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Executive Summary

The following technical report is an analysis of the existing lighting systems in The Virginia Commonwealth University. The information used in this report came for 1999 Bid Documents and *The IESNA Lighting Handbook* and ASHRAE 90.1 were referenced throughout.

The four areas of analysis are the Genetic Laboratory, the auditorium, the first and second floor lobby area, and the exterior walkway area between the classroom and laboratory buildings. The analysis included surface and furnishing characteristics, day lighting, light loss factors, controls, power density, tasks, and design criteria for each space. AGI 32 was used to develop models of the existing conditions for further analysis.

The lighting conditions throughout all of the spaces are satisfactory. The lighting and controls in each space are tailored to meet the needs of the specific tasks being performed in that area. The Genetics Lab is well lit for both classroom lectures and demonstrations and also adjustable for when performing experiments. A dimming system controls the auditorium's lighting system allowing for use of both marker boards and a projector screen along with enough light to perform tasks such as reading, note taking, and listening. The lighting system in the lobby provides direction for those passing through the space while highlighting the wood paneled walls. The exterior walkway between the laboratory and classroom buildings is lit so as to be able to see where one is going at night and to provide direction to the entrances of the buildings.

Genetics Laboratory

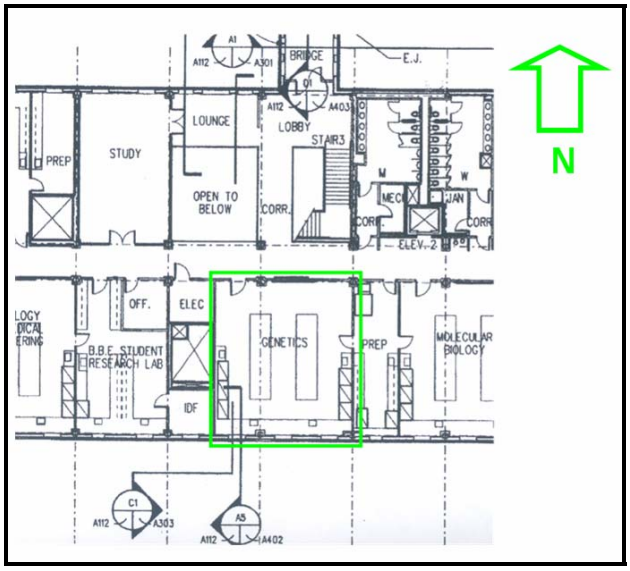

Figure 1.1 Genetics Laboratory Location

Space Description

The Genetics Laboratory is located on the second floor of the laboratory building. The main entrance is from the lobby on the north wall. There is also a doorway on the east wall that leads to a preparation room. The lab has 3 windows on the south wall allowing for some sunlight. The main functions of this space are as a learning area and a research area. The general lighting is provided with 1'x4' recessed fluorescent lensed troffers. These luminaires have (2) F32-T8 lamps with a CCT (Correlated Color Temperature) of 3500K.

Surface Materials		
Surface	**Material**	**Reflectance**
Ceiling	Acoustic Ceiling Tile	80%
Walls	Painted Gypsum Wall Board	95%
Floor	Vinyl Composition Tile	32%
Doors	Solid Core Wood (Maple)	31%
Glazing	Sealed Insulating Glass	16%
		Transmittance: 48%

Furnishings		
Description	**Materials**	**Reflectance**
Lab Benches	Stainless Steel Countertops	%
	Wood	15%
Lab Stools	Wood	15%
(1)Marker Board M1	White	90%
Cabinets	Laminated Glass Windows	16%
		Transmittance: 48%

Daylighting

Exterior windows are located along the south wall of the genetics lab. Depending on the weather and season, these could provide some sunlight into the lab. However, because it is a learning and research laboratory, the sunlight alone would not be enough to adequately illuminate this space. Therefore, an alternative source of light is necessary.

Luminaire Schedule								
Type	**Description**	**Lamp**			**Volts**	**Mounting**	**Ballast**	**Quantity**
		Number	**Type**	**Watts**				
F7	1'x4' recessed lensed troffer	2	F32-T8 3500K	32	277	Recessed	Electronic	42
W1	6" square wall mounted direct fluorescent	1	F32-T8 3500K	32	277	Surface	Electronic	4

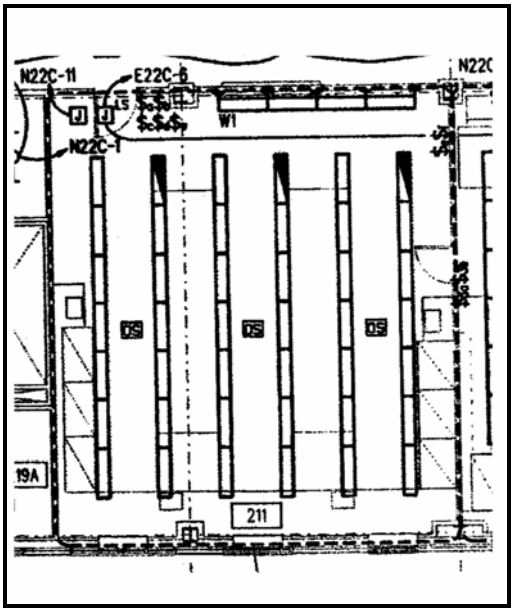

Figure 1.2 Genetics Laboratory Lighting Plan

Light Loss Factors							
Type	**BF**	**Cleaning Interval**	**Maintenance Category**	**LLD**	**RSDD**	**LDD**	**Total**
F7	0.88	Clean (12 months)	IV	0.90	0.96	0.89	0.68
W1	0.88	Clean (12 months)	IV	0.90	0.97	0.89	0.68

Existing Power Density

1.3W/sf

Controls

The lighting system in the Genetics Lab is controlled by a set of switches that allows a variety of light levels. The luminaires can be toggled to all on, all off, and other intermediate levels.

Task Descriptions:

The Genetics Lab is used as both a classroom and research facility. In the classroom setting, demonstrations will be done for students and directions issued in order to complete experiments. When used as a research facility, experiments will also take place. These activities will require such tasks as reading, writing, and precise measurements. All of which require careful measurement of horizontal and vertical illuminance. Horizontal illuminance will be critical in the research aspect, whereas, vertical illuminance will be critical during lectures and demonstrations for facial modeling.

Design Criteria:

The IESNA Lighting Handbook was referenced for the design criteria.

Appearance of Space and Luminaires

The luminaires should contribute to the academic atmosphere of the laboratory. They should encourage work to be done there. The fixtures should also not be distracting, as the students will be getting directions on how to do their work and demonstrations will be provided in this space.

Color Appearance (and color contrast)

Color contrast will be important as detailed experiments will be performed in the space. It will also be necessary for note taking and reading.

Daylight Integration and Control

The three windows on the south wall provide a view of the outdoors allowing the students to be more relaxed. This is especially important as experiments can be very tedious and time consuming. However, shades should be provided in order to control the sunlight during these tasks so that it does not become overwhelming.

Direct Glare

Direct glare should be avoided so that people who are in the laboratory for an extended period of time performing tedious experiments do not become uncomfortable due to it.

Flicker (and Strobe)

Flicker and strobe should also be avoided because of the experiments and so as not to distract from demonstrations and lectures.

Light Distribution on Surfaces

The entire lab should be well lit and the light distributed uniformly as students will be moving around a lot.

Light Distribution on Task Plane

Light distribution on the lab benches is extremely important. Demonstrations and experiments will be performed there along with note taking and reading.

Modeling of Faces and Objects

Facial modeling is important for lectures and object modeling is very important as the majority of tasks performed will be experiments and demonstrations.

Reflected Glare

The tops of the lab benches are stainless steel, so reflected glare should be controlled as much as possible, so as not to provide an unwanted distraction.

Source/ Task/ Eye Geometry

Source/ task/ eye geometry should add to the contrast of the task, but not take away from it.

System Control and Flexibility

The lighting system in the laboratory should be flexible and easily controlled as necessary light levels can vary from task to task.

