Performance

- Reduce energy consumption of entire building by 6-42% to respectively receive 1-16 points.

EQc6: Interior Lighting

- For at least 90% of individual occupant spaces, provide individual lighting controls that enable occupants to adjust the lighting to suit their individual tasks and preferences with at least three lighting levels or scenes (on, off, midlevel).
    - For multi-zone spaces, include multi-zone control system readily available to occupant
- For entire project, use light sources with a CRI of 80 or higher
- For all regularly occupied spaces, use light fixtures with a luminance of less than 2,500 cd/m^2 between 45° and 90° from nadir.

ENERGY ALLOWANCES

According to ASHRAE Standard 90.1 version 2010 (most recent version upon completion of thesis) space-by-space method, a classroom/lecture/training has an allowed wattage of 1.24 W/SF.

Energy Allowance (ASHRAE 90.1 – 2010)			
Space	Area (SF)	W/SF	Allowed Wattage
Lecture Hall	3200	1.24	3968 W

ASHRAE 2010 STANDARDS

Not all of the following standards will apply to each respective space. Reference those standards that apply to specific space in question.

9.4.1 Lighting Control

Any automatic control device required in sections 9.4.1.1, 9.4.1.2, and 9.4.1.4 shall either be manual on or shall be controlled to automatically turn the lighting on to not more than 50% power.

9.4.1.1 Automatic Lighting Shutoff

Interior lighting in buildings shall be controlled with an automatic control device to shut off building lighting in all spaces. This automatic control device shall function on either

1. a scheduled basis using a time-of-day operated control device that turns lighting off at specific programmed times—an independent program schedule shall be provided for areas of no more than 25,000 ft^2 but not more than one floor—or
2. an occupant sensor that shall turn lighting off within 30 minutes of an occupant leaving a space, or
3. a signal from another control or alarm system that indicates the area is unoccupied

9.4.1.2 Space Control

Each space enclosed by ceiling height partitions shall have at least one control device to independently control the general lighting within the space. Each manual device shall be readily accessible and located so the occupants can see the controlled lighting. All controlled lighting shall meet the following requirement:

1. an occupant sensor or a timer switch shall be installed that automatically turns lighting off within 30 minutes of all occupants leaving a space in classrooms and lecture hall.

2. each control device shall be activated either manually by an occupant or automatically by sensing an occupant. Each control device shall control a maximum of 2500 ft^2 area for a space 10,000 ft^2 or less and a maximum of 10,000 ft^2 area for a space greater than 10,000 ft^2. The occupant shall be able to override any time-of-day scheduled shutoff control for no more than two hours.

9.4.1.4 Automatic Daylighting Controls for Primary Sidelighted Areas
When the combined primary sidelighted area in an enclosed space equals or exceeds 250 ft^2, the lamps for general lighting in the primary sidelighted area shall be separately controlled by at least one multilevel photocontrol (including continuous dimming devices) having the following characteristics:

1. the light sensor for the photocontrol shall be remote from where calibration adjustments are made;
2. the calibration adjustments shall be readily accessible, and
3. the multilevel photocontrol shall reduce electric lighting in response to available daylight with at least one control step that is between 50% and 70% of design lighting power and another control step that is no greater than 35% (including off) of design power.

DESIGN CRITERIA PRIORITIZED

1. Meet ASHRAE Energy Code requirements
2. Create a public and visually comfortable space that provides sufficient and uniform lighting for task completion, thus introducing a public impression
3. Control lighting to meet various demands of space
4. Model the speaker's face well and provide adequate task lighting
5. Architecturally complement the space
6. Meet LEED requirements for lighting controls and minimum energy requirements

EVALUATION

VISUAL IMPRESSION CREATED BY LIGHTING SOLUTION

The architectural elements in the lecture hall promote movement and flow. The existing lighting complements the architecture well in that visual clutter is minimized and the architectural elements made the predominate forms. In the general lighting scene, the area of coverage is directly illuminated with overhead LED fixtures. The perimeter is strongly illuminated to encourage openness; custom wall panels are washed with in-grade fluorescent fixtures while a wall-mounted LED grazes the back feature wall. The typically unwanted cave-like effect is minimized: the space is open, not bound by planar walls—reinforced through the lighting—and comfortable.

METHOD/PROCESS

To generate detailed lighting calculations for the tiered lecture hall, computer software was used to simulate the existing lighting. The space was exported from Revit Architecture 2014 and then imported into 3DS Max Design 2014. The appropriate photometric lights (.ies files) were placed in the corresponding location per fixture schedule and reflected ceiling plans. The correct light loss factors (LLFs) were applied to each type of fixture. A summary of the lighting fixtures and LLFs applied is listed below under "Model Inputs". Simplified materials were assigned to the surfaces in the space, based on the reflectance values noted in the "Lecture Hall Materials" table above.

Radiosity is the processing system used in 3DS Max Design 2014 to calculate illuminance (lux). The renderings are performed using the default scanline renderer. This method of design is valid and accurate. Corresponding renderings, pseudo color images, and lighting analysis assistant allow for a complete lighting study.

MODEL INPUTS

The table below outlines the fixtures placed in the space along with the appropriate lamps, quantity of lamps per fixture type, quantity of fixtures, and the corresponding wattage consumed by the fixtures.

Lighting Fixtures Used				
Type	Lamp	Qty. of fixtures	Input Wattage (W)	Total Wattage (W)
F10	(1) 21W, T5, 4100K	28	25	700
L12	LED, 630 lm, 3000K	90	7.1	639
L16	LED, 860 lm, 4000K	7	25	175
L26	LED, 500 lm/ft, 3000K	11 (4')	7 W/FT	308
L30	LED, 1000 lm/ft, 4000K	6	56	336

The following table describes the applicable light loss factors applied to the existing lighting fixtures.

Light Loss Factors						
Type	Lamp Lumens		LLD	LDD	BF	Total
	Initial	Mean				
F10	1900	1767	0.93	0.94	1.06	0.93
L12	630	-	0.70	0.94	-	0.66
L16	860	-	0.70	0.94	-	0.66
L30	2000	-	0.70	0.94	-	0.66
L26	4000	-	0.70	0.94	-	0.66

RENDERINGS

Fig 1: General lighting render perspective

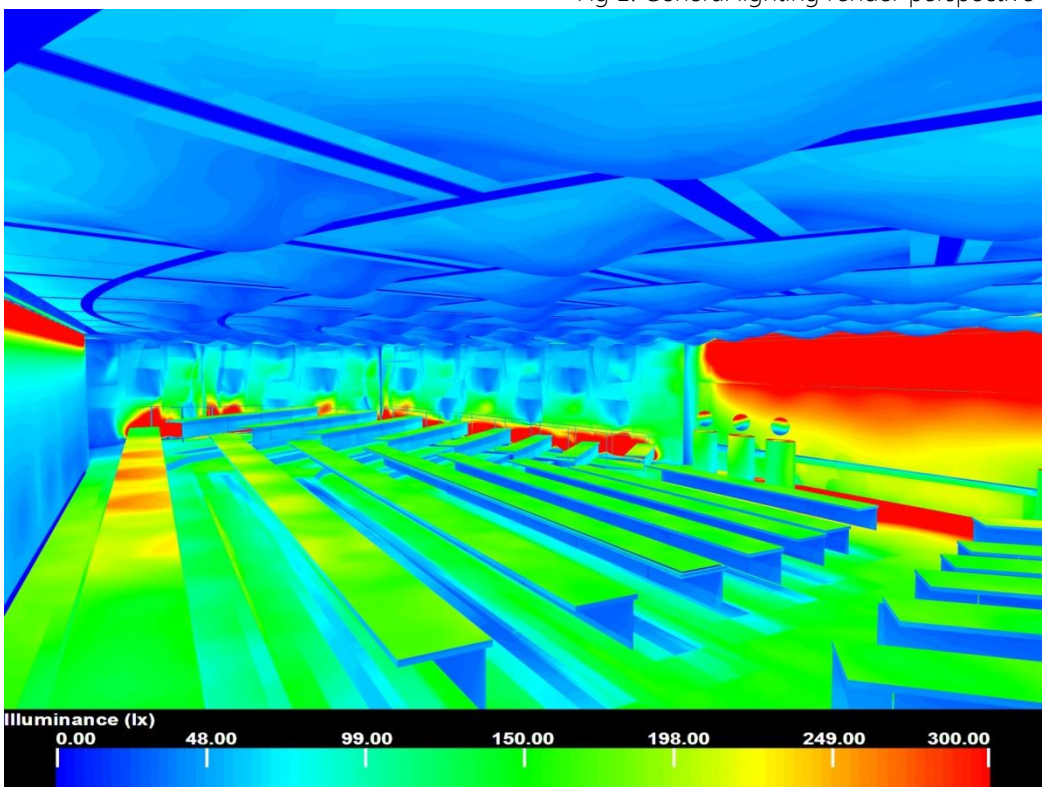


Fig 2: General lighting pseudo perspective

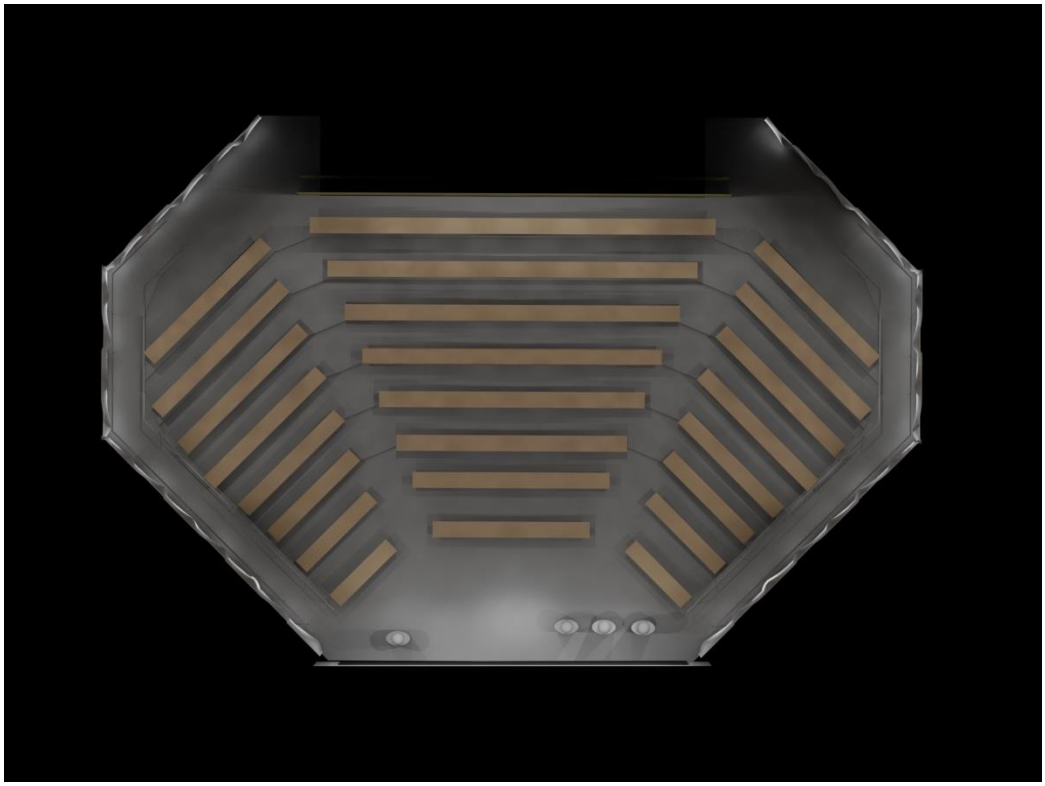


Fig 3: General lighting render top view

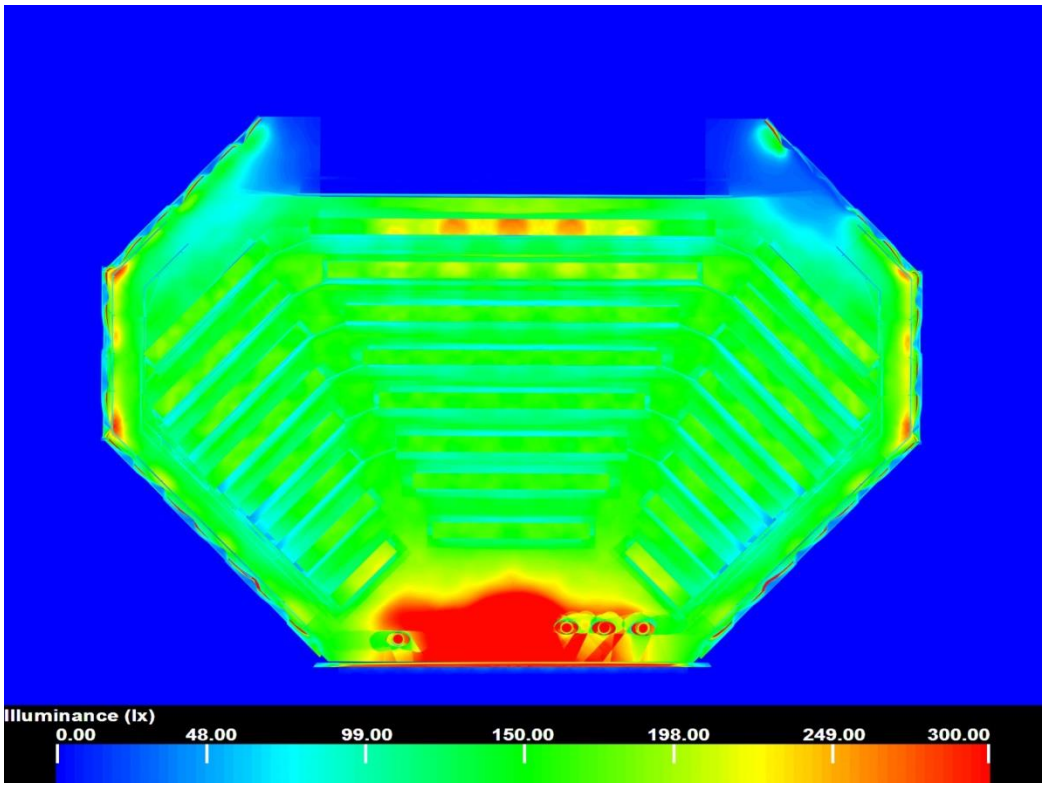


Fig 4: General lighting pseudo top view

Fig 5: A/V mode render perspective

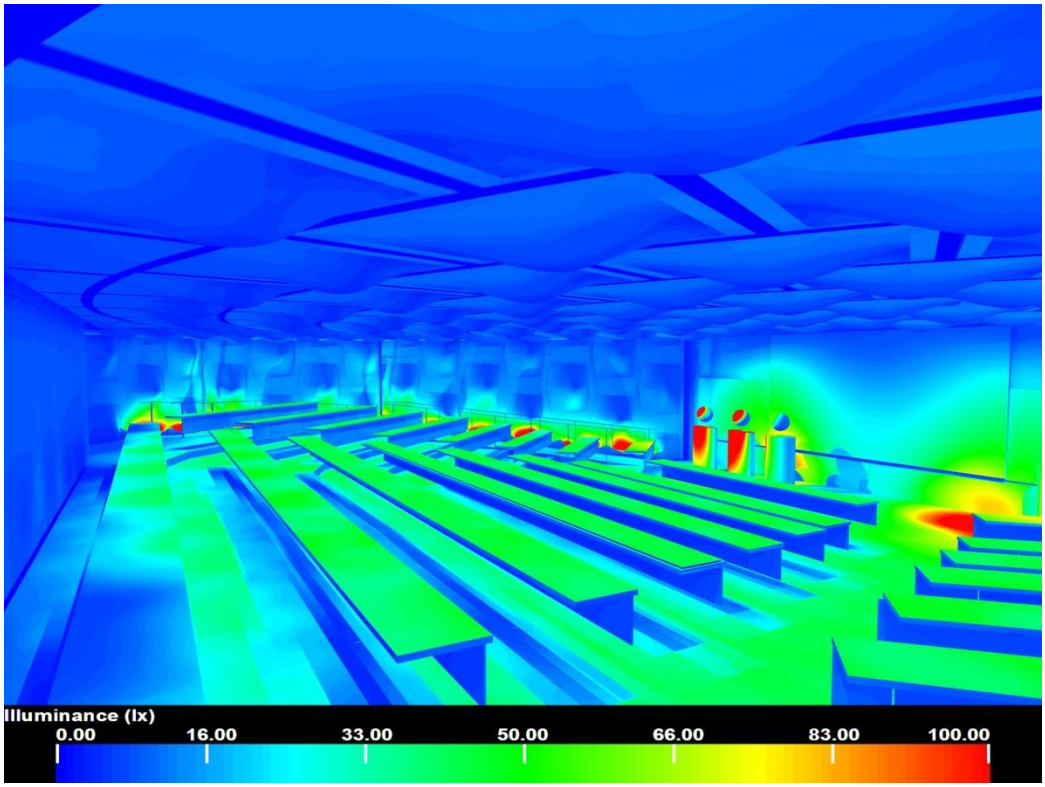


Fig 6: AV mode pseudo perspective

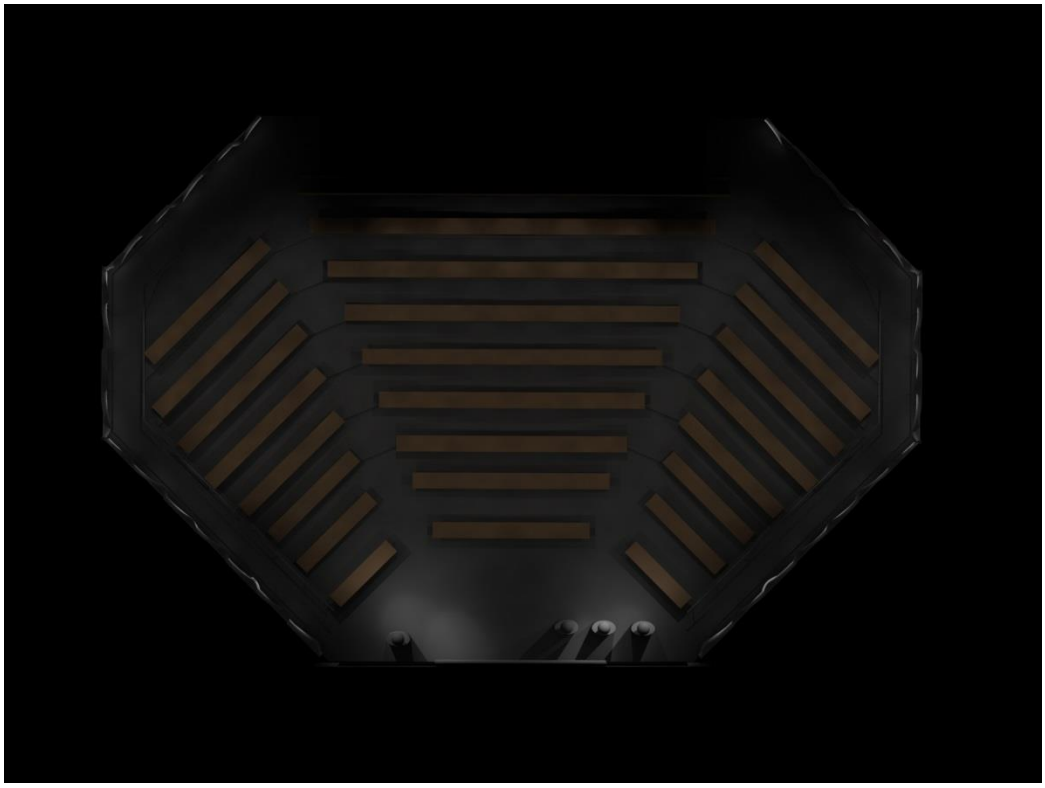


Fig 7: AV mode render top view

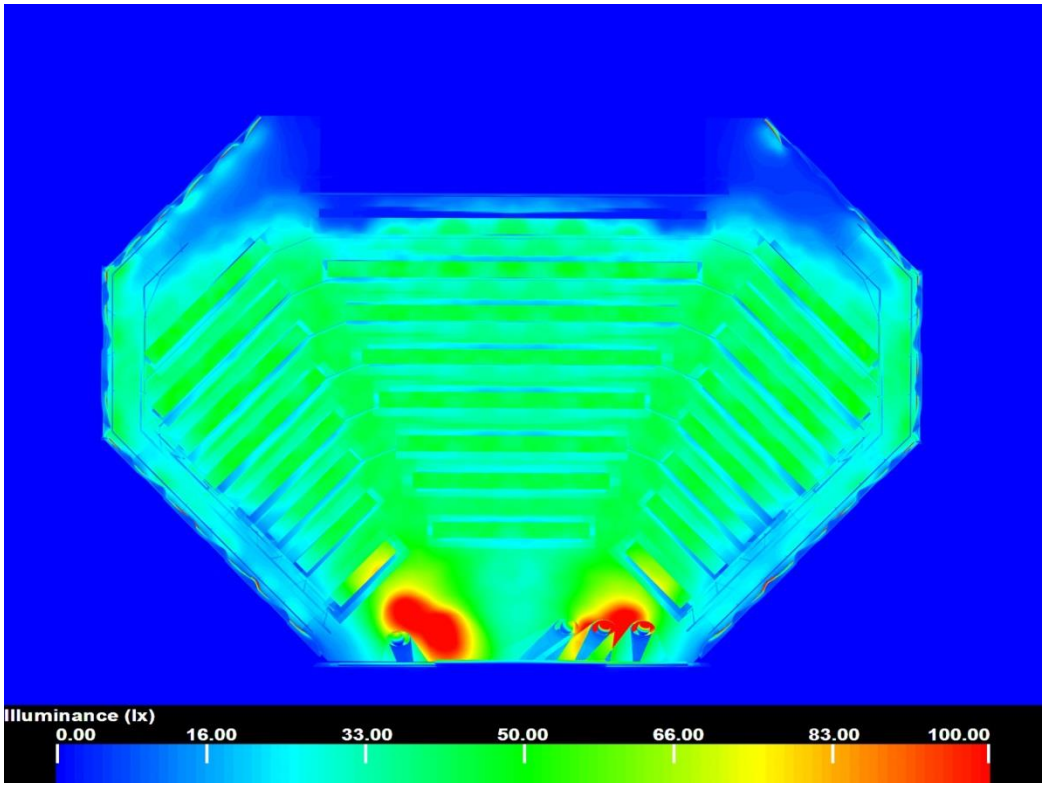


Fig 8: AV mode pseudo top view

QUANITATIVE COMPARISON

Here, the recommended illuminance levels, referencing the *IES Handbook*, are compared to the actual illuminance levels as found in the computer model. Light levels were calculated by studying a horizontal plane at the average desk to ceiling height, approximately 11'.

Illuminance (lux) - General Lighting - Audience		
Category	Recommended	Calculated
Avg. Maintained E_h	200	158
Avg. Maintained E_v (chalkboard)	400	258
Maximum E_h	--	165
Minimum E_h	--	148
Avg/Min E_h	2:1	1.07:1
Max/Min E_h	--	1.11:1

Illuminance (lux) - Presentation Lighting - Audience		
Category	Recommended	Calculated
Avg. Maintained E_h	50	48
Avg. Maintained E_v (Screen)	10	7.7
Maximum E_h	--	45
Minimum E_h	--	40
Avg/Min E_h	2:1	1.2
Max/Min E_h	--	1.13

Illuminance (lux) - General Lighting - Speaker		
Category	Recommended	Calculated
Avg. Maintained E_v	200	148

The following table compares the allowable energy consumption to the actual energy consumption as described by ASHRAE 90.1 – 2010 by the space-by-space method.

Energy Consumption (ASHRAE/IESNA 90.1 – 2010)		
Category	Allowable	Calculated
Area (SF)	-	3200
Input Wattage	3968	2158
Power Density (W/SF)	1.24	0.67

PERFORMANCE ANALYSIS

Overall, the current lighting design performs adequately in the lecture hall. The appropriate visual impression is created; however, with a LLF of 0.66 for LEDS, the recommended light levels (lux) are not met.

For a normal lighting scene, it is recommended the maintained average horizontal illuminance is 200 lux (for reading and writing). The existing overhead LEDs provide an average of 158 lux on the work surface. The tiered seating presents another challenge: the tables in the back are relatively brighter than the tables near the front of the room. In this way, the lighting is uniform across each table but not uniform across the entire room.

During a presentation mode, the direct LEDs are to be dimmed. The front wall-washers are switched off and the track lights dimmed. It is reasonably assumed that the perimeter wall washers are dimmed given the specified ballast. The flexibility of the current design meets the needs of the occupant. Light levels can be easily and effectively controlled to meet the IES recommendations for lighting the desk, speaker, and screen.

Direct glare is limited by mounting the over-head LED fixtures one inch above the finished custom ceiling. Additionally, the Kreon fixture has a 55° glare cutoff optic. Veiling reflections are effectively mitigated as a result of the mounting and distribution. The face of the speaker is modeled well using ideal lighting angles near 45° from nadir. Speakers are nearly illuminated to the recommended 200 lux average maintained vertically (average calculated at 148 lux). The chalkboard is not as bright as the IES recommends. However, the lighting is sufficient at an average of 258 lux. In general, lighting near the front of the room can be improved.

The ASHRAE 90.1 – 2010 Standards of 1.24 W/SF is met with a calculated load of 0.67 W/SF in this space. This is largely due to the use of improved LED technology and reliability. The efficient design corresponds to attainting LEED credit for minimum energy use and could potentially help maximize building energy efficiency. No daylighting is present in the space, yet ASHRAE Standards are addressed through the use of controls.

AREAS OF IMPROVEMENT

The current lighting design works well for its purpose. There is potential for a different overhead system that would increase task uniformity, making the room more open and comfortable. The irregular spacing of the custom ceiling panels presents an interesting challenge in the placement of lighting fixtures. Lighting near the front of the room

(southern end) could potentially be improved to provide more illumination on the chalkboard and speakers. Flexibility in the existing lighting design performs well; this concept will be carried through in the redesign of the lecture hall.

CIRCULATION SPACE – GROUND FLOOR LOBBY/LOUNGE

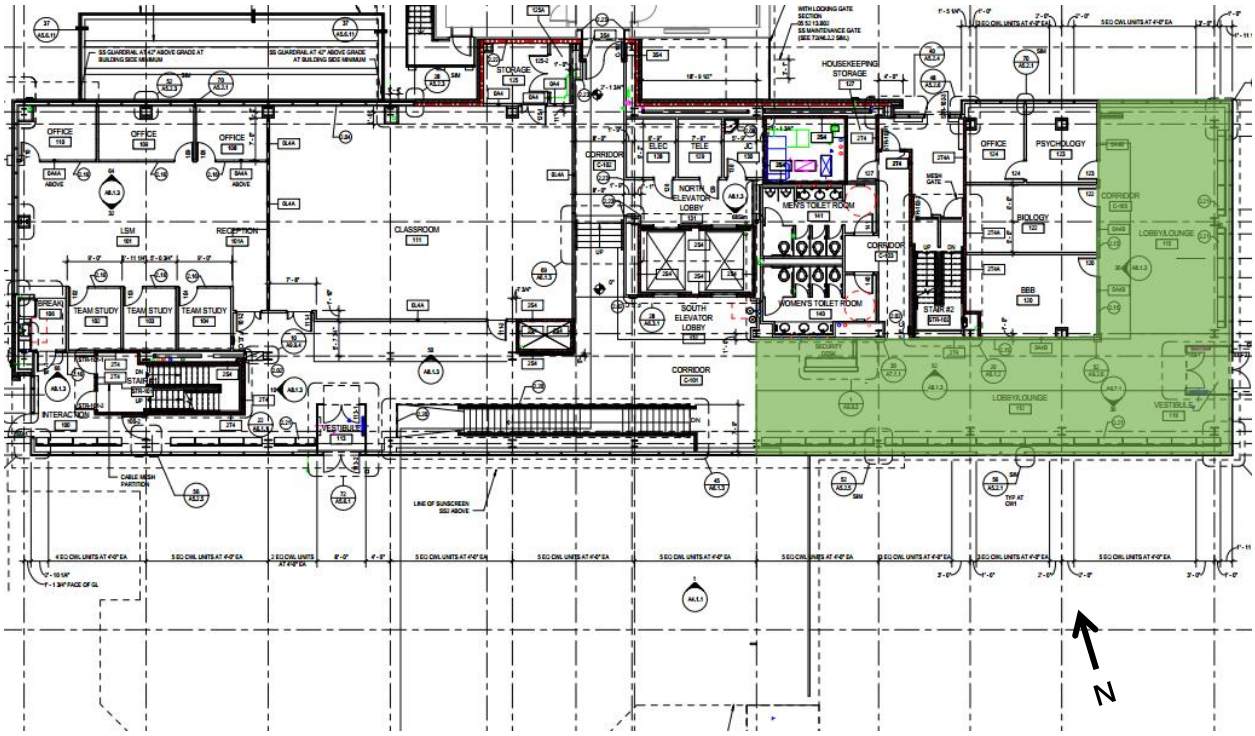
EXISITING CONDITIONS

The main L-shaped lobby and lounge is a welcoming space that is abundantly lit by daylight. The ceiling is kinetic in form and promises to provide opportunities for a unique lighting solution. It consists of a custom ceiling panel system with different sized perforations. The lower lobby consists of public seating as well a guard desk that faces south into the garden. Exterior vertical glazing spans from the floor to ceiling allowing for incredible views.

DIMENSIONS

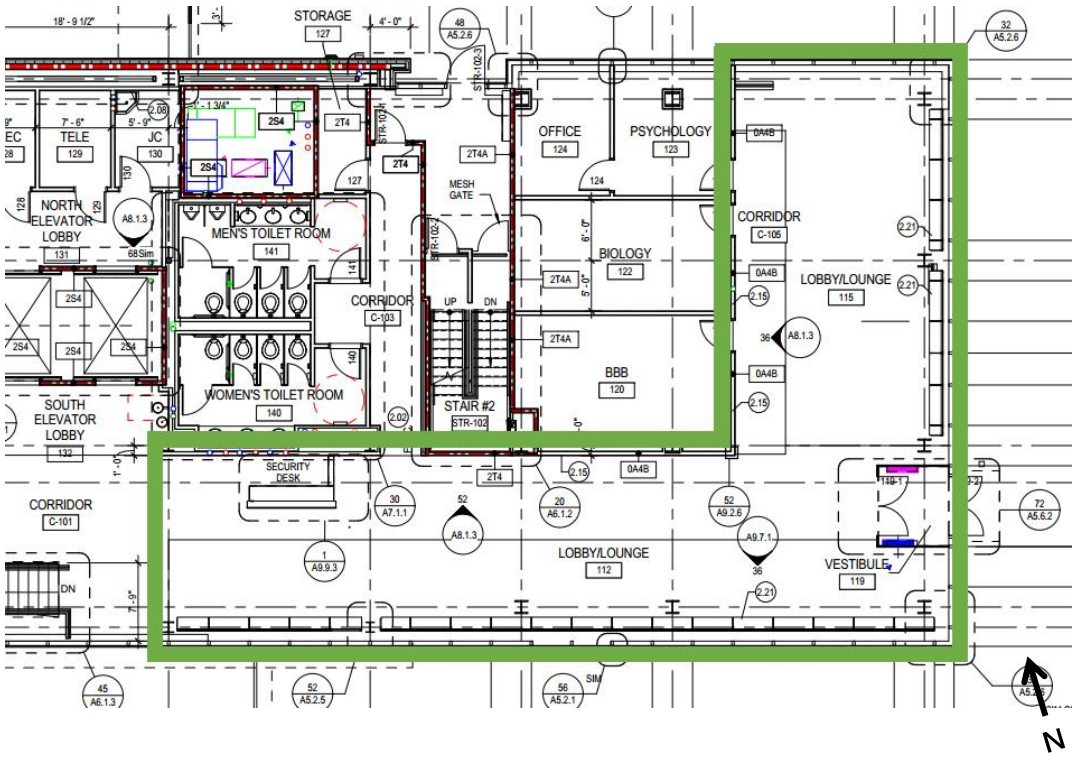
Area – 1180 ft^2.
Approximate width – 80 ft (L-shaped)
Approximate length – 60 ft (L-shaped)
Approximate ceiling height – 9’6”