Illuminance

Horizontal: E (50 fc)
Vertical: D (30 fc)

Power Allowance

ASHRAE 90.1 Standard: Using the Space-by-Space Method:
1.6W/sf allowable

Analysis of Existing System

AGI 32 was used to calculate the lighting conditions for the space. The reflectances and light loss factors state above were used to generate this computer model.

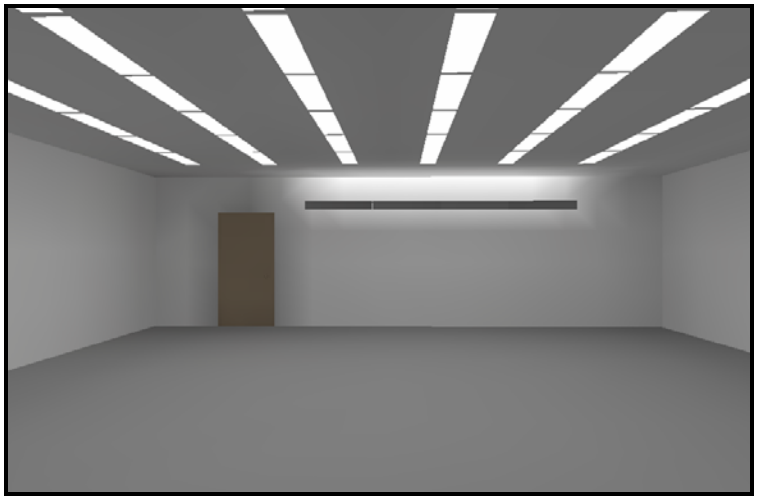

Figure 1.3 View of Genetics Laboratory looking North

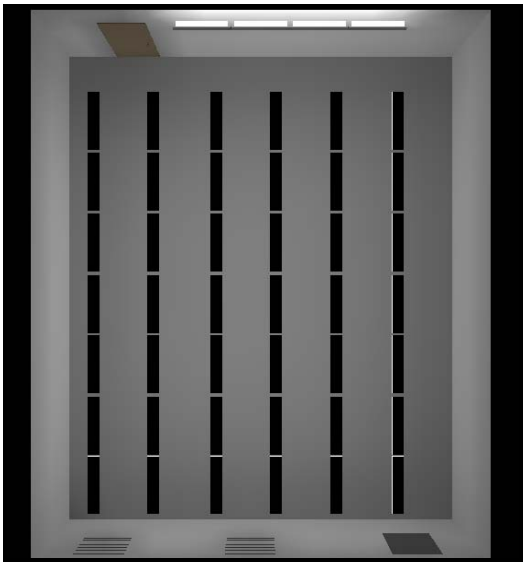

Figure 1.4 Plan View of Genetics Laboratory

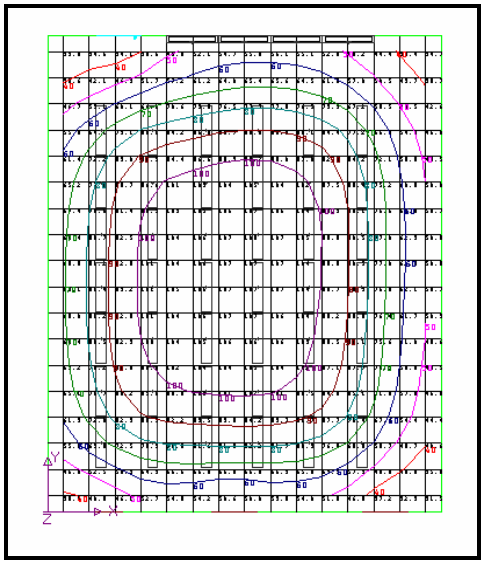

Figure 1.5 AGI32 Isoline diagram for Genetics Laboratory

For the Genetics Laboratory, a horizontal calculation grid was placed at 2.5 feet to simulate the task plane of the lab benches. An average illuminance of 76 fc was calculated. This is above the IES recommended amount, but since it is a research lab space, this number is also reasonable. However, decreasing it could also decrease the power density saving both energy and power. The space is evenly lit as can be seen in Figure 1.5. Overall, this design works well with this space.

Auditorium

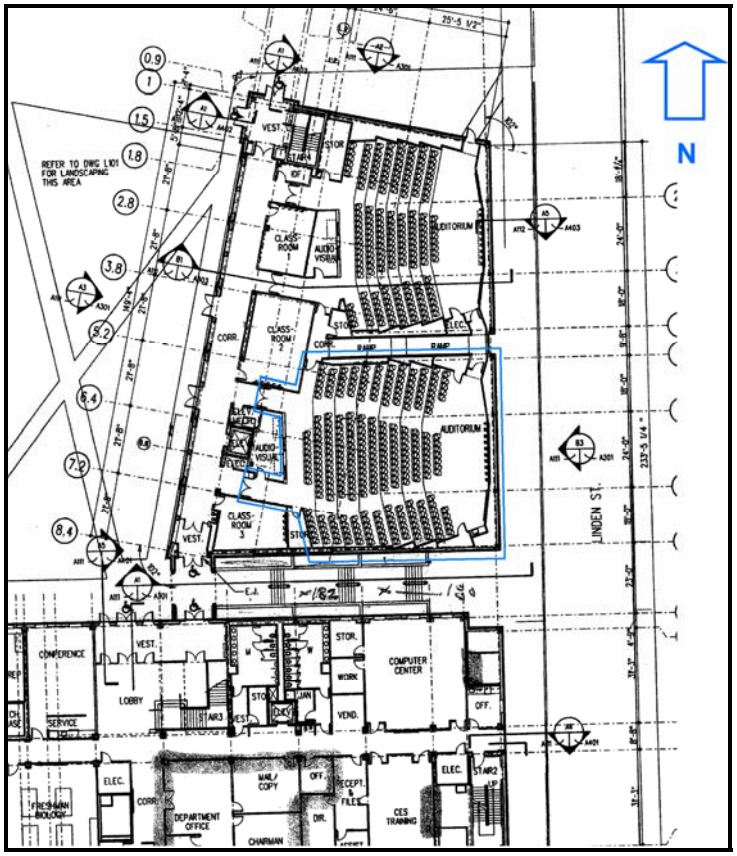

Figure 2.1 Auditorium Location

Space Description

The auditorium is located on the first floor of the classroom building. There are two main entrances on the west side of the room and two others on the north side. There are approximately 300 seats. Since the room is used primarily for class lectures, there are 2 white boards, 2 white boards on a horizontal track, and a projection screen mounted over the tracked white boards on the east wall. The space can also be used for speakers. The primary luminaires used include down lights, wall washers, and parabolic troffers.

Surface Materials		
Surface	**Material**	**Reflectance**
Ceiling	Acoustic Ceiling Tile	83%
	Gypsum Wall Board	60%
Walls	Acoustic Wall Panels	80%
Floor	Vinyl Composition Tile	32%
	Carpet	20%
Doors	Solid Core Wood (Maple)	31%
Glazing	Float Glass Type I	16%
		Transmittance: 48%

Furnishings		
Description		**Reflectance**
(2 Marker Boards (M1)	White	90%
(2) White Boards (M2)	White	90%
Projector Screen	20' wide centered over M2	90%
Fixed Seating	Fabric	15%