FLOOR PLAN



Reference: Sheet A2.1

ENLARGED FLOOR PLAN



Reference: Sheet A2.1

NORTH-SOUTH SECTION

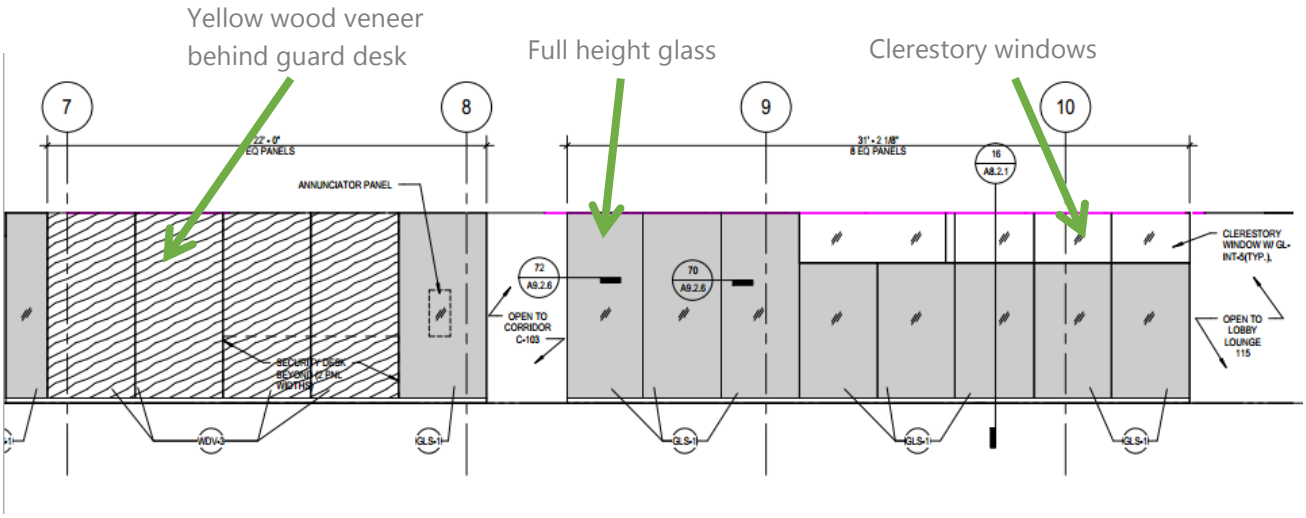
Reference: Sheet A4.2.1

FINISHES

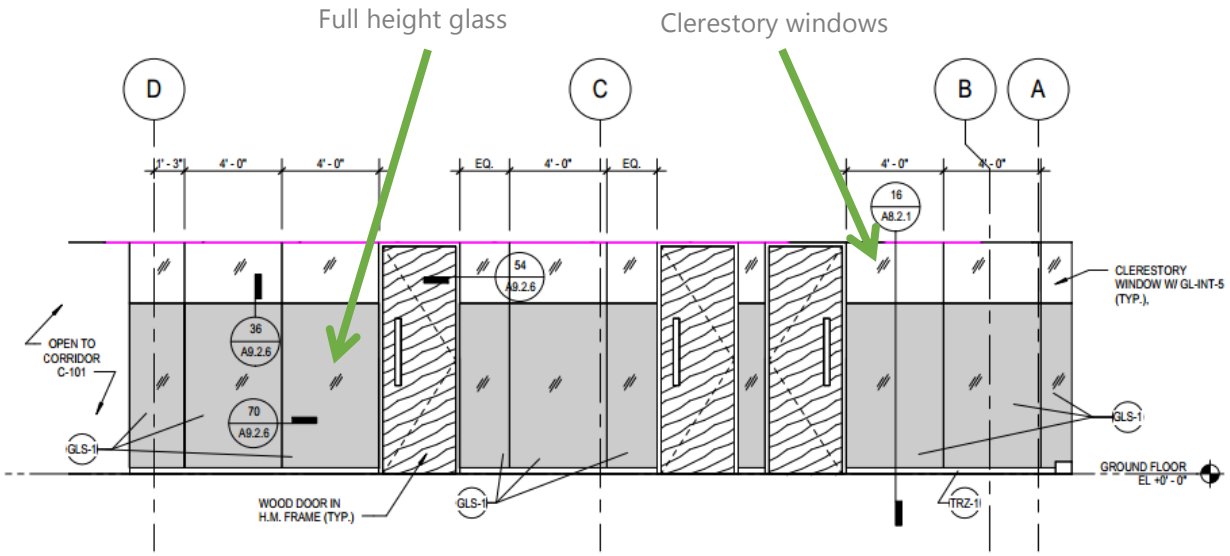
The ceiling consists of acoustic wood panels (2' x 4') with a grid of holes ranging from 1/2" to 2 1/2" in diameter. The interior walls are constructed of full height writable and magnetic glass (opaque glass backer). Like the furniture, the material reinforces collaboration in public spaces. Some interior walls of the lobby have laminated 65% clear clerestory windows for burrowing natural daylight.

A lighter terrazzo flooring material aids in daylight distribution deeper into the space. Behind the guard desk, there is a textured feature yellow wood wall.

INTERIOR ELEVATION (NORTH)



INTERIOR ELEVATION (WEST)



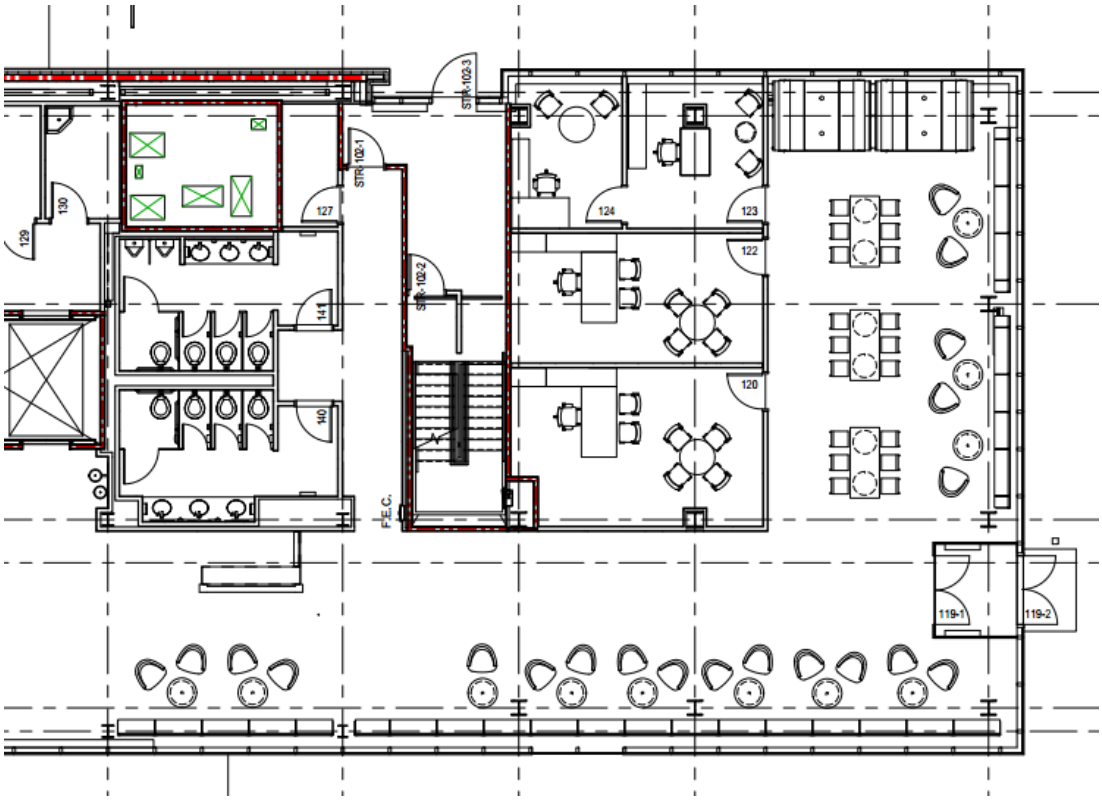
Lobby/Lounge Materials				
Surface	Material	Description	Style/Color	Reflectance (ρ)
Ceiling	AWC-1,2,3,4	Acoustical wood ceiling with varying grid of hole diameters	White oak wood	0.70
Walls	GLS/PNT-1/WDV3 and GL-INT-5	Ultra white, writable, magnetic glass, paint, clerestory windows, wood veneer feature wall	Glass, sea pearl white paint, yellow wood veneer	0.50*
Floor	TRZ-1	Terrazzo flooring	Pearl	0.30

*Reflectance averaged for materials; actual materials will exhibit varying values

GLAZING

Interior glass elements are described above. Exterior glazing on the ground floor is a 1" natural low-e insulated unit. This is typical on the south and east side. On the east side, at the main entrance vestibule, there is 1" natural low-e IGU with an imbedded custom digital image. The exterior glazing has a visibility of roughly 65%.

FURNITURE PLAN



Reference: Sheet AI2.1

FURNITURE/EQUIPMENT

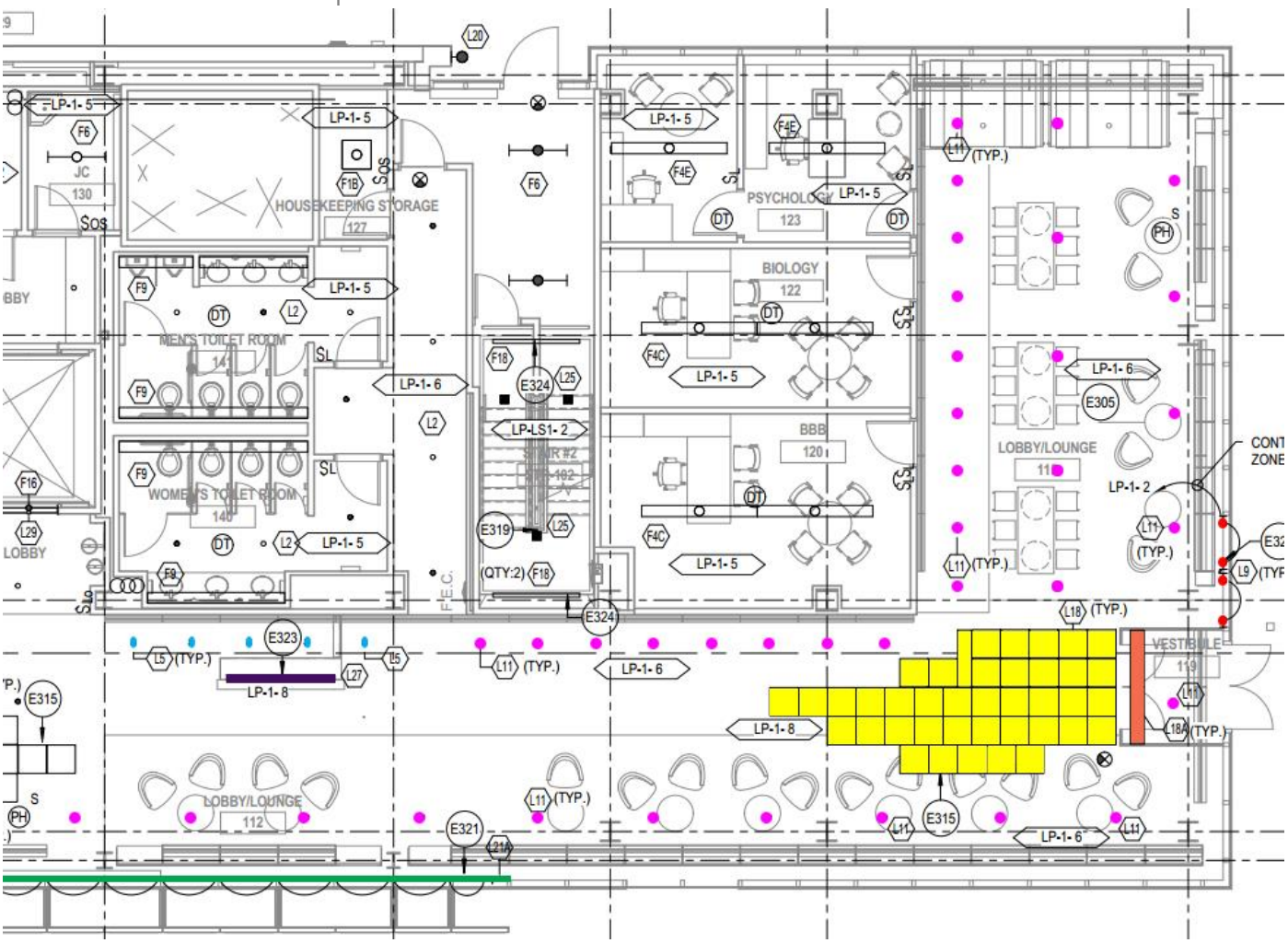
Public spaces are furnished as to promote community and public interaction between the users of the NSB Building. The seating is mobile and modern. As seen above, several loose chairs and coffee tables fill the space. Along the southern glazing, a wooden bench runs the length of the lobby. Additionally, larger tables with surrounding chairs are located in the eastern block of the space.

There is a special guard desk next to the elevator at the western end of the lobby. The lobby and lounge area have three 46" LED displays mounted on various interior walls (not seen in above furniture plan).

TASKS

Foremost, the lobby and lounge serve as an entrance space. Here, the ground floor lobby and lounge functions as a public transition space; since users will be orientating themselves to the NBS building, way-finding is an important activity. There may be some reading given the furniture plan. The guard desk introduces different tasks including reading, writing, and computer work.

EXISTING LIGHTING | REFLECTED CEILING PLAN



Reference: Sheet E3.1

Lobby/Lounge Existing Lighting								
Color	Type	Description	Manufac.	Model	Lamp	Mount	Input Watts	Voltage
	L5	Recessed lensed LED wall wash	Gotham	Evo Wallwash	LED, 1800 lm, 3500K	Recessed	18W	277 V
	L9	Linear LED with acrylic diffuse lens	LEDLinear	VarioLED Flex Hydra HD6	LED, 190 lm/ft, 3500K	Surface	1.8W/FT	277 V
	L11	Recessed 2" dia. LED downlight	Prescolite	D2	LED, 850 lm, 3500K	Recessed	20W	277 V
	L18	2' x 2' LED light panel	Corelite	Edgelit	LED, 2100 lm, 3500K	Pendant	24W	277 V

	L18A	1' x 4' LED light panel	Corelite	Edgelit	LED, 2100 lm, 3500K	Pendant	24W	277 V
	L21A	Linear LED	Ecosense	Linear Int LP	LED, 160 lm, 3500K	Surface	7W/FT	277 V
	L27	Edge lit LED light panel (96" x 32.5")	DLC	Lumisheet LED light panel	LED, 4100K	Surface	80W	277 V

The lobby/lounge area is fitted entirely with LED fixtures. In this way, the space is energy efficient and controllable. Functional lighting fixtures have dimming capabilities in response to ample amounts of natural light that enters the space. Although not always true, the mostly 3500K lighting installation would introduce some color uniformity.

VarioLED fixtures (L9) backlight the main entrance glazing with a custom digital print. The functional lighting is addressed by perimeter downlights (L11) and Corelite LED light panels mounted above the perforated ceiling in certain areas (L18). LED wall washers highlight the feature wall behind the guard desk while surface mounted LED strips (installed within an architectural extrusion) along the southern façade provide a soft brightness on the ceiling. These particular fixtures are classified as decorative. Above the guard desk are DLC LED edge lit light panels which provide task lighting for the guard.

CONTROLS/BALLASTS/DRIVERS

Since the current lighting solution is LED based, all the fixtures in this space require a driver. The wall washers and downlights have 0-10V dimming capabilities. As a result of the mounting conditions and location, the sign lighting and mullion mounted LED linear fixtures require remote drivers.

Lighting in the lobby is controlled by a programmed time schedule to ensure maximum energy savings. Linear LED (L21A) will turn on at sunset and off at 2 AM. Signage lighting (L9) will turn on at sunset and off and sunrise. The wall washers (L5) and downlights (L11) are programmed to respond to photocell sensors; when there is adequate daylight, these fixtures will turn off (including emergency lighting).

EMERGENCY LIGHTING

Besides emergency exit signs, several LED downlights serve as unswitched light fixtures connected to the emergency power system.

DESIGN CRITERIA/CONSIDERATIONS

QUALITATIVE CRITERIA

Very Important

- **Light Distribution on Task Plane**
  - During the day, recommended light levels (referencing the tenth edition IES handbook) will be met. At night, it is important that the electric lighting produces the recommended light levels for safety and architectural value.

- **Daylighting Integration and Controls**
  - The lobby and lounge receive ample daylight throughout the year; the lighting should effectively respond to daylight to maximum energy savings and improve the daylight quality in the space

- **Appearance of Space and Lighting Fixtures**
  - The entrance is the most public area in the building. The perforated ceiling introduces a dynamic element in the space. For these reasons, the lighting solution should reinforce the architectural details and render the materials appropriately. This will ensure a visually appealing entrance.

- **Occupant Orientation**
  - Way-finding is important so that occupants are comfortable in the space and can easily orient themselves to the building.

- **Direct Glare**
  - The southern orientation of the space and south-facing guard desk requires careful consideration to combat direct glare from sunlight.

Important

- **Accenting**
  - Architectural elements should be accented for aesthetic appeal.

- **Color Appearance and Color Contrast**
  - Aesthetically, the lighting should render colors of materials and users well so that space is naturally comfortable.

DESIRED PYSHCOLOGICAL IMPRESSION

As outlined by John Flynn and discussed by Gary Steffy, the goal of the redesigned lighting in the lobby and lounge is to ultimately encourage a public and relaxed impression on occupants.

QUANTITATIVE CRITERIA

Recommended Horizontal Illuminance – Important

- IES Classification | Common Applications
    - Transition spaces, lounges, social/waiting areas
        - Category J: 40 lux (4.0 fc), at ground
        - Avg/Min: 2:1
    - Transition spaces, lobbies, reading/work areas
        - Category N: 150 lux (15.0 fc)
        - Avg/Min: 2:1
    - Transition spaces, reception lobbies, desk top
        - Category N: 150 lux (15.0 fc)
        - Avg/Min: 4:1

Given the space type and function, uniformity is not critically important. Visually, a non-uniform lighting scheme will facilitate a hospitality-like environment; this could be beneficial since it is a lobby and lounge area meant to draw outside occupants in and likewise, impress the users upon entry. Recommended horizontal light levels are derived for effective way-finding and isolated desk work.

Recommended Vertical Illuminance - Important

- IES Classification | Common Applications
    - Transition spaces, lounges, social/waiting areas
        - Category J: 15 lux (1.5 fc), at ground
    - Transition spaces, reception lobbies, desk top
        - Category N: 50 lux (5.0 fc)
    - Transition spaces, reception lobbies, focal wall behind desk
        - 750 lux (75.0 fc), 5:1 focal-point-to-task illuminance ratio

It is important to model faces well for security purposes. In this regard, appropriate light distribution and fixture spacing should be utilized. One goal for the lighting should be to softly highlight the feature wall to create a visual edge and focal point.

Signage lighting is more concerned with luminance ratios than illuminance. In this sense, mock-ups or computer simulations modeling the custom glazing is recommended.

LEED-NC v4 Draft

EAp2: Minimum Energy Performance

- Comply with the mandatory and prescriptive provisions of ANSI/ASHRAE/IESNA Standard 90.01-2010.

EAc2: Optimize Energy Performance

- Reduce energy consumption of entire building by 6-42% to respectively receive 1-16 points.

EQc6: Interior Lighting

- For at least 90% of individual occupant spaces, provide individual lighting controls that enable occupants to adjust the lighting to suit their individual tasks and preferences with at least three lighting levels or scenes (on, off, midlevel).
    - For multi-zone spaces, include multi-zone control system readily available to occupant
- For entire project, use light sources with a CRI of 80 or higher
- For all regularly occupied spaces, use light fixtures with a luminance of less than 2,500 cd/m^2 between 45° and 90° from nadir.

EQc7: Daylight

- Demonstrate through annual computer simulations that spatial daylight autonomy$_{300/50\%}$ (sDA$_{300/50\%}$) of at least 55% is achieved for 2 points in regularly occupied spaces; 75% for 3 points

EQc8: Quality Views

- Achieve a direct line of sight to the outdoors via vision glazing for 75% of all regularly occupied floor area, no obstructed by frits, fibers, patterned glazing, or added tints.
    - 75% of all regularly occupied spaces must also have multiple lines of sight to vision glazing in different directions at least 90 apart.
    - Views must include a flora, fauna, or sky and objects at least 25 feet from the exterior of the glazing.

ENERGY ALLOWANCES

According to ASHRAE Standard 90.1 version 2010 (most recent version upon completion of thesis) space-by-space method, a lobby has an allowed wattage of 0.90 W/SF.

Energy Allowance (ASHRAE 90.1 – 2010)			
Space	Area (SF)	W/SF	Allowed Wattage
Lobby	1180	0.90	1062 W

ASHRAE 2010 STANDARDS

Reference pages 13-14 of this document.

DESIGN CRITERIA PRIORITIZED

1. Meet ASHRAE Energy Code requirements
2. Implement daylighting strategies and controls to optimize energy efficiency
3. Create a visually appealing space for users inside the lobby and viewers outside the building
4. Meet IES recommendations for light levels in transition space/lobby
5. Provide for way-finding and occupant orientation through lighting in conjunction with materials and interior planning
6. Meet LEED requirements for lighting controls and minimum energy requirements

EVALUATION

VISUAL IMPRESSION CREATED BY LIGHTING SOLUTION

The present lobby/lounge lighting solution is visually unobtrusive—fixtures are small and hidden within the architecture. The full height glazing allows for an interesting view into the lobby and lounge from the south and east. Downlights light perimeter vertical surfaces to reinforce spatial boundaries; perimeter surface mounted LED strips softly illuminate the ceiling along the southern facade. From the outside, this concept visually creates a glowing box on which the rest of the building sits. The building appears to float on the lobby as light from the inside spills out onto the surrounding site. By keeping direct light away from the center of the lobby, one would feel relaxed in the public setting. The appropriate architectural elements are highlighted: the signage glazing near the entrance vestibule, wall behind the guard desk, and ceiling perforations.

QUANITATIVE COMPARISON

Lighting Fixtures Used				
Type	Lamp	Qty. of fixtures	Input Wattage (W)	Total Wattage (W)
L5	LED, 1800 lm, 3500K	5	18W	90
L9*	LED, 190 lm/ft, 3500K	4 (8' each)	1.8W/FT	57.6
L11	LED, 850 lm, 3500K	37	20W	740

L18*	LED, 2100 lm, 3500K	39	24W	936
L18A	LED, 2100 lm, 3500K	1	24W	24
L21A*	LED, 160 lm, 3500K	10 (8' each)	7W/FT	560
L27	LED, 4100K	1	80W	80

*Considered decorative lighting (1W/SF)

The following table compares the allowable energy consumption to the actual energy consumption as described by ASHRAE 90.1 – 2010 by the space-by-space method.

Energy Consumption (ASHRAE/IESNA 90.1 – 2010)		
Category	Allowable	Calculated
Area (SF)	-	1180
Input Wattage	1062	934
Power Density (W/SF)	0.90	0.79

To meet code, it is inferred that the LED light panels above the ceiling (L18) and signage LED strips (L9) are decorative. The architectural extrusion LED strips run the length of the entire southern corridor. Since the space studied only includes a couple of these fixtures, they were excluded from the LPD calculation.

PERFORMANCE ANALYSIS

Currently, the lighting solution is simple yet effective. Functionally, way-finding is achieved by lighting the feature wall behind the guard desk. The perforated ceiling is backlit with LED panels in areas with biggest perforations—this reflects the occupants' travel patterns and area of congestion. Occupant orientation is again reinforced. Glare is minimized by the choice and placement of fixtures.

ASHRAE 90.1 – 2010 Standards are met in the lobby and lounge. By implementing photocells and LED dimming in response to daylight, the solution becomes energy efficient. A sustainable solution is able to provide appropriate light levels while maintaining the architectural integrity of the interior. The efficient design corresponds to attainting LEED credit for minimum energy use and could potentially aid in the LEED credit for maximizing building energy efficiency. LEED credits for daylighting and views are also applicable.

AREAS OF IMPROVEMENT

A more expressive or abstract lighting solution could benefit the space. It is equally important, however, that visual clutter is minimized. Perhaps something can be done in relation to the perforated ceiling that would reinforce the conceptual design and identify the lobby as a piece of art. A relatively non-uniform lighting approach can

make the space feel like a higher-end lobby. Instead of placing downlights in the ceiling, linear fixtures or indirect lighting could mitigate potential glare issues and avoid unwanted scalloping on the interior walls.

Daylighting plays an important role in the lobby and lounge. The current control scheme is effective and should be implemented in the redesign. If possible, more electrical lighting should be controlled this way to produce an even more energy efficient building. Views to the exterior should be maximized not only during the day but also at night.

LARGE WORKSPACE SPACE – GROUND FLOOR CLASSROOM

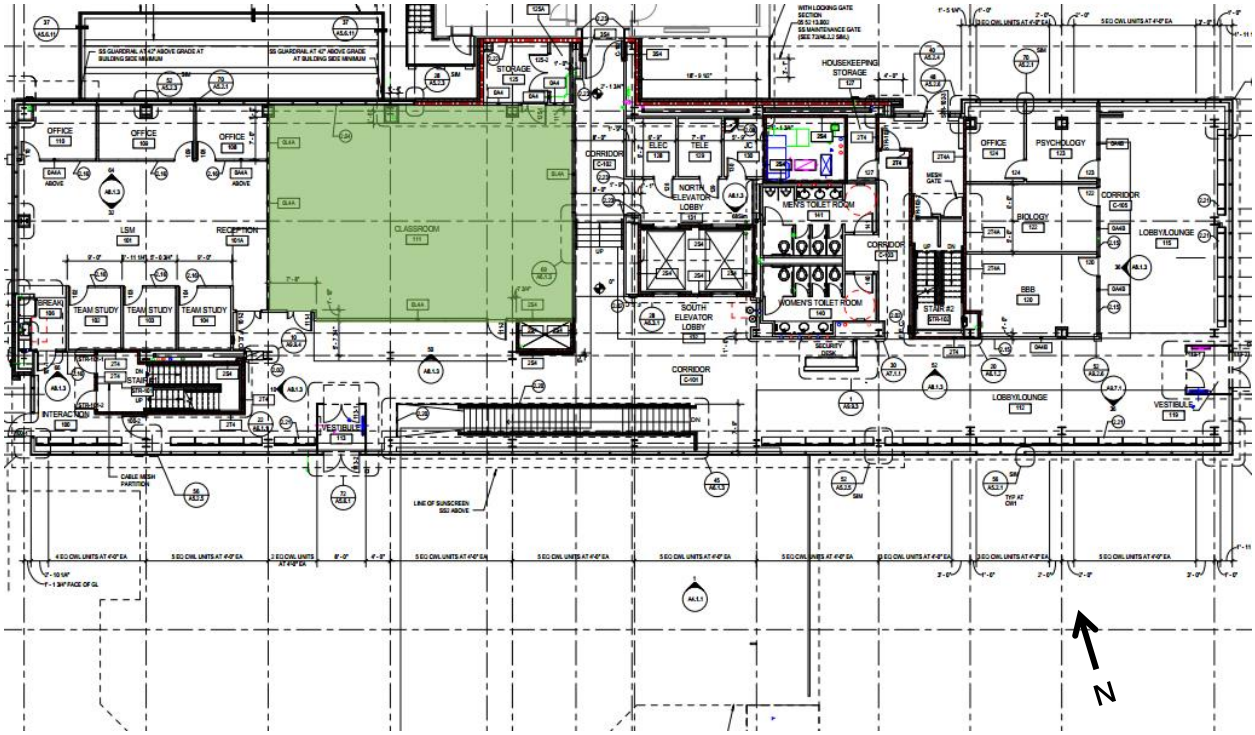
EXISITING CONDITIONS

On the ground floor, a large classroom is arranged to inspire collaboration and teamwork. Learning in this classroom is interactive. The interior design is relatively simple and uncluttered. Northern windows allow for potentially good diffuse daylighting. Several televisions and projector screens surround the classroom.

DIMENSIONS

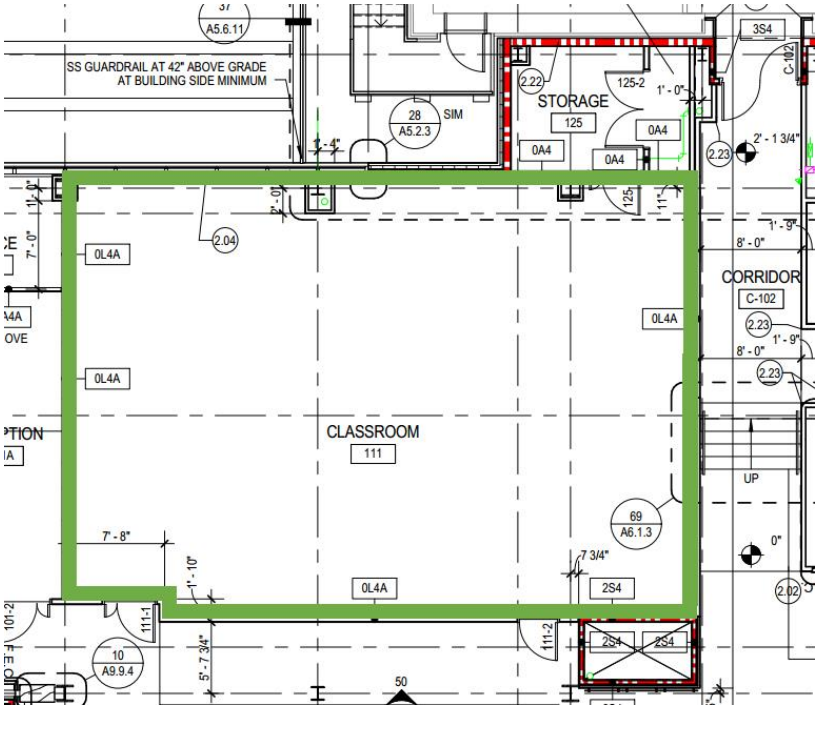
Area – 1700 ft^2.
Approx. width – 50 ft
Approx. length – 34 ft
Approx. ceiling height – 9'6"

FLOOR PLAN



Reference: Sheet A2.1

ENLARGED FLOOR PLAN



Reference: Sheet A2.1

NORTH-SOUTH SECTION

Reference: Sheet A4.2.1

FINISHES

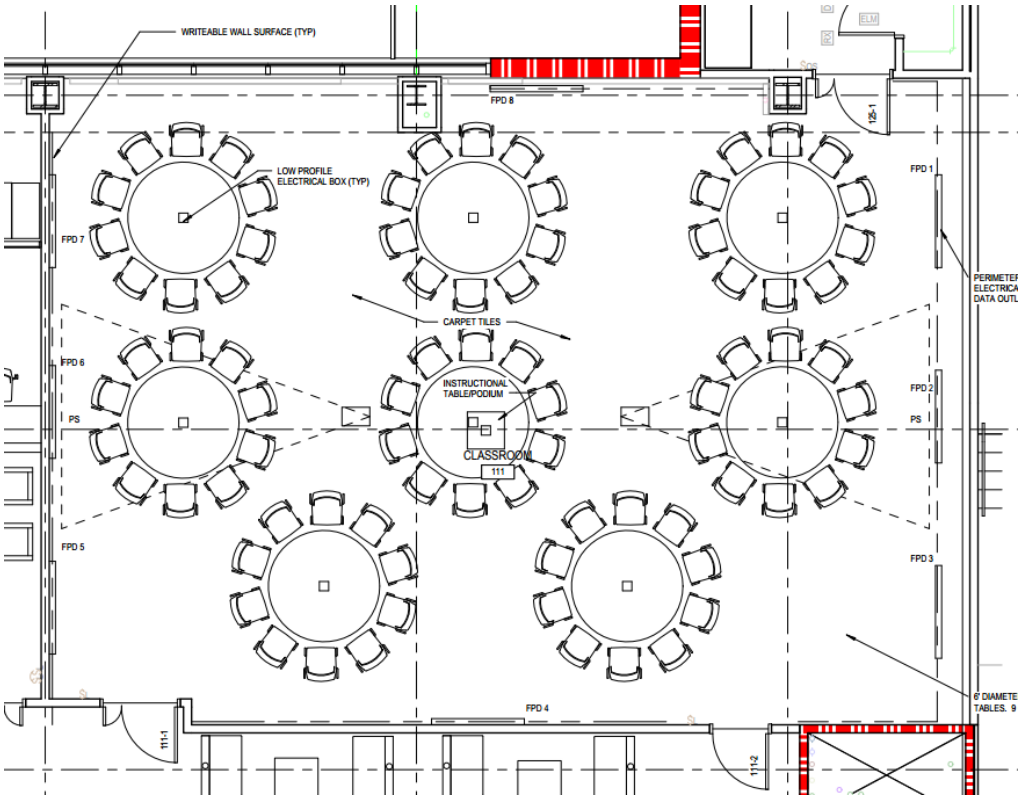
Typical acoustic ceiling tile spans the classroom. Walls are painted a slightly off-white color and are writable. This eliminates the need for a chalkboard/whiteboard. The carpet is a variation of three carpet tile colors that are placed and patterned so that stripes alternate between dark gray and green.

Classroom Materials				
Surface	Material	Description	Style/Color	Reflectance (ρ)
Ceiling	ACT-2	Acoustic ceiling tile	White acoustic tile	0.80
Walls	PNT-1	Painted gypsum walls	Sea Pearl	0.50
Floor	CPTT-3,4,5	Three variations of carpet tile	Stone, Ivy/Stone, Ivy	0.25

GLAZING

There are only northern facing windows in this classroom. The windows are 1" natural low-e clear insulated glazing units with 62% visibility. The glazing has a 2.14 light to solar gain ratio (LSG).