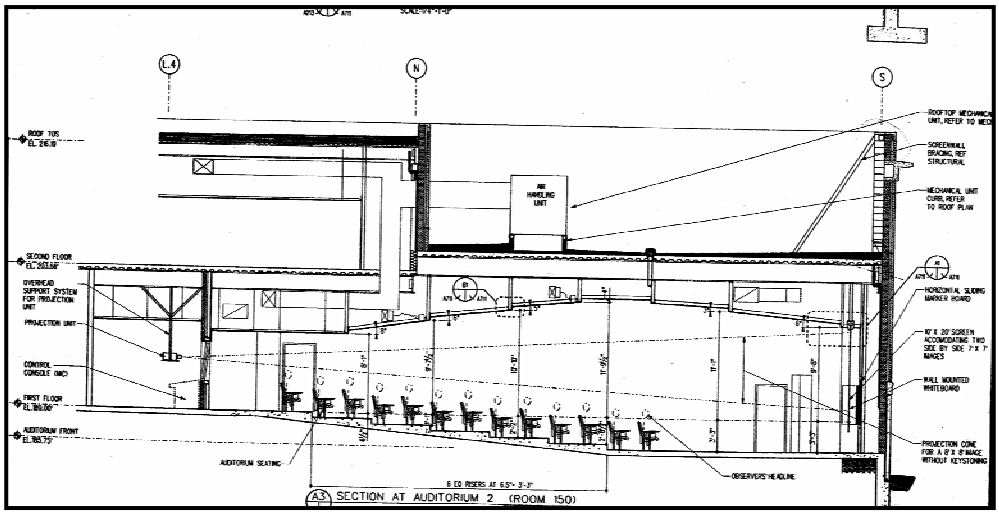

Figure 2.2 Auditorium Section

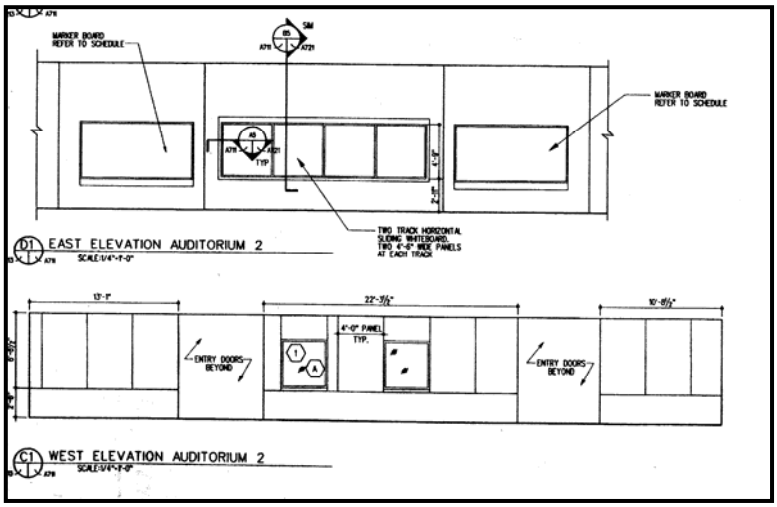

Figure 2.3 Auditorium Sections (East and West)

Luminaire Schedule								
Type	Description	Lamp			Volts	Mounting	Ballast	Quantity
		Number	Type	Watts				
D1	6" dia. incandescent downlight	1	150W A-21 1F	150	120	Recessed		24
D1A	6" dia. incandescent wall washer	1	150W A-21 1F	150	120	Recessed		24
D2	6" dia. incandescent downlight	1	150W PAR- 38FL	150	120	Recessed		3
D4	7" dia. recessed compact fluorescent	1	18W Quad 3500K	18	277	Recessed	Electronic	4
F4A	2'x2' parabolic troffer 3" deep cells, 18 cells	3	31W T-8 U-1 5/8" 3500K	31	277	Recessed	Electronic	37
WW1	24" fluorescent wall washer	2	55W BIAX 3500K	55	277	Semi-recessed	Electronic	8

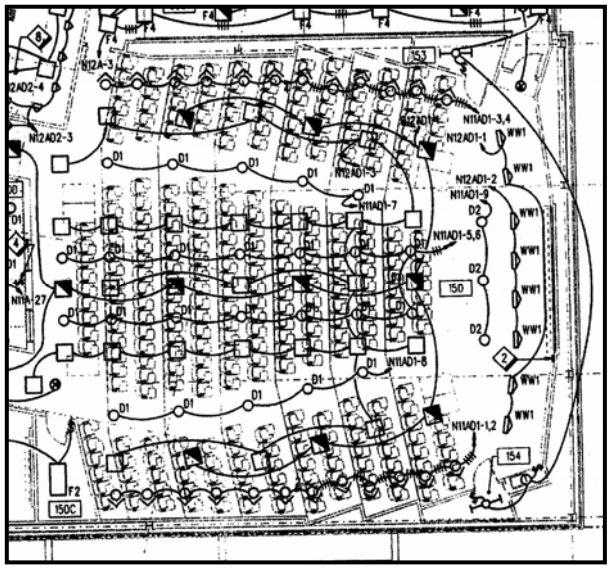

Figure 2.4 Auditorium Lighting Plan

Light Loss Factors							
Type	**BF**	**Cleaning Interval**	**Maintenance Category**	**LLD**	**RSDD**	**LDD**	**Total**
D1	1.00	Clean (12 months)	V	0.90	0.97	0.88	0.77
D1A	1.00	Clean (12 months)	V	0.90	0.96	0.88	0.76
D2	0.95	Clean (12 months)	IV	0.90	0.97	0.88	0.73
D4	0.96	Clean (12 months)	IV	0.86	0.96	0.89	0.71
F4A	0.88	Clean (12 months)	IV	0.95	0.96	0.89	0.71
WW1	1.00	Clean (12 months)	IV	0.86	0.96	0.89	0.73

Existing Power Density

2.5W/sf

Controls

The luminaires in the auditorium are controlled through a programmable dimming panel which allows for various levels of light depending on the task at hand. The dimming system is separated into 6 zones and 4 scenes.

Task Descriptions:

The Auditorium functions as a lecture hall for students and also for guest speakers. Both faculty and students will be attending different types of lectures. Reading from pamphlets and notes close up and the white board and projector screen which can be close for some while quite far for others. During a class lecture, a lot of writing will be going on too.

Design Criteria:

The IESNA Lighting Handbook was referenced for the design criteria.

Appearance of Space and Luminaires

The appearance of the luminaires and space for the auditorium is important in that the luminaires should provide adequate light without being distracting. The auditorium is large, so with the speaker being so far away from the listeners at times, it is easier to become distracted.

Color Appearance (and color contrast)

The color appearance and contrast should also be considered. The auditorium hosts distinguished speakers and students are taking notes everyday.

Direct Glare

Direct glare should be avoided as the ceiling is arced and the seating is sloped. The speaker and the audience should not be distracted or "blinded" by any direct glare.

Flicker (and Strobe)

Flicker and strobe is another distraction that should be avoided. Because of the size of the space, it can be hard to concentrate and the lighting should not add to this.

Light Distribution on Surfaces

The light distribution should be uniform, but should also not be monotonous as the eye can get tired from that.

Light Distribution on Task Plane

Light distribution on the task plane is important for the students taking or reading notes. Adequate light should be provided on the task plane so that the students are not straining their eyes.

Luminances of Room Surfaces

The room surfaces should also be well illuminated, especially the whiteboards at the front of the room. Proper light should be provided for the projector screen too, so that the audience will be able to read off of them without a problem due to the lighting.

Modeling of Faces and Objects

Since there are lectures and presentations being put on everyday, facial modeling is very important.

Points of Interest

The light should direct the students' attention to the front of the room and to the marker boards and projection screen.

Shadows

Shadows should be avoided between the speaker and the marker boards and projection screen as they will both need to be adequately visible to the audience.

Source/ Task/ Eye Geometry

Source/ task/ eye geometry is important for students taking notes during lectures as they will need to be able to see the desktop area.

System Control and Flexibility

The auditorium lighting system should be easily controlled and very flexible as many different tasks requiring different levels of light are performed here. Lectures using the marker boards will require more light than a presentation on the projection screen.

Illuminance

Horizontal: E (50 fc)
Vertical: B (5 fc)

Power Allowance

ASHRAE 90.1 Standard: Using the Space-by-Space Method:
0.9W/sf to 3.2W/sf allowable

Analysis of Existing System

AGI 32 was used to calculate the lighting conditions for the space. The reflectances and light loss factors state above were used to generate this computer model. The auditorium space was modeled in the basic shape but with a flat floor and ceiling that were the maximum height reached in the planned space. The luminaires were then mounted at the height that they would be with the sloped ceiling. This created the effect of "floating luminaires" seen in Figures 2.5 and 2.6. Overall, the lighting effect was very similar.