FURNITURE PLAN



Reference: Sheet AQ2.1.1A

FURNITURE/EQUIPMENT

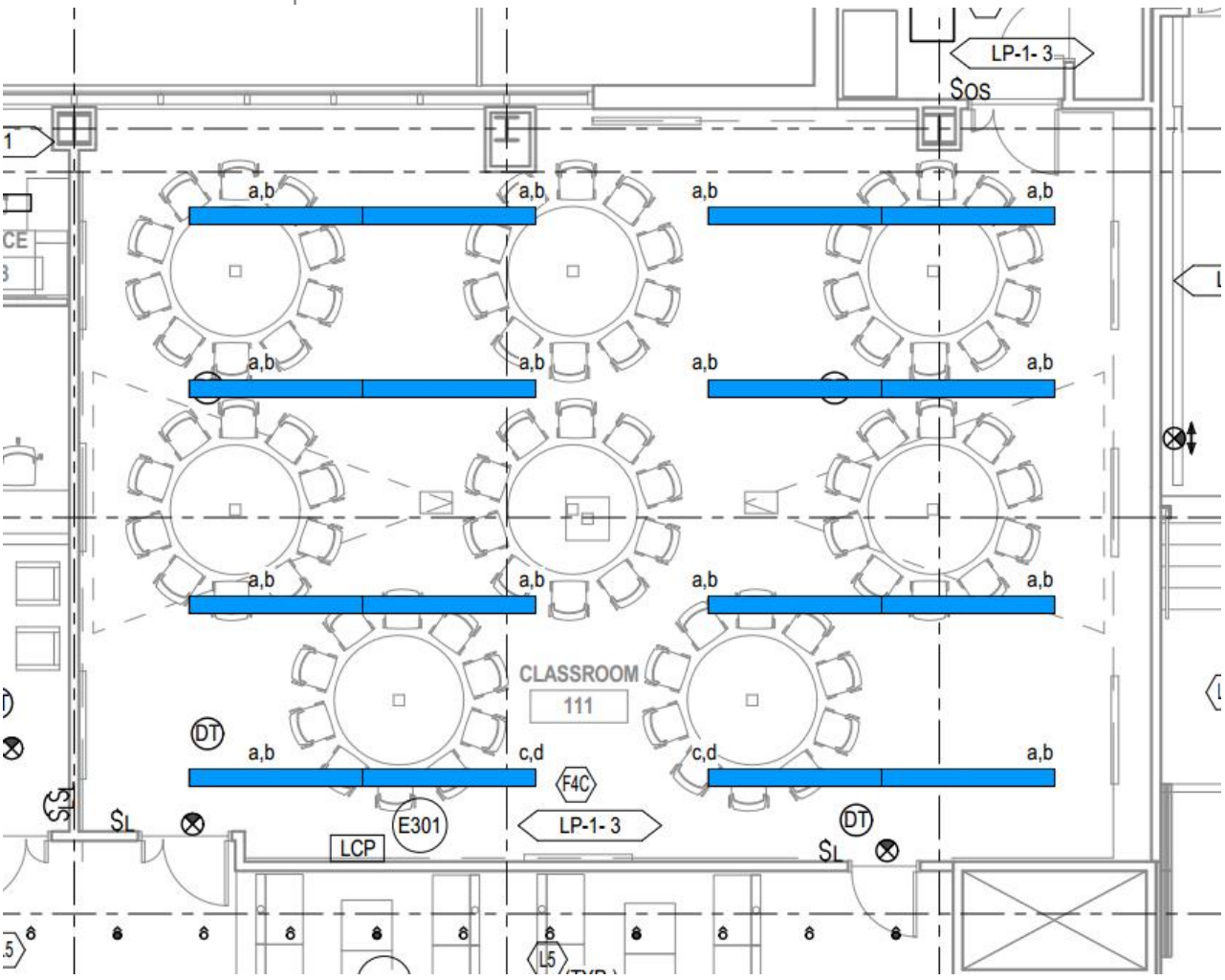
Collaborative and interactive spaces serve as inspiration for the furniture selection. Currently, eight large tables with mobile seating fill the majority of space. A lecture

podium is to be placed in the center of the room. Eight televisions are mounted on the walls. The east, west, and south walls each have one roll-away projection screen and corresponding projector.

TASKS

The classroom is meant to be flexible and used often for A/V presentations (projector and televisions). Reading and writing is an important task that requires comfortable and appropriate lighting. Computer use is probable.

EXISTING LIGHTING | REFLECTED CEILING PLAN



Reference: Sheet E3.1

Classroom Existing Lighting								
Color	Type	Description	Manufac.	Model	Lamp	Mount	Input Watts	Voltage
	F4C	8' low profile direct/indirect fluorescent pendant	Peerless	Bruno	(2) 28W T8 in cross section	Pendant	96W	277 V

Sixteen suspended direct/indirect fluorescent fixtures illuminate the room. Each fixture is 8' in nominal length. The varying functions of the space facilitate a lighting controls system that creates several lighting modes.

CONTROLS/BALLASTS/DRIVERS

Standard T8 ballasts are used. The room is controlled by a Creston iLUX Master Control product; a lighting control panel is mounted on the southern wall. This panel has five different scenes: lights on, lights off, a low light level, medium light level, high light level, and A/V mode. Another control panel controls the window shades. The different scenes affect both the lighting and shades. There are two dual technology sensors upon entry of the classroom. These sensors control the overhead lighting, effectively addressing ASHRAE standards.

EMERGENCY LIGHTING

No emergency lighting in classroom.

DESIGN CRITERIA/CONSIDERATIONS

QUALITATIVE CRITERIA

Very Important

- **Light Distribution on Task Plane**
  - Being this is a classroom, uniform and appropriate light levels are of high importance.

- **Direct Glare**
  - The collaborative set up of the space introduces multiple viewing directions. This presents a challenge when controlling direct glare which could be uncomfortable to the users in the space, negatively effecting user productivity and retentiveness.

- **Lighting Controls**
  - Several scenes of lighting are required to ensure proper light levels when performing a variety of tasks. At a minimum, the lighting controls and

fixtures should be flexible and responsive enough to allow for a general light setting and an A/V presentation setting.

Important

- **Appearance of Space and Lighting Fixtures**
  - Since people will be utilizing the classroom readily, it is important to consider what the fixtures will look like. The architecture is relatively simple and typical of a classroom. In this way, lighting can either work in harmony with the space or create visual clutter.

- **Daylighting Integration and Controls**
  - The only daylight apertures are located to the north of the classroom. Shading and daylight controls should be considered for user comfort, especially during an A/V presentation when the room generally needs to be darker.

DESIRED PYSHCOLOGICAL IMPRESSION

As outlined by John Flynn and discussed by Gary Steffy, the goal of the redesigned lighting in the classroom is to introduce a public environment.

QUANTITATIVE CRITERIA

Recommended Horizontal Illuminance – Very Important

- IES Classification | Education
  - Reading and Writing, print media, 12-pt font
    - Category O: 200 lux (20.0 fc), at desk top
    - Avg/Min: 2:1
  - Classrooms, general classrooms, learning/teaching, AV
    - Category K: 50 lux (5.0 fc), at desk top
    - Avg/Min: 2:1

Most importantly, horizontal average maintained light levels should be met for reading/writing and AV presentations. Uniformity is also critical in a work space where movement and collaboration will occur. A uniform lighting design will create a comfortable and productive environment.

Recommended Vertical Illuminance - Important

- IES Classification | Education
    - Reading and Writing, print media, 12-pt font
        - Category O: 50 lux (5.0 fc)
        - Avg/Min: 2:1
    - Classrooms, general classrooms, learning/teaching, AV
        - Category K: 30 lux (3.0 fc)
        - Avg/Min: 2:1

Reasonably, vertical illuminance is most important during an A/V presentation. Higher luminance ratios ensure that the projector screen or television is easy to see and read. The lighting solution should attempt to diminish the cave-effect; hereby, controlled vertical illumination of the walls is an important criterion.

LEED-NC v4 Draft

EAp2: Minimum Energy Performance

- Comply with the mandatory and prescriptive provisions of ANSI/ASHRAE/IESNA Standard 90.01-2010.

EAc2: Optimize Energy Performance

- Reduce energy consumption of entire building by 6-42% to respectively receive 1-16 points.

EQc6: Interior Lighting

- For at least 90% of individual occupant spaces, provide individual lighting controls that enable occupants to adjust the lighting to suit their individual tasks and preferences with at least three lighting levels or scenes (on, off, midlevel).
    - For multi-zone spaces, include multi-zone control system readily available to occupant
- For entire project, use light sources with a CRI of 80 or higher
- For all regularly occupied spaces, use light fixtures with a luminance of less than 2,500 cd/m^2 between 45° and 90° from nadir.

ENERGY ALLOWANCES

According to ASHRAE Standard 90.1 version 2010 (most recent version upon completion of thesis) space-by-space method, a classroom has an allowed wattage of 1.24 W/SF.

Energy Allowance (ASHRAE 90.1 – 2010)			
Space	Area (SF)	W/SF	Allowed Wattage
Classroom	1700	1.24	2108 W

ASHRAE 2010 STANDARDS

Reference pages 13-14 of this document.

DESIGN CRITERIA PRIORITIZED

1. Meet ASHRAE Energy Code requirements
2. Provide sufficient light levels and uniformity for reading/writing/presentations
3. Create visually open and public environment
4. Implement shading and daylight controls for improved visual quality
5. Meet LEED requirements for lighting controls and minimum energy requirements

EVALUATION

VISUAL IMPRESSION CREATED BY LIGHTING SOLUTION

Like many classrooms, this classroom's lighting solution is uniform and implies openness. The lighter materials make the room visually large. Indirectly lighting the ceiling reduces the fixture glare due to minimizing luminance contrast ratios. Indirect lighting reinforces a public Flynn mode and makes an occupant feel welcomed into the space. Emotionally, the space feels productive, lively, and comfortable.

METHOD/PROCESS

Here, the same method/process as lecture hall is used.

MODEL INPUTS

The table below outlines the fixture types placed in the space along with the appropriate lamps, quantity of lamps per fixture type, quantity of fixtures, and the corresponding wattage consumed by the fixtures.

Lighting Fixtures Used				
Type	Lamp	Qty. of fixtures	Input Wattage (W)	Total Wattage (W)
F4C	(2) 28W T8	16	96	1536

The following table describes the applicable light loss factors applied to the existing lighting fixtures.

Light Loss Factors						
Type	Lamp Lumens		LLD	LDD	BF	Total
	Initial	Mean				
F4C	2725	2590	0.95	0.94	0.88	0.79