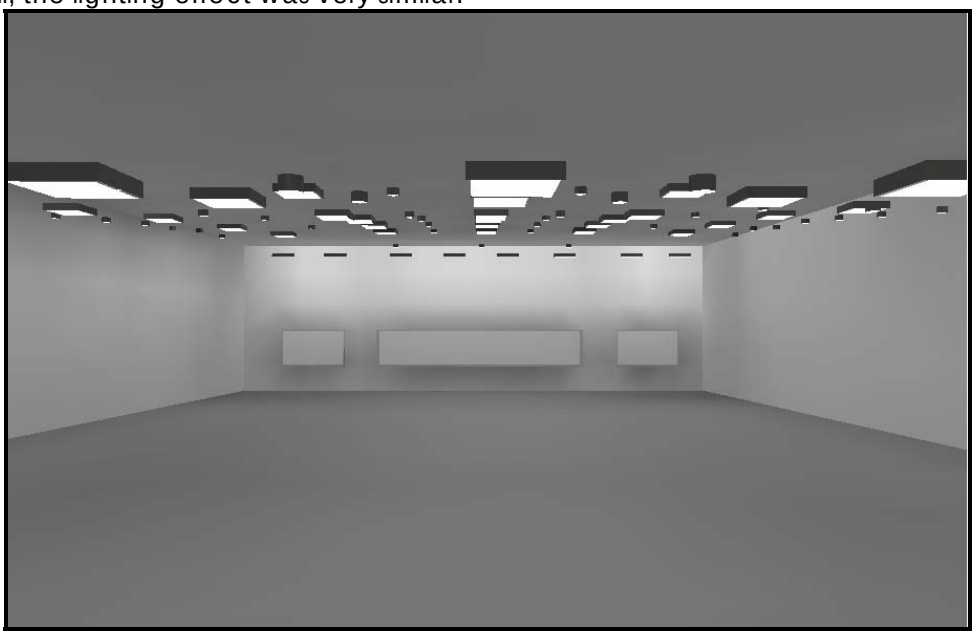

Figure 2.5 View of the auditorium looking east

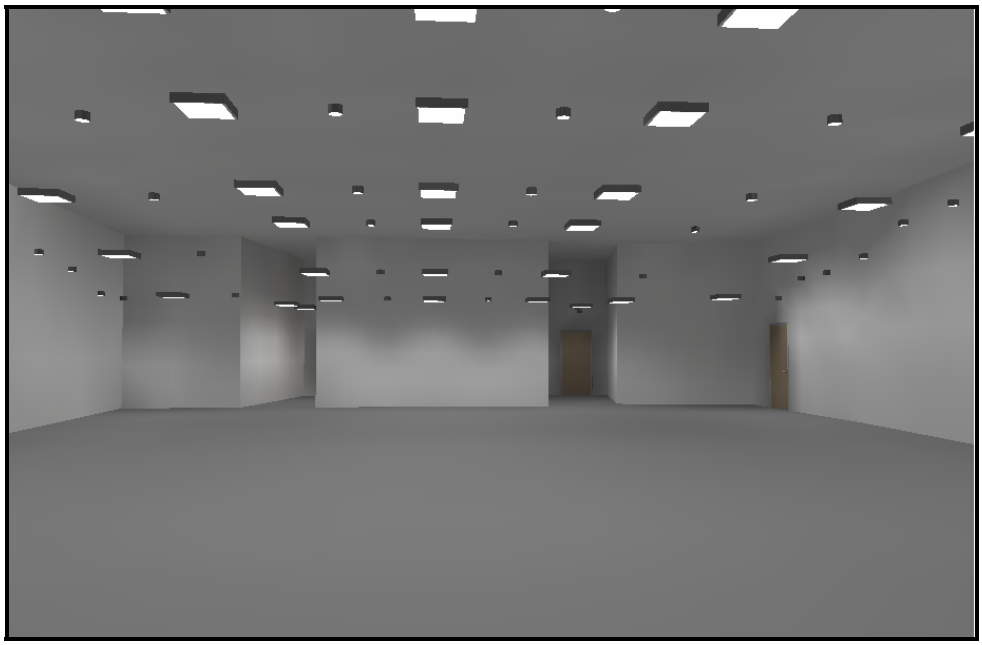

Figure 2.6 View of the auditorium looking west

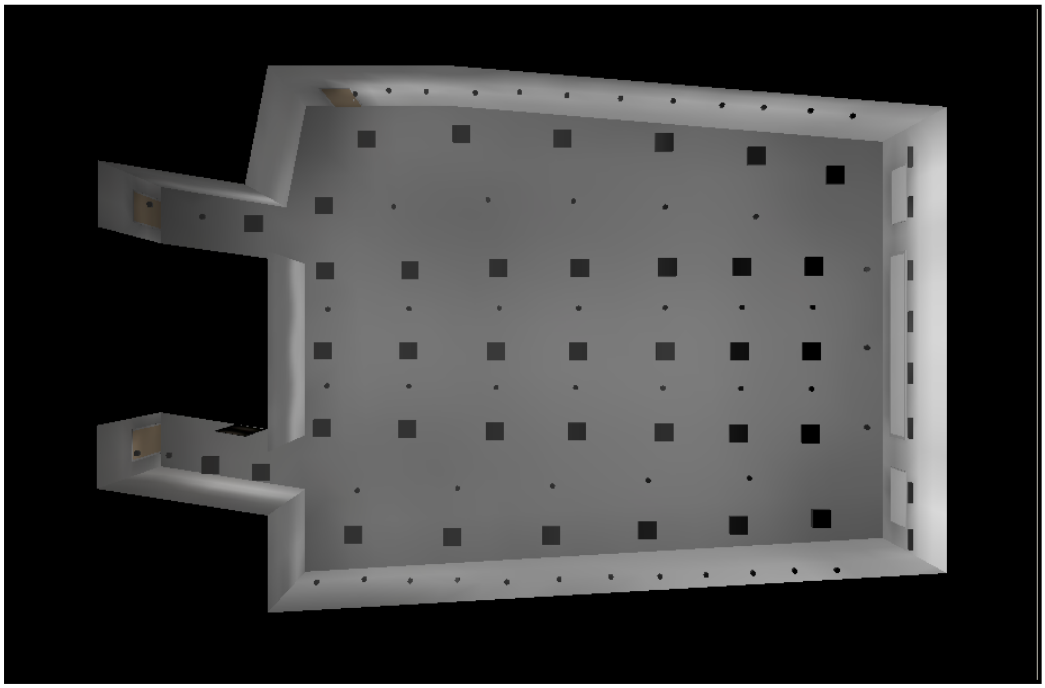

Figure 2.7 Plan view of the auditorium

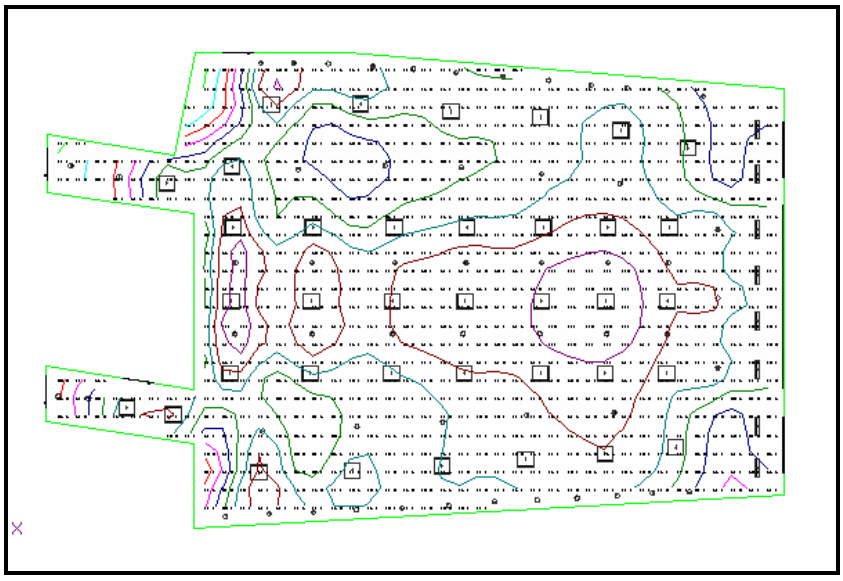

Figure 2.8 AGI32 Isoline view of the auditorium

A calculation grid for the auditorium was placed at 2.5' as this is the height of the chair desks. The calculated average illuminance was 78 fc. This is above the IES recommended level of 50 fc. The lighting system in the auditorium is controlled through a dimmer panel, so it is rare that all of the luminaires will be turned on to their full capacity at one time. It is more likely that they will be dimmed to a level that a task requires. Overall the space is well illuminated with enough variety so that they eye won't get bored.

Lobby

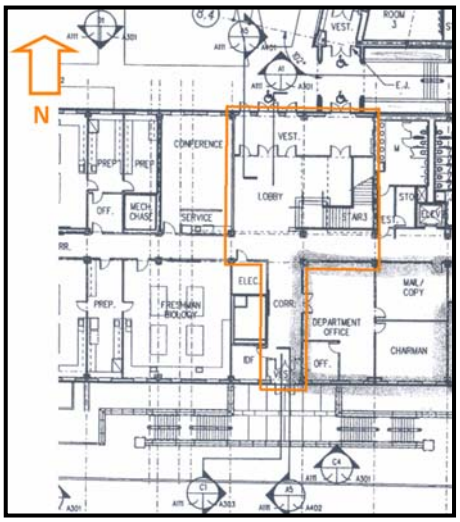

Figure 3.1 First Floor Lobby Location

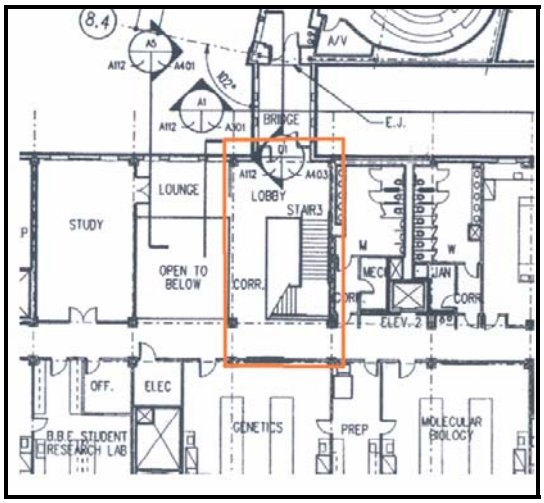

Figure 3.2 Second Floor Lobby Location

Space Description

The lobby area being considered exists on two levels. The main level has an entrance from the quad on the north and an entrance on the south from the street. A hallway runs east and west through the middle of the building, cutting the lobby into two pieces on the main floor. In the northeast corner, a stairwell goes to the second floor, where there is another lobby area. There is a bridge that enters the lobby from the north connecting the second floors of the classroom and laboratory buildings. Another hallway, directly above the one on the first floor, runs east and west at the southern border of the second floor lobby. These are the two main circulation spaces in the building. Down light luminaires and a decorative pendant provide the general lighting for the lobby areas.

Surface Materials		
Surface	**Material**	**Reflectance**
Ceiling	Acoustic Ceiling Tile	83%
	Gypsum Wall Board	60%
Walls	Gypsum Wall Board	60%
	Wood Paneling	16%
Floor	Vinyl Composition Tile	32%
	Slate	29%
Doors	Solid Core Wood (Maple)	31%
Glazing	Sealed Insulating Glass	16%
		Transmittance: 48%

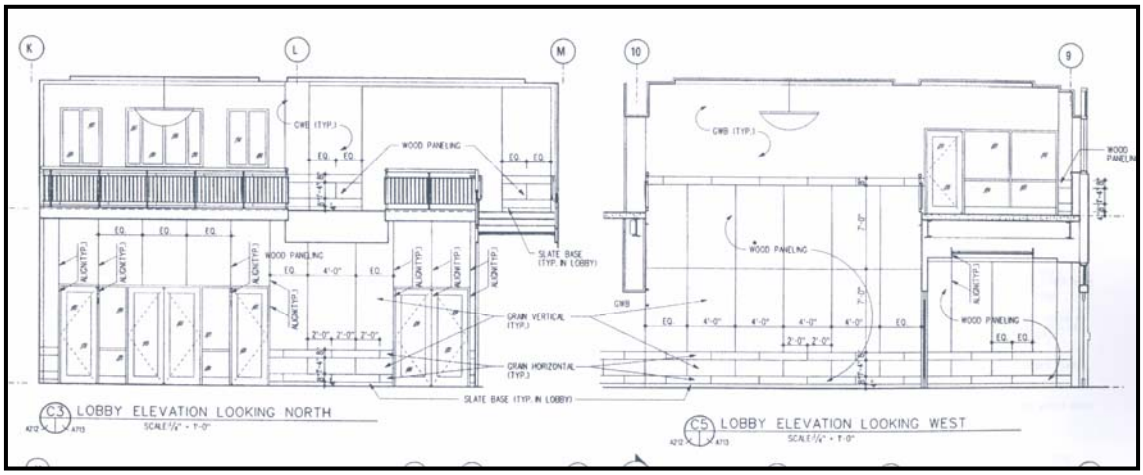

Figure 3.3 North and West Lobby Elevations

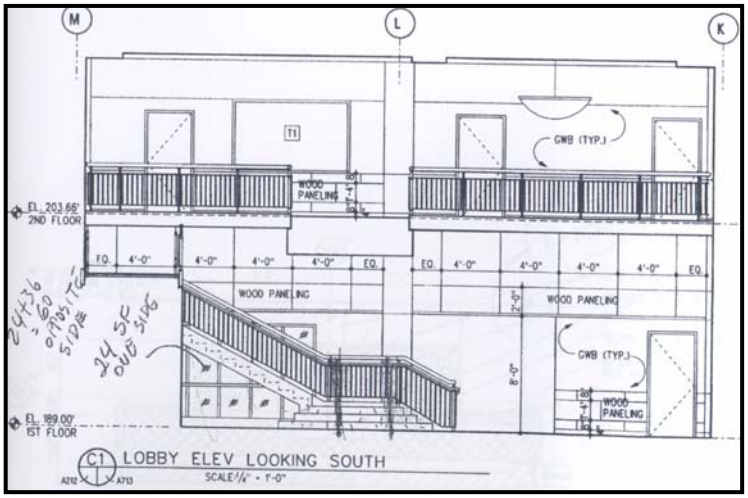

Figure 3.4 South Lobby Elevation

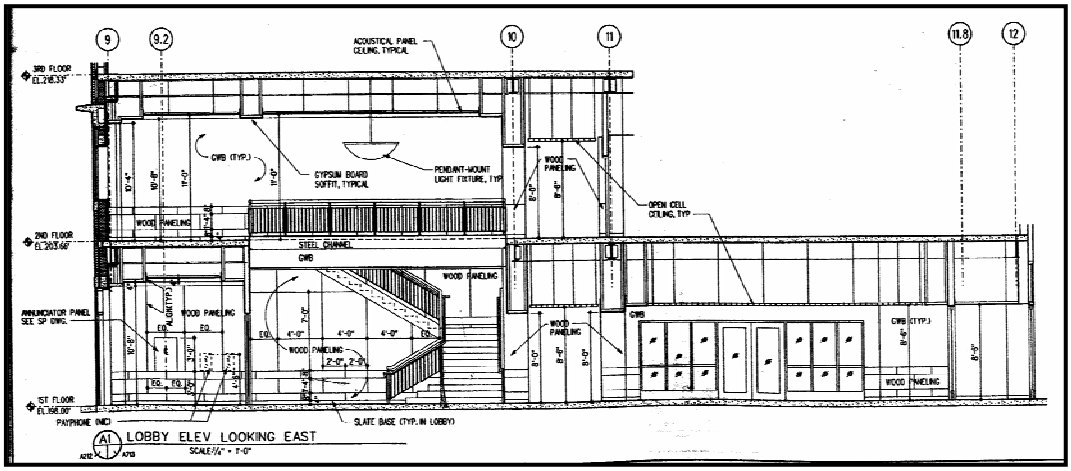

Figure 3.5 East Lobby Elevation

Daylighting

The exterior doors consist of solid wood core and have small window openings. Therefore, some daylight will come in, but even on the sunniest of days, it would not be enough to illuminate the entire lobby area.