RENDERINGS

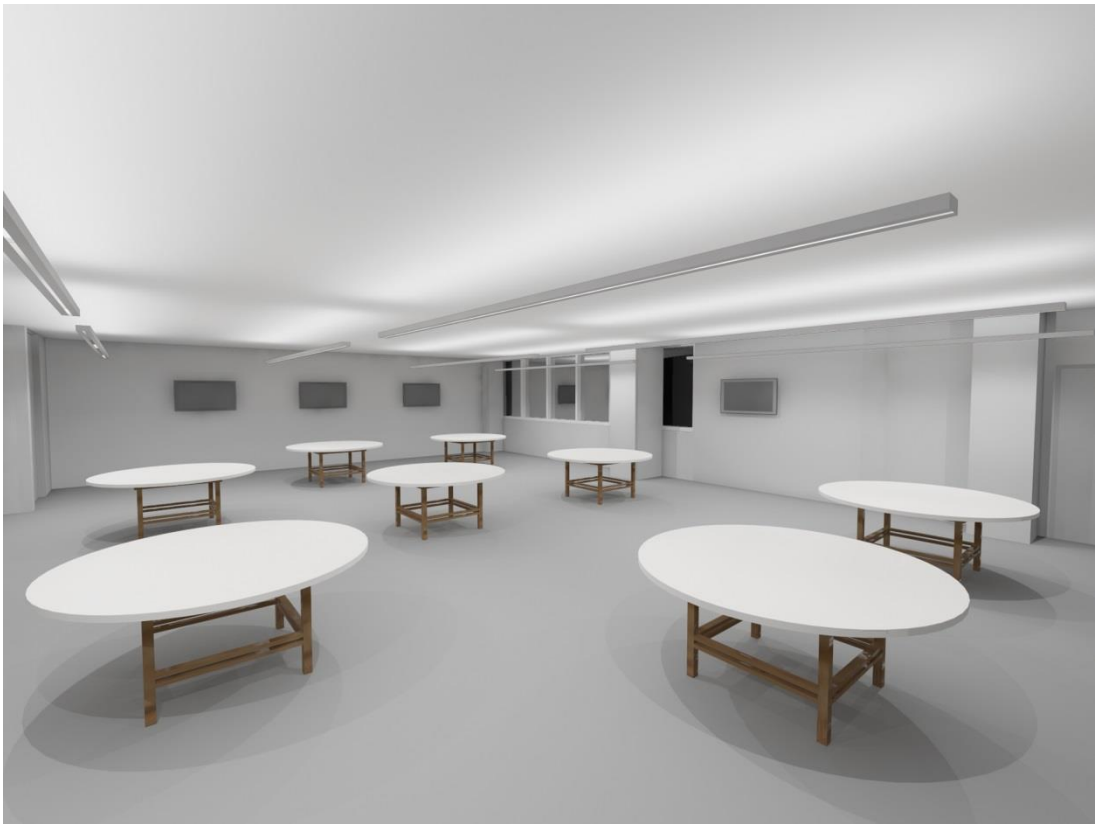


Fig 9: Task lighting scene render perspective

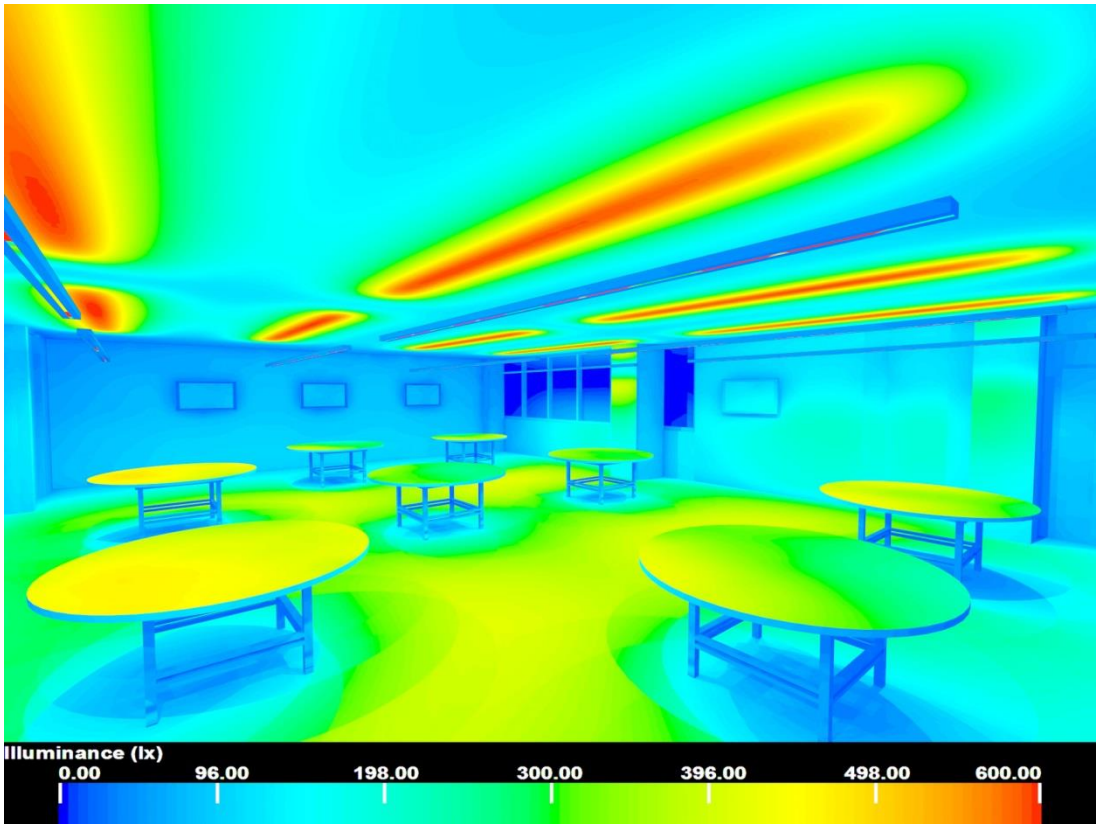


Fig 10: Task lighting scene pseudo perspective

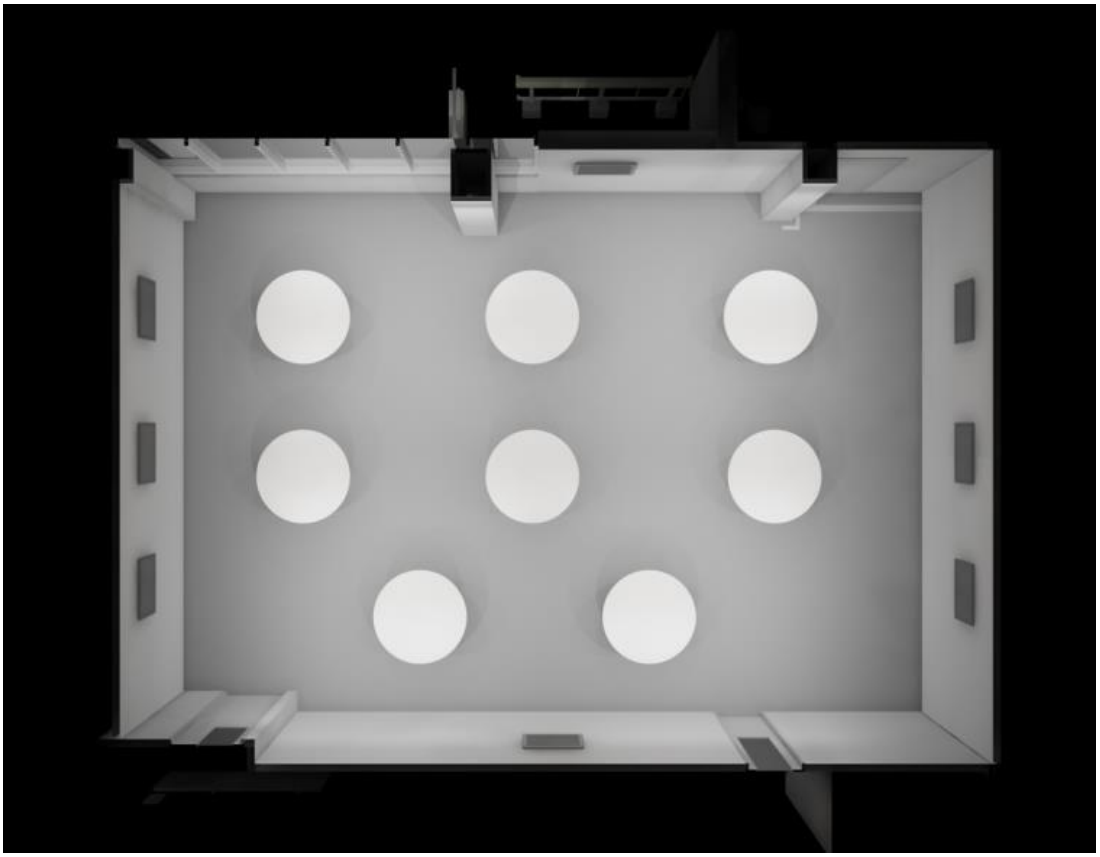


Fig 11: Task lighting render top view

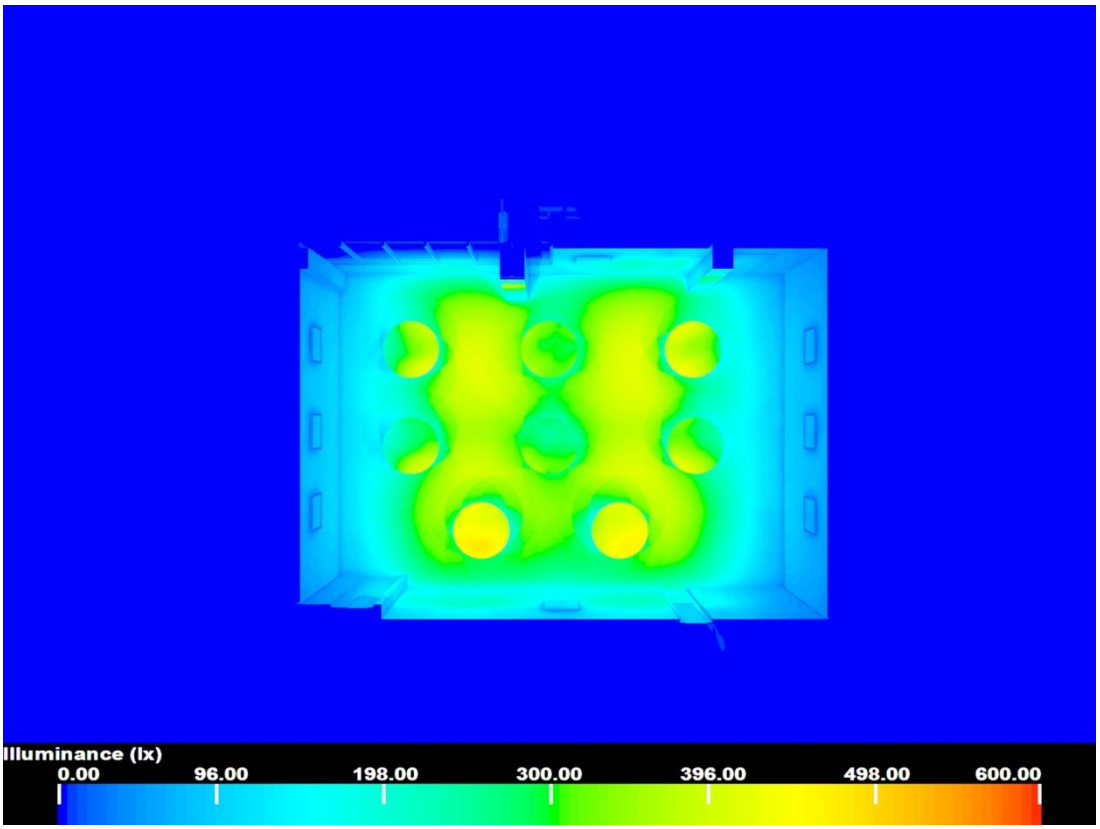


Fig 12: Task lighting pseudo top view

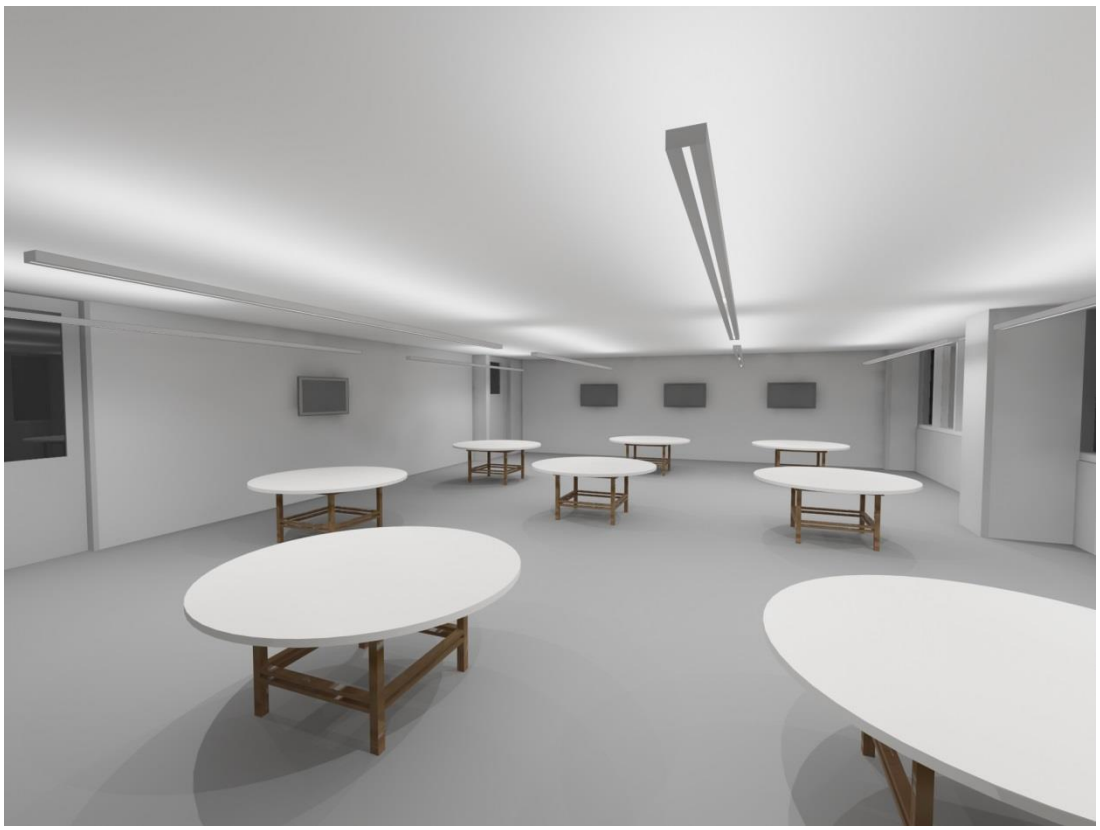


Fig 13: AV mode render perspective

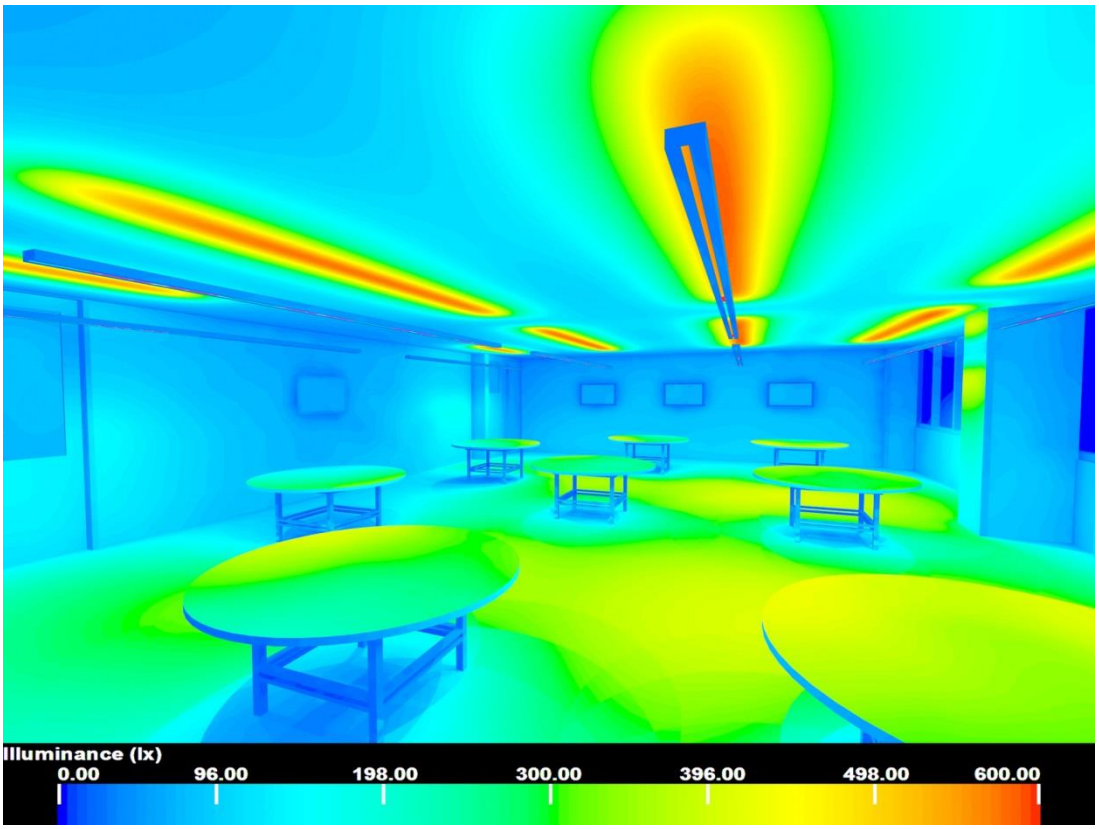


Fig 14: AV mode pseudo perspective

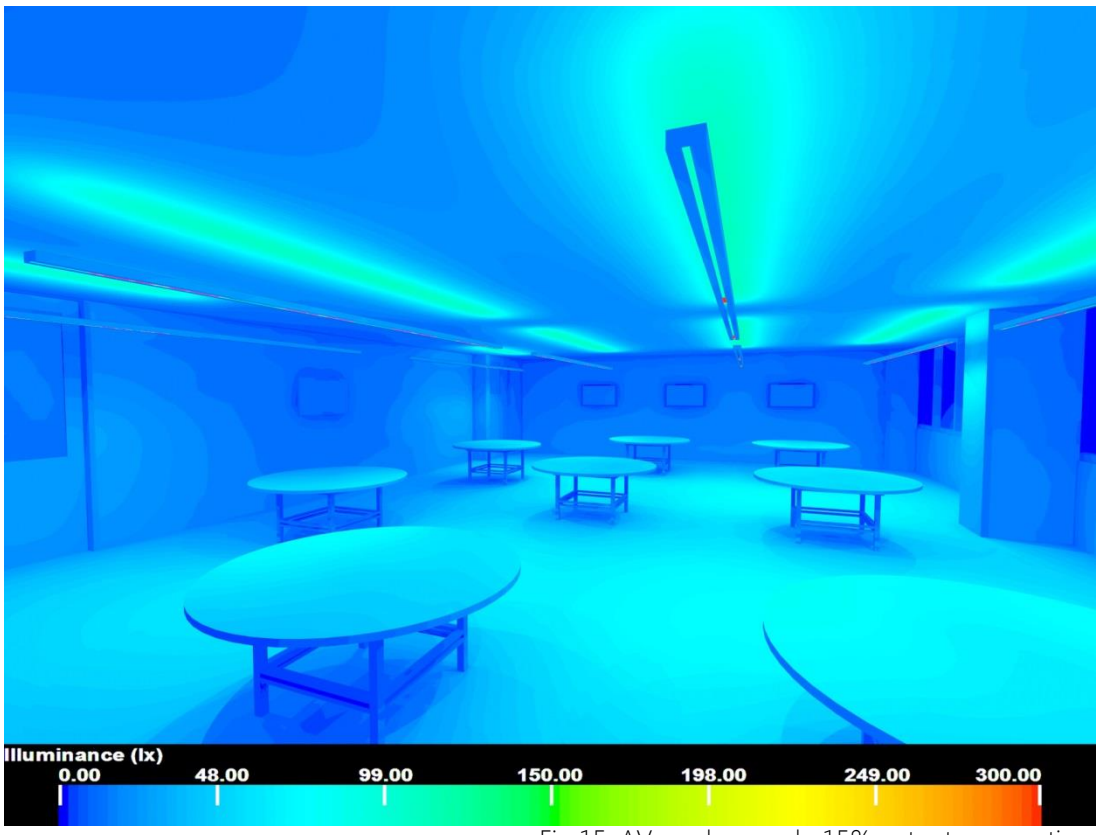


Fig 15: AV mode pseudo 15% output perspective

QUANITATIVE COMPARISON

Here, the recommended illuminance levels, referencing the *IES Handbook*, are compared to the actual illuminance levels as found in the computer model. A horizontal calculation plane was set at desk height for computing the averages.

Illuminance (lux) - General Lighting		
Category	Recommended	Calculated
Avg. Maintained E_h	200	280
Maximum E_h	--	385
Minimum E_h	--	235
Avg/Min E_h	2:1	1.19:1
Max/Min E_h	--	1.64:1

Illuminance (lux) – A/V Presentation Lighting		
Category	Recommended	Calculated
Avg. Maintained E_h	50	280*
Maximum E_h	--	334
Minimum E_h	--	230
Avg/Min E_h	2:1	1.21:1
Max/Min E_h	--	1.45:1

*The A/V scene specifies to turn off two fixtures near the south side of the room; however, it does not specify the output of the remaining fixtures. It was assumed that these are dimmable. With this assumption, the remaining pendants were dimmed to 15% light output to achieve IES recommendation.

Illuminance (lux) – All Lighting Zones On		
Category	Recommended	Calculated
Avg. Maintained E_h	200	560

The following table compares the allowable energy consumption to the actual energy consumption as described by ASHRAE 90.1 – 2010 by the space-by-space method.

Energy Consumption (ASHRAE/IESNA 90.1 – 2010)		
Category	Allowable	Calculated
Area (SF)	-	1700
Input Wattage	2108	1536
Power Density (W/SF)	1.24	0.90

PERFORMANCE ANALYSIS

Calculated current lighting in the classroom is too bright. The illuminance levels are considerably higher than the IES recommendations for reading and writing. Moreover, the A/V scene could be improved. Although two fixtures are switched off—so that users can see the southern television screen better—the remaining fixtures stay on. The average across the desks in the AV setting is approximately 250 lux if not dimmed. To meet IES recommendations, the remaining fixtures need to be dimmed to 15% output. Finally, with all the lamps on (high light scene), the room is really bright. An average of approximately 560 lux was calculated on the desks.

Regardless, lighting in the classroom is relatively uniform. The direct component of the fixtures and orientation creates some non-uniformity: some desks appear to have higher light levels than others. The cave-like effect is minimized by using direct-indirect fixtures. Glare is less concerning due to the optics of the fixture and photometric distribution (lower candela values at higher angles).

The current fluorescent system meets ASHRAE 90.1 – 2010 Standards of 1.24 W/SF. The calculated load is 0.90 W/SF. T8 lamps have general good light output to input power ratios. Relatively higher reflectance values in the space help to distribute light throughout the area of coverage. ASHRAE standards are further addressed by the control system. Methods implemented include dual technology sensors and auto-on to 50% output.

AREAS OF IMPROVEMENT

Improvement of the current lighting system focuses on producing appropriate light levels. Direct/indirect pendants are appropriate for the space; however, lower light levels could potentially yield more energy savings given how bright the space is currently. On the same note, the lighting control system can be improved to optimize viewing conditions for A/V presentations. A dimming system will make viewing presentations easier and more energy efficient.

A more uniform lighting design is desirable. A fixture with more indirect output would diffusely spread light throughout the room. Importantly, unwanted hotspots on the ceiling or pools of light should be a visual consideration. Although more of an architectural change, daylighting could be made more useful in this space. Relocating or increasing the window size could address this issue. Note, this could adversely affect the mechanical loads and would require analysis.