Luminaire Schedule

Type	Description	Lamp			Volts	Mounting	Ballast	Quantity
		Number	Type	Watts				
D3	7" dia. recessed HID downlight	1	70W MH 2500K	70	277	Recessed	High PF	11
D3A	7" dia. recessed HID wall washer	1	70W MH 2500K	70	277	Recessed	High PF	3
D4	7" dia. recessed compact fluorescent downlight	1	18W Quad 3500K	18	277	Recessed	Electronic	17
D7	7" dia. recessed compact fluorescent downlight	2	18W Quad 3500K	18	277	Recessed	Electronic	16
F3	2'x2' recessed semi-direct	2	40W BIAX 3500K	40	277	Recessed	Electronic	7
P3	42" dia. Decorative indirect pendant	4	26W Quad 2700K	26	277	Pendant	Electronic	1

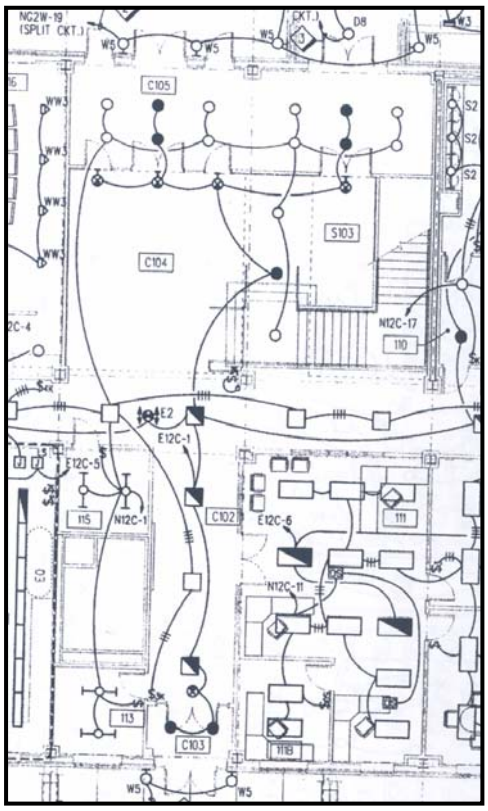

Figure 3.6 First Floor Lobby Lighting Plan

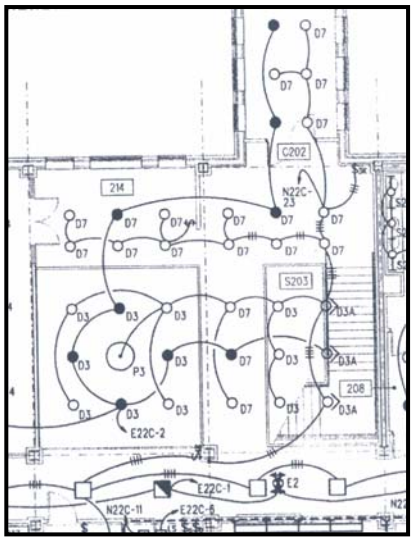

Figure 3.7 Second Floor Lobby Lighting Plan

Light Loss Factors							
Type	**BF**	**Cleaning Interval**	**Maintenance Category**	**LLD**	**RSDD**	**LDD**	**Total**
D3	0.95	Clean (12 months)	II	0.80	0.97	0.93	0.69
D3A	0.95	Clean (12 months)	III	0.80	0.97	0.90	0.66
D4	0.96	Clean (12 months)	IV	0.86	0.96	0.89	0.71
D7	0.96	Clean (12 months)	III	0.86	0.97	0.90	0.72
F3	0.88	Clean (12 months)	III	0.95	0.96	0.90	0.72
P3	1.00	Clean (12 months)	II	0.86	0.89	0.93	0.71

Existing Power Density

1.5W/sf

Controls

The first floor lobby area is controlled through a switch located by the south entrance to the building. There is a switch by the north bridge entrance which controls the second floor lobby space.

Task Descriptions:

The lobby area is a circulation space, so the main task for the lighting is to provide guidance as to which direction to go for the people passing through. The first floor area of the lobby is also a transition space from sunlight to electric light.

Design Criteria:

The IESNA Lighting Handbook was referenced for the design criteria.

Appearance of Space and Luminaires

The appearance of the lobby and luminaires is extremely important as this is the first area someone sees when they walk into the building. It is important for the lobby to represent the building in a positive way and to provide direction.

Color Appearance (and color contrast)

The lobby walls are wood paneled therefore the color appearance of the lobby is very important so as to make the wood appear bright and vibrant.

Daylight Integration and Control

The doors are glass with wood trim on both the vestibule to lobby entrance and outside to vestibule entrance on the north and south ends of the building. These areas provide a bit of a view outdoors while also allowing for the transition between the sunlight and electric light.

Light Distribution on Surfaces

The light distribution on the walls and floor should be uniform, but varied enough so that the eye does not get bored. It should also be distributed in a way as to provide direction.

Luminances of Room Surfaces

The wood paneled walls should be well illuminated in order to give the space brightness since it has limited daylight.

Points of Interest

The lighting should highlight points of interest such as artwork on the walls and also the corridors, exit areas, and stairwell so as to provide people with a direction to go.

Reflected Glare

Reflected glare of the luminaires in the glossy wood paneling should be avoided so that as people are making the transition between daylight and electric light or just passing through they do not feel uncomfortable.

Sparkle/ Desirable Reflected Highlights

The luminaires should provide necessary highlights for visual interest in the space as people are passing through.

Surface Characteristics

The luminaires should enhance the texture of the wood paneling that highlights the area.

Illuminance

Horizontal: C (10 fc)
Vertical: E (50 fc)

Power Allowance

ASHRAE 90.1 Standard: Using the Space-by-Space Method:
1.8W/sf allowable
1.0W/sf additional for decorative (chandelier type) lighting

Analysis of Existing System

AGI 32 was used to calculate the lighting conditions for the space. The reflectances and light loss factors state above were used to generate this computer model. The lobby was rendered using basic colors to represent the wood paneling and the stairs in order to get an idea of the way the light would interact with the vibrant colors.