OUTDOOR SPACE – SOUTHERN FAÇADE AND SITE

EXISITING CONDITIONS

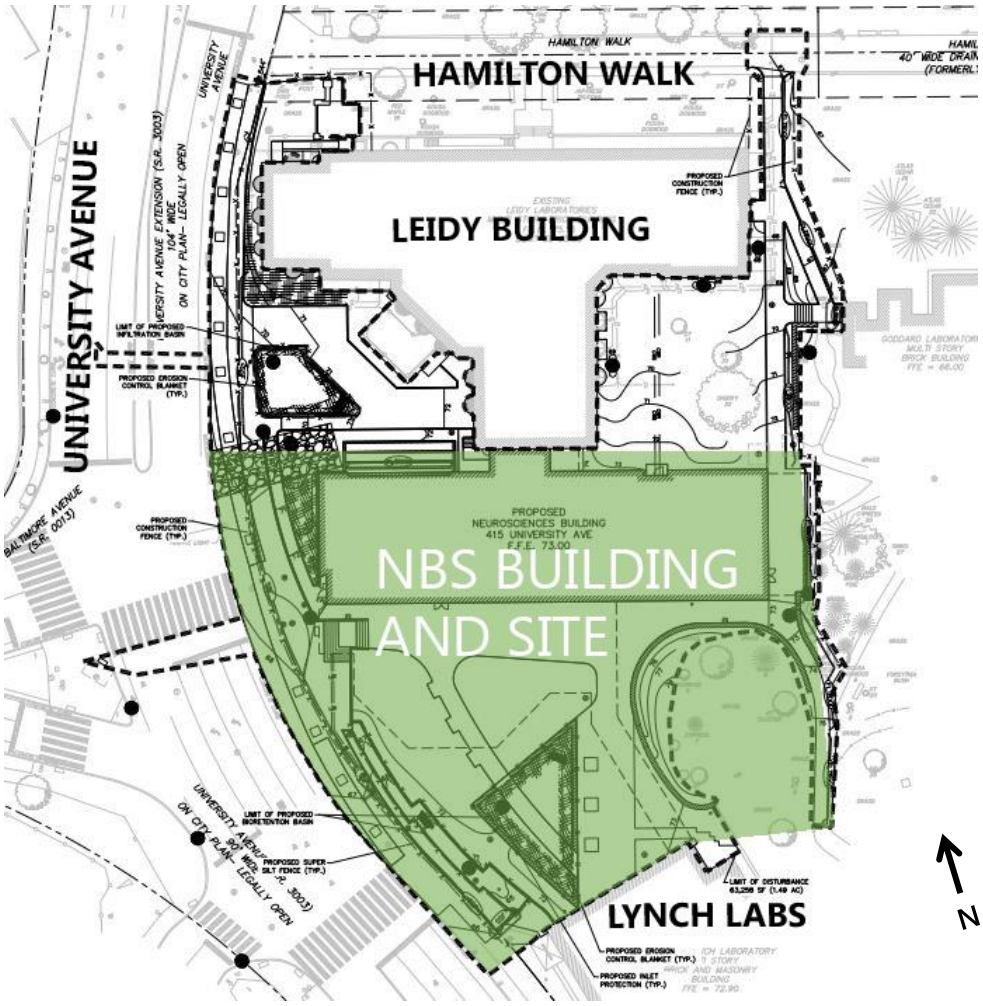
The scrim on the southern wall is a recognizable architectural feature that strongly impacts the architectural concept. Visually, the sunscreen appears to be growing, stretching the aluminum openings into irregular and organic shapes. The scrim spans across the majority of the southern façade, floating above the ground floor.

Large areas of glazing and metal panels render the building modern and transparent. The surrounding site consists of various plantings and bluestone pavers. On the east, the building cantilevers over a pedestrian walk way. Below, the entire site will be discussed; however, the lighting redesign will focus on the southern façade and site.

DIMENSIONS

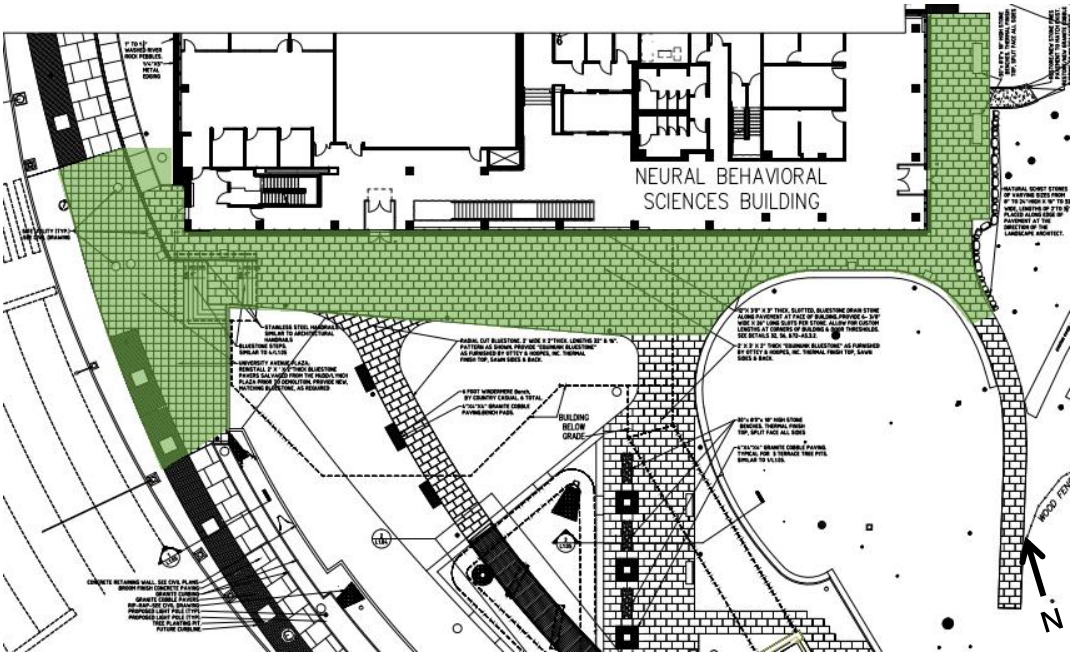
Building grounds area – 39000 ft^2
Approximate scrim width – 140 ft
Approximate scrim height – 48 ft

SITE PLAN



Reference: Sheet CS0501

ENLARGED SITE PLAN



Reference: Sheet L1.03

VIEW LOOKING WEST FROM GARDEN

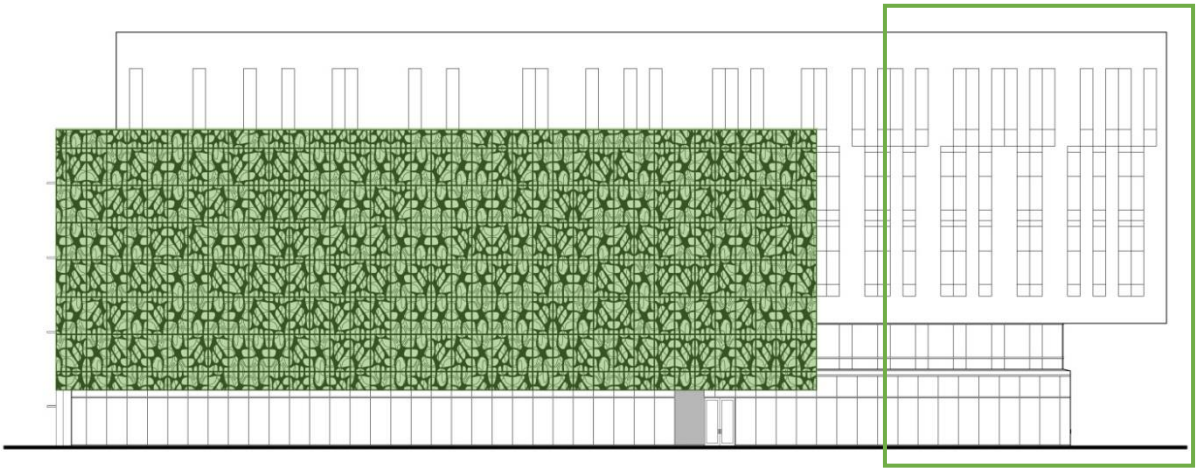
FINISHES + GLAZING

The vertical scrim is a single sheet of painted aluminum panel with areas of solid metal, perforated metal with a 40% openness factor (3/8" diameter holes), and voids to create

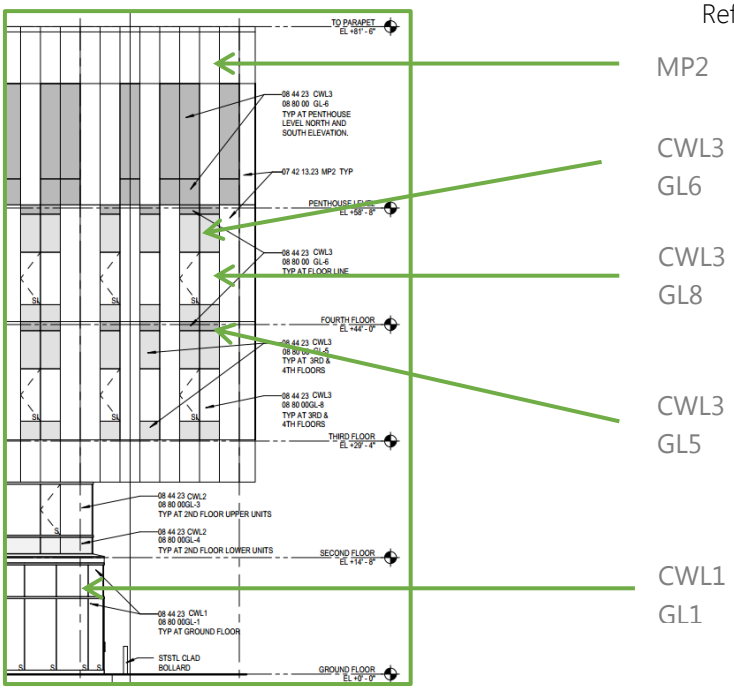
the appearance of multiple layers. The panel units are 3/8" thick. The curtain wall is a butt glazed system with painted aluminum mullions and 1" insulated clear and spandrel glass, adding frit where the scrim does not screen the glazing along the second floor. Metal panels on the southern face of the building are white and gray. Natural low-e 1" clear insulated glazing units span the ground floor corridor and lobby.

A laminated wood ceiling (similar to lobby/lounge) at the exterior soffit overhangs the pedestrian walkway.

SOUTH ELEVATION



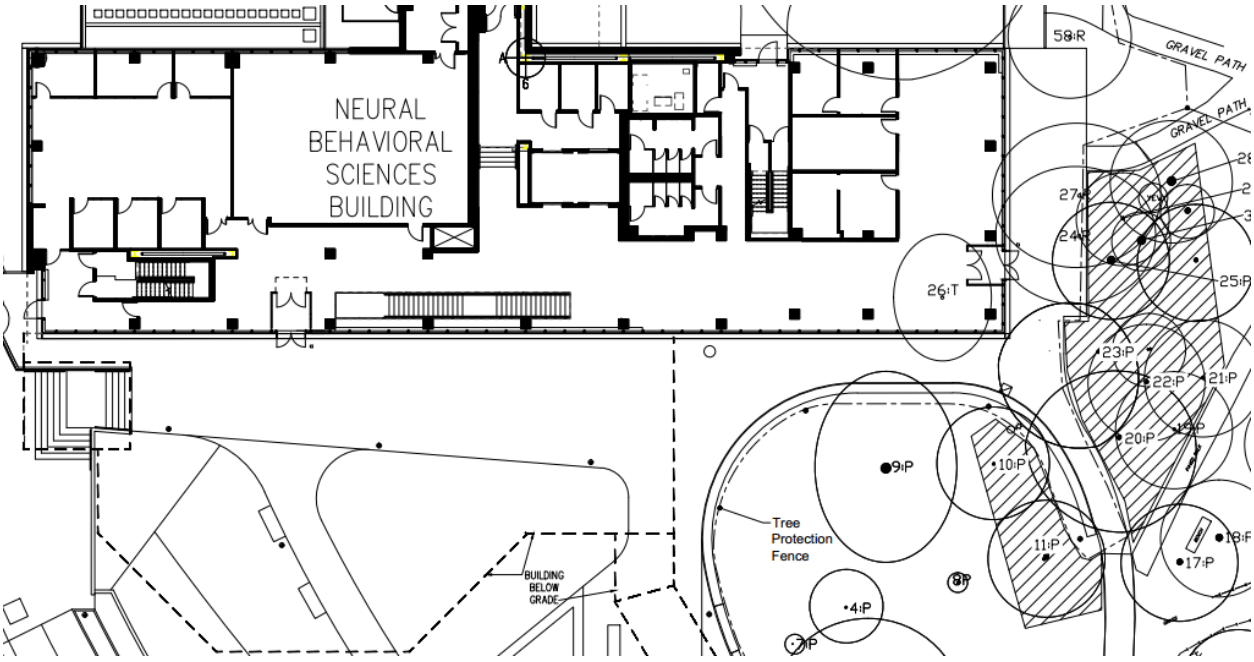
Reference: Sheet A4.1.1



Façade and Site Materials				
Surface	Material	Description	Style/Color	Reflectance (ρ)
Scrim	SS-2	Solid and perforated aluminum panel	Gray	0.45
Exterior Walls	CWL1, CWL2, CWL3, MP2	Various types of curtain walls, white metal panels, gray metal panels	Gray, white	0.40*
Site	Pavers	12" x 3" pavers	Bluestone	0.20
Exterior Ceiling	AWC-1,2,3,4	Acoustical wood ceiling with varying grid of hole diameters	White oak wood	0.70

*Reflectance averaged for materials; actual materials will exhibit varying values

PLANTING PLAN



Reference: Sheet AI2.1

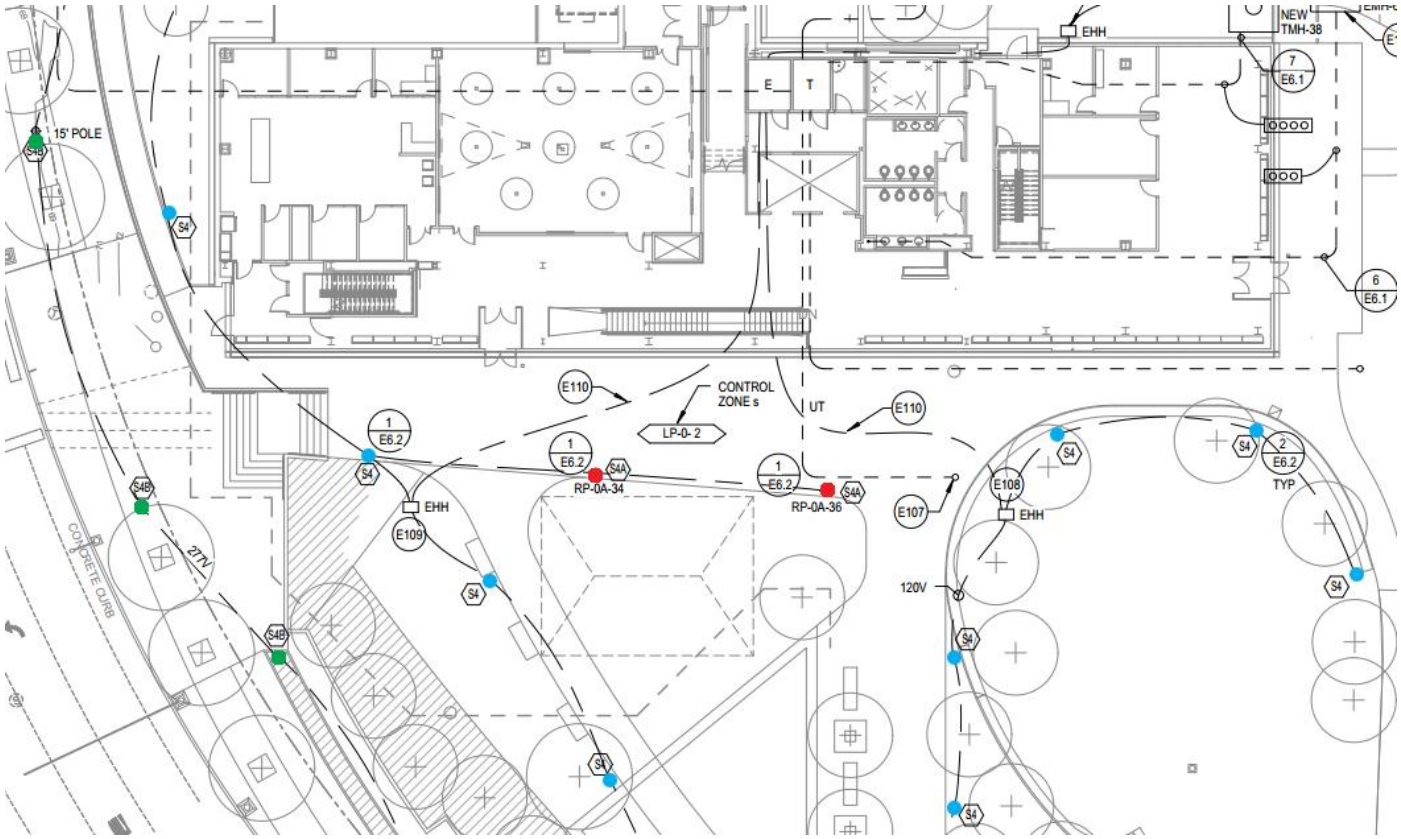
PLANTING

Immediate to the building, the site is fairly open. There are various trees to the east of the NBS building: horsechestnut, Lydia Morris holly, common crapemyrtle, and Maidenhair trees. Grass is to be planted in between the paver walkways.

TASKS

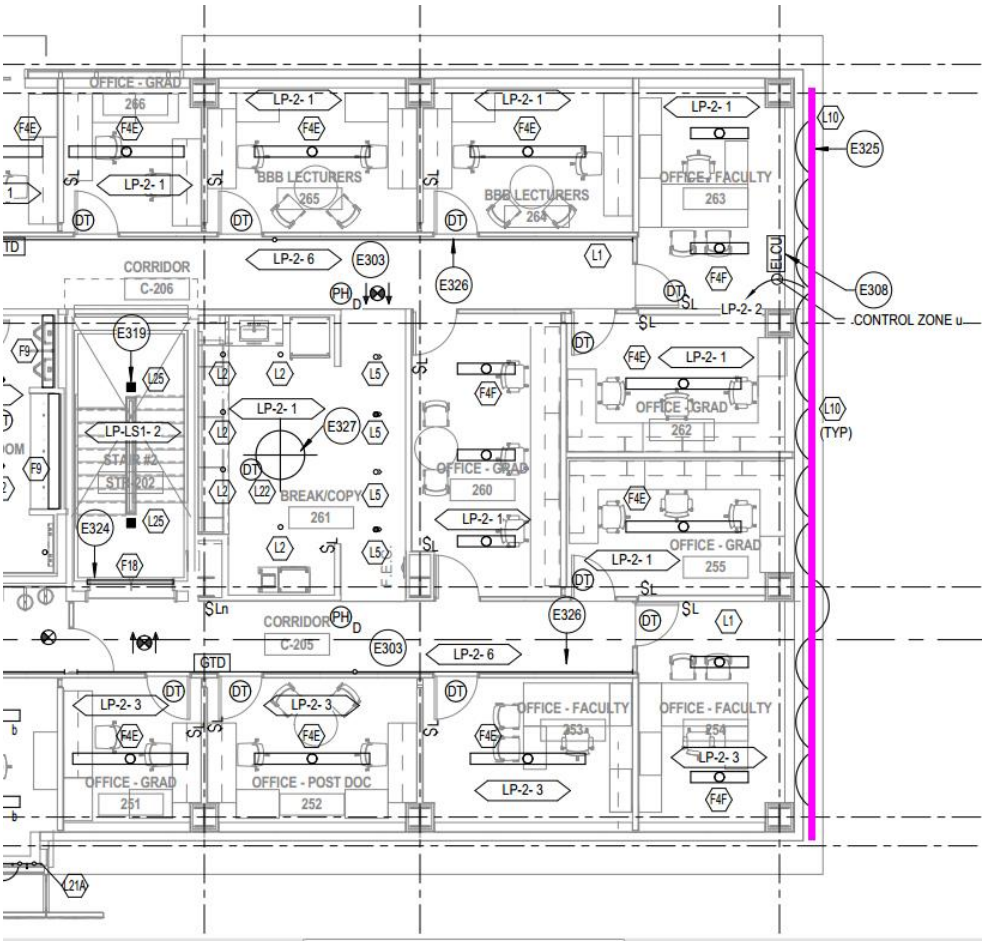
Night time pedestrian way-finding and safety are of great importance. The exterior lighting should ensure a safe and comfortable environment. Visual tasks address human activity and movement. Orientating an occupant to the entry spaces and building should also be a lighting goal.

EXISTING LIGHTING | PLAN I



Reference: Sheet E3.0

EXISTING LIGHTING | PLAN II



Reference: Sheet E3.2

South Exterior Existing Lighting								
Color	Type	Description	Manufac.	Model	Lamp	Mount	Input Watts	Voltage
	S4	UPenn standard decorative exterior lighting fixture	Street Lighting Equip. Corp.	Beacon LRK-3D	LED, 3500K	Pole	55W	277 V
	S4A*	UPenn standard decorative exterior lighting fixture	Street Lighting Equip. Corp.	Beacon LRK-3D	LED, 3500K	Pole	55W	277 V
	S4B**	UPenn standard decorative exterior lighting fixture	Street Lighting Equip. Corp.	Beacon LRK-3D	LED, 3500K	Pole	55W	277 V

	L10	Linear LED fixture, IP66 rating	Color Kinetics	eW Graze QLX Powercore	LED, 580 lm/ft, 3500K	Surface	10W/FT	277 V

A standard of University of Pennsylvania, the exterior site lighting is realized with pole mounted LED fixtures with a type V direct distribution. Surface mounted linear LED fixtures (L10) are mounted to the exterior ledge uplighting the canopy overhang. Not shown above, linear LEDs run the length of the corridor along the southern façade. These are installed within an architectural extrusion and light the interior ceiling (reference lobby existing lighting, fixture L21).

CONTROLS/BALLASTS/DRIVERS

Existing exterior lighting is a retrofit LED system. Linear canopy LED fixtures have ELV dimming capabilities; the canopy lights are programmed to turn on at sunset and turn off at sunset. The exterior poles follow a similar time schedule.

EMERGENCY LIGHTING

The canopy fixtures (L10) are connected to an emergency power lighting control unit and serves as egress lighting.

DESIGN CRITERIA/CONSIDERATIONS

QUALITATIVE CRITERIA

Very Important

- **Light Distribution on Task Plane**
  - Providing for safe pedestrian travel is important to ensure security.

- **Lighting Controls**
  - Exterior lighting should be controlled so that the fixtures are only on when needed, i.e. at sunset. This will increase energy savings.

Important

- **Accent**
  - Highlighting the exterior architectural elements can add drama and visual appeal. The lighting should be responsive to the architecture and applied appropriately.

- **Appearance of Space and Lighting Fixtures**
  - Specify fixtures that are compliant with campus standards.

DESIRED PYSHCOLOGICAL IMPRESSION

As outlined by John Flynn and discussed by Gary Steffy, the goal of the redesigned lighting solution for the façade and site is to warrant a festive psychological response by viewers. This could be realized by applying color or dynamic effects to the façade and/or lighting.

QUANTITATIVE CRITERIA

Recommended Horizontal Illuminance – Important

- IES Classification | Common Applications
    - Building Entries, paths to curbs, medium activity, LZ2
        - Category C: 4 lux (0.4 fc), at ground plane
        - Avg/Min: 3:1
    - Building Entries, Canopied entries/exit, medium activity, LZ2
        - Category F: 10 lux (1.0 fc), at ground plane
        - Avg/Min: 2:1
        - Max/Avg: 3:1

Horizontal illuminance ensures that pedestrians can see where they are going. There is potential for more activity at night time if there are night classes, sporting events nearby, or other events held in the building.

Recommended Vertical Illuminance – Very Important

- IES Classification | Exterior (Moderate Ambient Lighting) + Common Applications
    - Facade, low reflectance, medium activity, LZ2
        - Category M: 100 lux (10.0 fc)
    - Building Entries, Canopied entries/exit, medium activity, LZ2
        - Category F: 6 lux (0.6 fc), at 5' above grade
    - Building Entries, paths to curbs, medium activity, LZ2
        - Category C: 1 lux (0.1 fc), at ground plane
        - Avg/Min: 3:1

Facial recognition is critical for safety and security. Dark shadows should be avoided. If the façade was to be highlighted, proper luminance ratios compared to the surroundings and NBS building would require assessment.

LEED-NC v4 Draft

SSc6: Light Pollution Reduction

- For LZ2, maximum allowed percentage of total luminaire lumens emitted above horizontal not to exceed 1.5%; building façade exempt.

EAp2: Minimum Energy Performance

- Comply with the mandatory and prescriptive provisions of ANSI/ASHRAE/IESNA Standard 90.01-2010.

EAc2: Optimize Energy Performance

- Reduce energy consumption of entire building by 6-42% to respectively receive 1-16 points.

MODEL LIGHTING ORDIANANCE

Classified as LZ2, consider allowance of 8 lumens/SF for lighting the building façade (reference Performance Method Additional Initial Luminaire Lumen Allowances).

Additionally, consider a maximum vertical illuminance at any point in the plane of the property line of 3.0 lux (0.3 fc).

ENERGY ALLOWANCES

According to ASHRAE Standard 90.1 version 2010 (most recent version upon completion of thesis) for building exteriors, zone 3 type construction has the following allowances.

Energy Allowance (ASHRAE 90.1 – 2010)			
Space	Area (SF)	W/SF	Allowed Wattage
Building Grounds	39000	0.16	6240 W
Facade	6720	0.15	1008 W

ASHRAE 2010 STANDARDS

Reference pages 13-14 of this document.

DESIGN CRITERIA PRIORITIZED

1. Meet ASHRAE Energy Code requirements
2. Create safe environment with proper vertical illumination
3. Accent southern scrim to add drama to exterior
4. Limit uplight to minimize light pollution
5. Meet LEED requirements for lighting controls and minimum energy requirements

EVALUATION

VISUAL IMPRESSION CREATED BY LIGHTING SOLUTION

Existing exterior lighting is purely functional, effectively making occupants feel safe and secure at night. Visually, however, the exterior lighting does not add much to the building. The current exterior lighting is realized with a campus standard pole LED fixture. These are placed to provide functional light but do not necessarily imply any particular emotional response. Uplighting the canopy overhang does add some drama to the exterior, effectively highlighting the architectural massing.

The building is lit from within, yielding the structure as a sort of beacon on campus. While the scrim casts interesting shadows during the day, at night a bright interior can be seen through the organic forms. From the south, the building appears to be floating on a layer of light; focusing less on a particular visually appealing exterior lighting solution and more on the glow from within is an interesting notion.

QUANITATIVE COMPARISON

Lighting Fixtures Used				
Type	Lamp	Qty. of fixtures	Input Wattage (W)	Total Wattage (W)
S4	LED, 3500K	16	55W	880
S4A	LED, 3500K	3	55W	385
S4B	LED, 3500K	7	55W	165
L10	LED, 580 lm/ft, 3500K	13 (4' each)	10W/FT	520

The following table compares the allowable energy consumption to the actual energy consumption as described by ASHRAE 90.1 – 2010 by the space-by-space method.

Energy Consumption (ASHRAE/IESNA 90.1 – 2010) - Facade		
Category	Allowable	Calculated
Area (SF)	-	6720
Input Wattage	1008	0
Power Density (W/SF)	0.15	0.0

Energy Consumption (ASHRAE/IESNA 90.1 – 2010) – Building Grounds		
Category	Allowable	Calculated
Area (SF)	-	39000
Input Wattage	6240	1430
Power Density (W/SF)	0.16	0.04

No direct light is currently applied to the façade. Likewise, efficient LED pole fixtures are spaced so that the current LPD for the building grounds easily complies with the standard.

PERFORMANCE ANALYSIS

Although not particularly interesting, the exterior lighting does perform well. The space appears safe and inviting. By allowing light to spill out onto the exterior surfaces, some drama is introduced. Illuminating the underside of the overhang canopy reinforces the architectural massing and provides soft indirect light at the canopy entrance. This is ideal for vertical illumination.

In accordance with ASHRAE 90.1 – 2010, the existing lighting design meets the required LPDs listed. All the exterior lighting is on a programmed time schedule; this complies with ASHRAE Standards and warrants LEED credit. The choice of light fixtures minimizes unwanted uplight. The lighting is contained well in the exterior space, lowering the chance of potential light trespass.

AREAS OF IMPROVEMENT

Exterior lighting may perform well but there is certainly room for visual improvement. The landscaping and southern scrim are open canvases; lighting has a great potential to conceptually strengthen the connection between the NBS building, site, and surrounding context. Perhaps lighting the scrim façade and overhang canopy would add visual dynamic. Vertical illumination and lighting for safety will drive the design; artistic expression can elegantly light the space while still meeting IES recommendations.

REFERENCES

ASHRAE Standard 90.1 – Energy Standard for Buildings Except Low-Rise Residential Buildings. 2010th ed. N.p.: ASHRAE, n.d. Print.

DiLaura, David, Kevin Houser, Richard Mistrick, and Gary Steffy. *Illuminating Engineering Society The Lighting Handbook*. 10th ed. N.p.: IESNA, n.d. N. pag. Print.

"New Construction & Major Renovations." *New Construction*. U.S. Green Building Council, 2013. Web. 16 Sept. 2013. <http://www.usgbc.org/leed/rating-systems/new-construction>.

Model Lighting Ordinance (MLO). 2011. N.p.: IDA-IESNA, n.d. Print.

APPENDIX A | MATERIALS

Lecture Hall Materials				
Surface	Material	Description	Style/Color	Reflectance (ρ)
Ceiling	ACP-1/PNT-8	Arktura custom white fiberglass ceiling panel system with specular finish, paint behind	Light yellow, iron ore SW7069 paint	0.75
Walls	AWP-1/WDV-3	Arktura custom white feiberglass wall panel system with specular finish, back wall yellow wood veneer	Light yellow panel/medium finish wood	0.75/0.50
Floor	RSF-3	Optima Series 1/8" homogeneous vinyl sheet	Cool Beige	0.30
Lobby/Lounge Materials				
Surface	Material	Description	Style/Color	Reflectance (ρ)
Ceiling	AWC-1,2,3,4	Acoustical wood ceiling with varying grid of hole diameters	White oak wood	0.70
Walls	GLS/PNT-1/WDV3 and GL-INT-5	Ultra white, writable, magnetic glass, paint, clerestory windows, wood veneer feature wall	Glass, sea pearl white paint, yellow wood veneer	0.50
Floor	TRZ-1	Terrazzo flooring	Pearl	0.30
Classroom Materials				
Surface	Material	Description	Style/Color	Reflectance (ρ)
Ceiling	ACT-2	Acoustic ceiling tile	White acoustic tile	0.80
Walls	PNT-1	Painted gypsum walls	Sea Pearl	0.50
Floor	CPTT-3,4,5	Three variations of carpet tile	Stone, Ivy/Stone, Ivy	0.25
Façade and Site Materials				
Surface	Material	Description	Style/Color	Reflectance (ρ)
Scrim	SS-2	Solid and perforated aluminum panel	Gray	0.45

Exterior Walls	CWL1, CWL2, CWL3, MP2	Various types of curtain walls, white metal panels, gray metal panels	Gray, white	0.40
Site	Pavers	12" x 3" pavers	Bluestone	0.20
Exterior Ceiling	AWC-1,2,3,4	Acoustical wood ceiling with varying grid of hole diameters	White oak wood	0.70

APPENDIX B | LIGHT FIXTURE SCHEDULE

F4C	8' low profile direct/indirect fluorescent pendant	Peerless	Bruno	(2) 28W T8 in cross section	Pendant	96W	277 V
F10	Linear fluorescent in-grade wall wash	WE-EF	ETR 140	(1) 21W, T5, 4100K	In-grade	25W	277 V
L5	Recessed lensed LED wall wash	Gotham	Evo Wallwash	LED, 1800 lm, 3500K	Recessed	18W	277 V
L9	Linear LED with acrylic diffuse lens	LEDLinear	VarioLED Flex Hydra HD6	LED, 190 lm/ft, 3500K	Surface	1.8W/FT	277 V
L10	Linear LED fixture, IP66 rating	Color Kinetics	eW Graze QLX Powercore	LED, 580 lm/ft, 3500K	Surface	10W/FT	277 V
L11	Recessed 2" dia. LED downlight	Prescolite	D2	LED, 850 lm, 3500K	Recessed	20W	277 V
L12	Low profile linear LED downlight	Kreon	Nuit	LED, 630 lm, 3000K	Pendant	7.1W	277 V
L16	Track-mounted LED spot	LSI	Lumlex 2044	LED, 860 lm, 4000K	Track	25W	277 V
L18	2' x 2' LED light panel	Corelite	Edgelit	LED, 2100 lm, 3500K	Pendant	24W	277 V
L18A	1' x 4' LED light panel	Corelite	Edgelit	LED, 2100 lm, 3500K	Pendant	24W	277 V
L21A	Linear LED	Ecosense	Linear Int LP	LED, 160 lm, 3500K	Surface	7W/FT	277 V
L26	4" x 4" continuous lensed linear LED	A-Light	D3 Series	LED, 500 lm/ft, 3000K	Wall	7W/FT	277 V
L27	Edge lit LED light panel (96" x 32.5")	DLC	Lumisheet LED light panel	LED, 4100K	Surface	80W	277 V
L30	Linear LED asymmetric wall wash	A-Light	D7 Series	LED, 1000 lm/ft, 4000K	Recessed	56W	277 V
S4	UPenn standard decorative exterior lighting fixture	Street Lighting Equip. Corp.	Beacon LRK-3D	LED, 3500K	Pole	55W	277 V
S4A	UPenn standard decorative exterior lighting fixture	Street Lighting Equip. Corp.	Beacon LRK-3D	LED, 3500K	Pole	55W	277 V

S4B	UPenn standard decorative exterior lighting fixture	Street Lighting Equip. Corp.	Beacon LRK-3D	LED, 3500K	Pole	55W	277 V