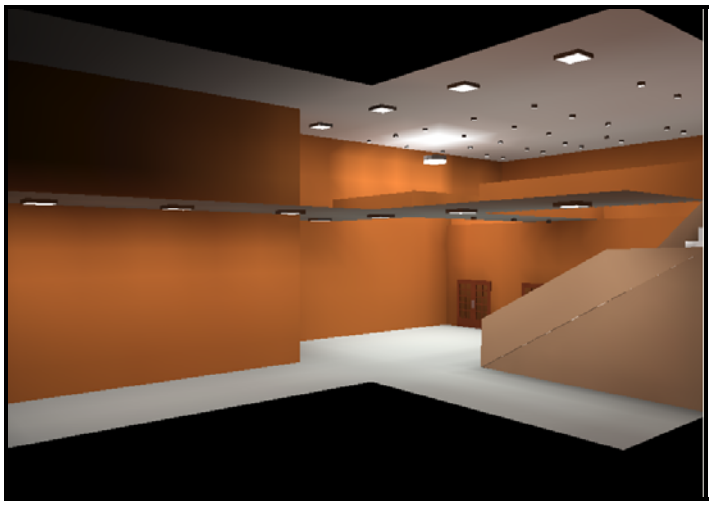

Figure 3.8 Northwest view of the lobby

Figure 3.9 Southeast view of the lobby

Figure 3.10 Plan view of the lobby

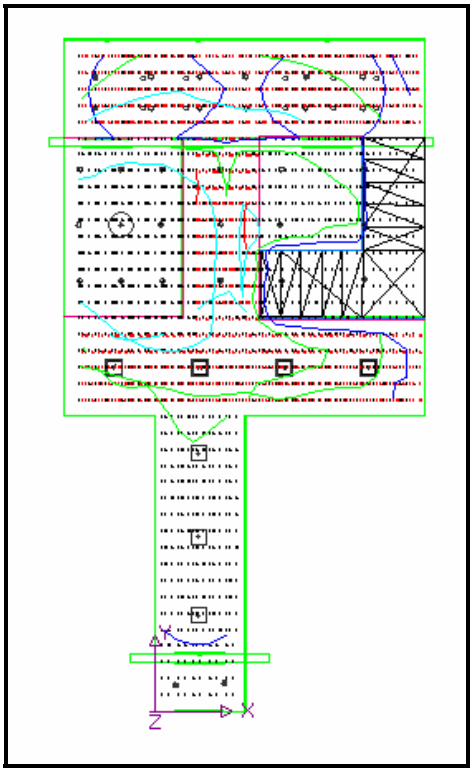

Figure 3.11 AGI32 Isoline view of the lobby

In the lobby, a calculation grid was placed at 0' on both the upper and lower levels. On the lower level, an average illuminance of 25 fc was calculated. An average illuminance of 17 fc was calculated. Both of these are above the IES recommended. However, these levels and luminaires show off the wood paneling on the walls and maintain a classic academic feel to the space while providing direction for people. The light levels could be brought down a bit to lower the power density even more. Overall, the lobby is satisfactorily lit.

Exterior

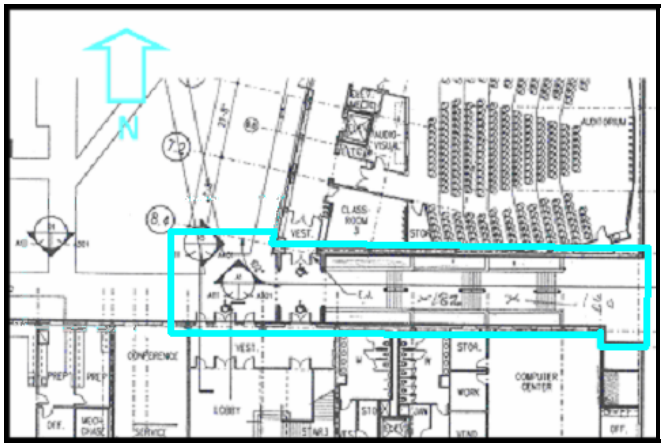

Figure 4.1 Exterior Location

Space Description

The exterior area being considered is the narrow area between the classroom and laboratory buildings. The classroom building is on the northeast and is two stories tall. The laboratory building on the south is three stories tall. There is also a bridge overhead that connects the second floors of both buildings. On the northwest is a quad which is the main area of exterior circulation for the students. The west end of the exterior area is a street entrance. This would mainly be used by faculty, but is not as traversed as the quad area. However, it must still be illuminated. The existing lighting in this area now is provided by recessed step lights. There are also decorative wall mounted fixtures to illuminate the entrances to both buildings.

Surface Materials		
Surface	**Material**	**Reflectance**
Exterior Walls	Brick	20%
	Precast Concrete	38%
Ground	Grass	9%
	Concrete	40%
Doors	Solid Core Wood (Maple)	31%
Glazing	Sealed Insulating Glass	16%
		Transmittance: 48%

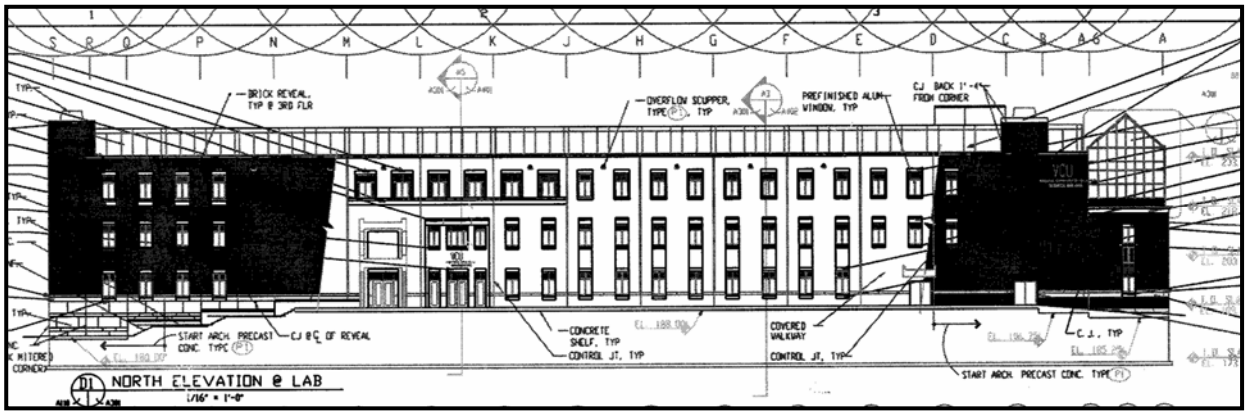

Figure 4.2 Exterior North Elevation

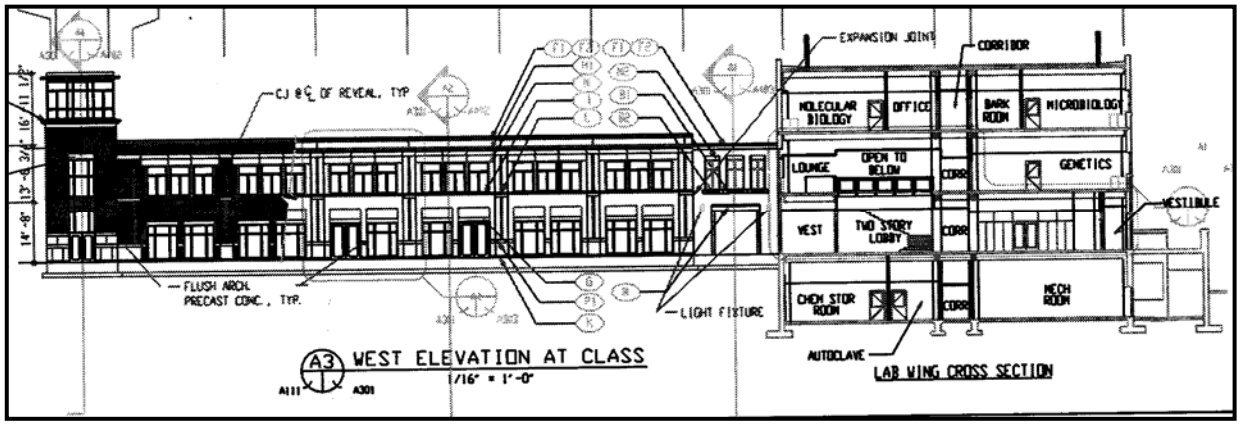

Figure 4.3 Exterior West Elevation

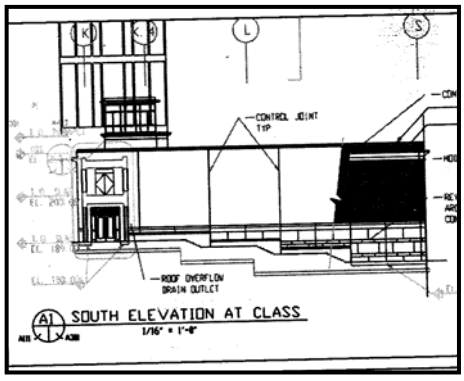

Figure 4.4 Exterior South Elevation

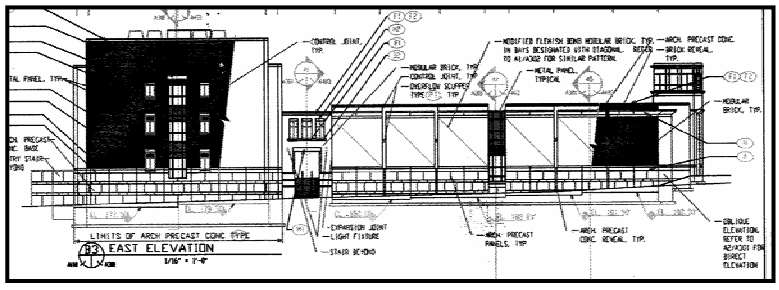

Figure 4.5 Exterior East Elevation

Luminaire Schedule								
Type	Description	Lamp			Volts	Mounting	Ballast	Quantity
		Number	Type	Watts				
D8	8" dia. HID recessed lensed downlight	1	70W MH 3200K	70	277	Recessed	High PF	3
W3	13"x 5 1/2" recessed step light	1	70W MH 4100K	70	277	Recessed	High PF	14
W5	22" dia. Decorative wall mounted fixture	1	100W MH 4100K	100	277	Surface	High PF	6

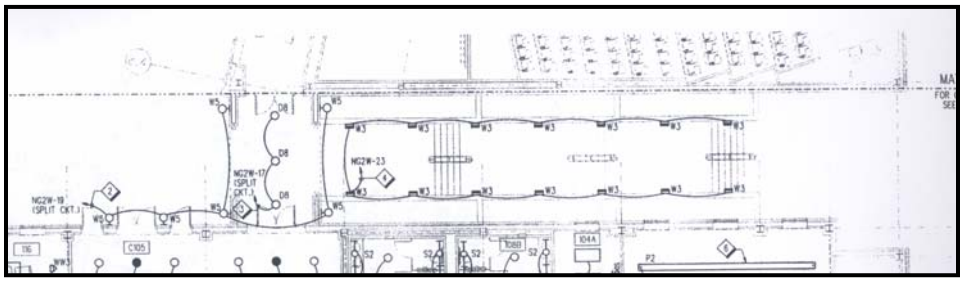

Figure 4.6 Exterior Lighting Plan

Light Loss Factors							
Type	BF	Cleaning Interval	Maintenance Category	LLD	RSDD	LDD	Total
D8	0.95	Clean (12 months)	IV	0.80	0.97	1.00	0.74
W3	0.95	Clean (12 months)	III	0.80	0.96	1.00	0.73
W5	0.95	Clean (12 months)	III	0.83	0.96	1.00	0.76

Existing Power Density

0.73W/sf

Controls

The exterior lighting is controlled through the use of a photo sensor and a seven channel electronic time system. This allows the lighting to come on if it is a dark day and to automatically come on for the night.

Task Descriptions:

The exterior area is used as a main circulation space for anyone using the two buildings or just passing through. The main task is to direct people as to where to go. Because it is outside and such a narrow, but tall, space, it is necessary that it be illuminated well in order for people to see where they are going at night or on dark days.

Design Criteria:

The IESNA Lighting Handbook was referenced for the design criteria.

Appearance of Space and Luminaires

The appearance of the luminaires is important to the exterior space because they must match the academic theme of the rest of the campus. The quad has campus standard luminaires and the exterior space being analyzed has luminaires that provide the same feeling as those.

Points of Interest

The luminaires should guide the way to points of interest such as the building entrances and lead the people along the provided walkways at night.

Surface Characteristics

The luminaires should bring out and distinguish the characteristics of the building materials (brick, concrete, glass, etc.)

System Control and Flexibility

The exterior lighting should be controlled through both photo sensors and time sensors, so that there is light if it is dark day or night and also so that the lights will automatically turn on as the sun sets.

Illuminance

Horizontal: A (5 fc)- walkways
B (10 fc)- exterior entrances
Vertical: A (1 fc)- facial recognition

Power Allowance

ASHRAE 90.1 Standard: Using the Space-by-Space Method:
Building Entrance with Canopy: 3W/sf allowable
Building Entrance without Canopy: 33W/lf allowable
Building Facades: 0.25W/sf allowable

Analysis of Existing System

AGI 32 was used to calculate the lighting conditions for the space. The reflectances and light loss factors state above were used to generate this computer model.

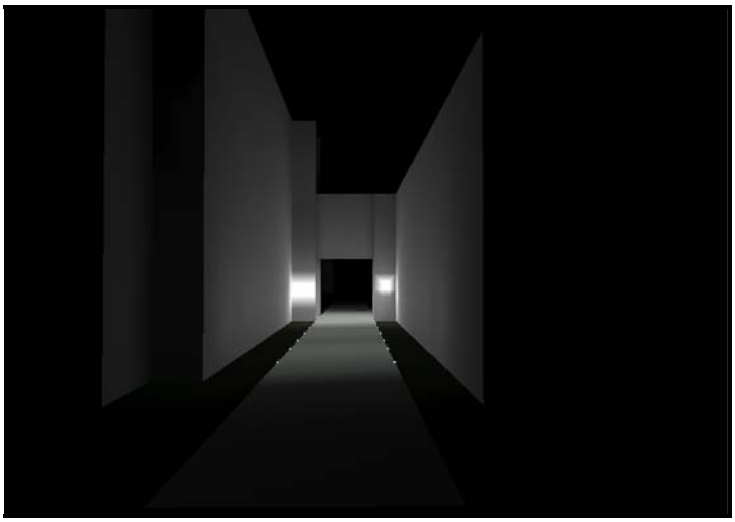

Figure 4.7 Exterior View Looking West

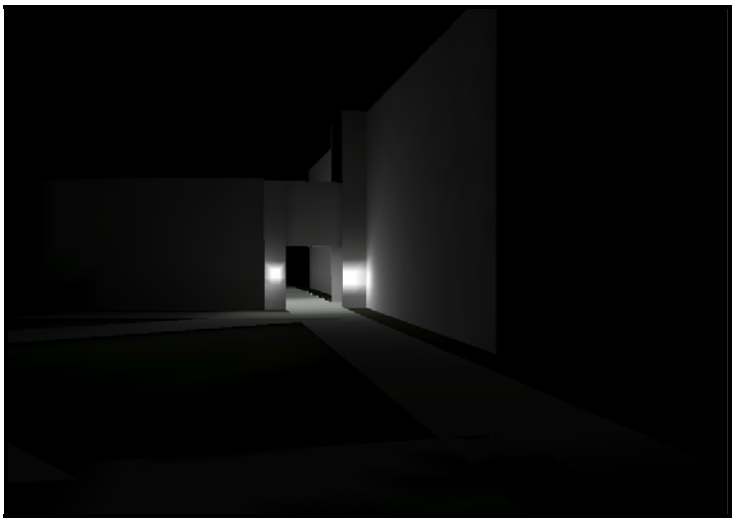

Figure 4.8 Exterior View Looking East

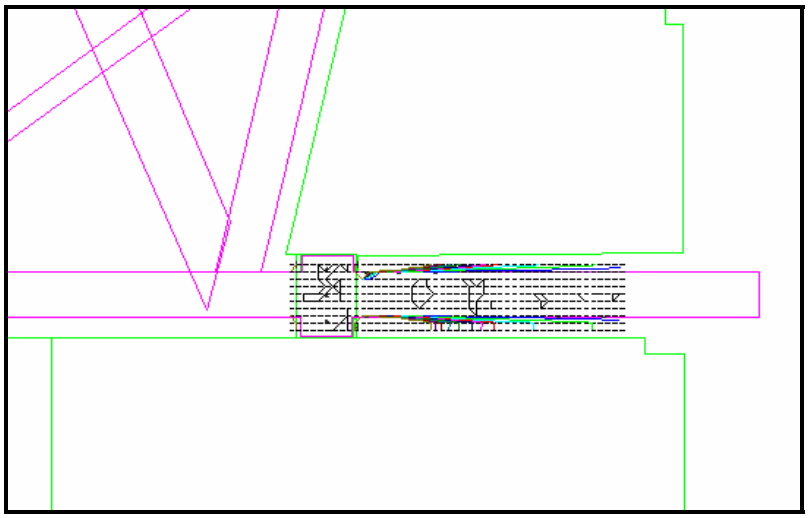

Figure 4.9 AGI32 Isoline Exterior View

A calculation grid was placed at 0' over the area of concern, the exterior walkway between the laboratory and classroom buildings. An average illuminance of 0.82 fc was calculated here. Overall, this is below the IES recommended, however if each space is considered, it is closer. The entrances are just below the recommended 10 fc and the walkways only a little less than 5 fc. In reality light from the quad would contribute more to the entrances of the two buildings. This space could use a little more light and still be below the allowable power density.