ESL-TR-97/06-01

LIGHTING SURVEY RESULTS AT THE LANGFORD ARCHITECTURE CENTER AND ESTIMATED SAVINGS BY DELAMPING

REPORT

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Submitted June 1997

ABSTRACT

This report presents the results of a survey conducted to measure the illuminance levels in all rooms in the Langford Architecture Center buildings. The purpose of this survey was to investigate which rooms are over illuminated, and thus present a potential to be delamped. This survey was part of the investigation to determine the effective strategy to reduce the lighting electricity use in Langford Architecture Center.

The results showed that the rooms that can be delamped are the studios, the computer labs at the ground floor of Building A, and most perimeter offices in Building A and C. The results also showed that, while the illuminance levels in some of the rooms were not high, the lighting power density was actually very high. This is caused by the type of the inefficient fixtures and the non energy-efficient lamps and ballasts that are currently installed.

It was previously estimated that 30% of the current fixtures could be delamped, resulting in an estimated annual energy cost savings of $9,200. However, several other strategies should be included with the delamping, such as adding more task lighting, lowering the position of the indirect fixtures in the studios, replacing the current fixture covers, and changing the current lamps and ballasts with the energy-efficient lamps and ballasts.

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LIGHTING SURVEY RESULTS AT THE LANGFORD ARCHITECTURE CENTER AND ESTIMATED SAVINGS BY DELAMPING

I. INTRODUCTION

The electricity and thermal energy use of the Langford Architecture buildings are monitored by the Energy Systems Laboratory (ESL) as part of the campus-wide effort initiated in the Spring of 1995 by President Bowen. The monitoring includes the whole-building electricity use (WBE), the motor control center (MCC), the chilled water and hot water consumption. As part of the monitoring study, in May 1996 an on-off test was conducted to determine the lighting load in the studios in Building A. Results of the study were used to estimate the savings that could be achieved by turning off the studio lights during unoccupied periods (Soebarto et al., 1996). During the 1996 Christmas break we conducted a shut-down test of all unnecessary lights in the three Architecture buildings. The objective of this shut-down was to measure the actual savings from turning off all unnecessary lights during unoccupied periods (Soebarto, et al., 1997).

The results showed that during the shut-down period, the total electricity use was reduced by 40%, bringing down the hourly electricity use from 420 kW or 2.4 Watt/sq.ft. -- if the lights had not been turned off -- to 320 kW or 1.8 Watt/sq.ft. If the lighting shut-off program during unoccupied periods was to be continued for the remainder of the semester, it was estimated that this program would save about $13,700 per year. To continue this program, however, the estimated labor cost to manually turn off the unnecessary lights during unoccupied periods was about $5,000 per year, resulting in an estimated net savings of about $8,700.

Another alternative strategy that would not require any personnel to manually turn off the lights was then analyzed. The strategy is to delamp the rooms whose current illuminance levels and/or lighting power density are excessively high. To determine which rooms can be delamped, a lighting survey was conducted on March 6, 7, 17 to 19, 1997. The main objective of this survey was to measure the current illuminance levels in all rooms in buildings A, B and C and estimate their lighting power densities. The amount of electricity use reduction by delamping was then estimated based on the results of this survey.

II. METHODS

The illuminance levels were measured with two calibrated illuminance (foot candle) meters. In each space, the levels were measured at the height of the task as well as directly under the light source. At least 4 measurements were taken in each space. In the space where daylight is accessible, the measurements were taken in two conditions, with the lights turned on and off. The lighting power density was generally estimated from the lighting drawings and schedules although in some rooms the lighting power (Wattage) was also measured.

While the purpose of this survey was not to scientifically investigate the quality of the current lighting condition, the occupants were also asked to give their opinions and suggestions about the current lighting conditions in the buildings, both on their quantity and quality. Several questions were asked, such as: (1) are you satisfied with the lighting in your room?, (2) what do you think about lowering the general lighting in your room and use task lighting?, (3) would you like to turn off the lights when you leave your rooms?, and (4) do you have any suggestions about the lighting in your room and in Architecture buildings?

The measured illuminance levels were then compared to IES recommended values for general illumination (IES 1987). The purpose of this comparison was to see if the current illuminance levels in particular rooms exceed the IES recommended values. The comparison results were then used to determine whether those rooms should be delamped. In addition to comparing the measured illuminance levels to the IES recommended values, the estimated lighting power densities were compared to ASHRAE recommended lighting power densities for general lighting (ASHRAE 1985). Thus, it was possible that, while the measured illuminance levels in a particular space did not exceed the IES recommended values, delamping would still be considered because the lighting power density exceeded the ASHRAE recommended values. The IES recommended values are presented in the Appendix B.

III. RESULTS

The results of this lighting survey are summarized below. More detailed results are presented in Tables 1 to 8.

III.1. Building A

III.1.1. Studios, classrooms, and some offices

a. Illuminance level and lighting power density

In Building A, the illuminance levels in many of the studios, classrooms, and offices that do not have access to daylight are actually **within** or **lowe**r than the IES recommended illuminance levels for those functions (24 to 50 fc). However, most of these rooms have high lighting power density (more than 2 Watt/sq.ft.). This is caused by the design of the current light fixture (a single 40-W lamp per fixture)which is totally indirect and suspended close to the ceiling which is very far from the task (Fig. 1).

b. Delamping potential

It is difficult to justify delamping these rooms based only on the current illuminance levels and lighting power densities. Delamping these rooms would reduce the currently already low illuminance levels even lower. This could be a problem especially in the studios where adequate task lighting is very critical.

Therefore, applying delamping in these rooms has to be integrated with other solutions, such as:

- Adding power outlets in the studios to accommodate the task lighting. Most students in the studios indicated that they would like to use their own task lights.
- Encouraging the faculty/staff to provide their own task lighting and not use the overhead lights in their office.
- Lowering the current height of the suspended fixtures and modify the fixtures to be direct/indirect.
- Installing timers in the studios so that the general lighting would automatically turn off after midnight on a regular basis.

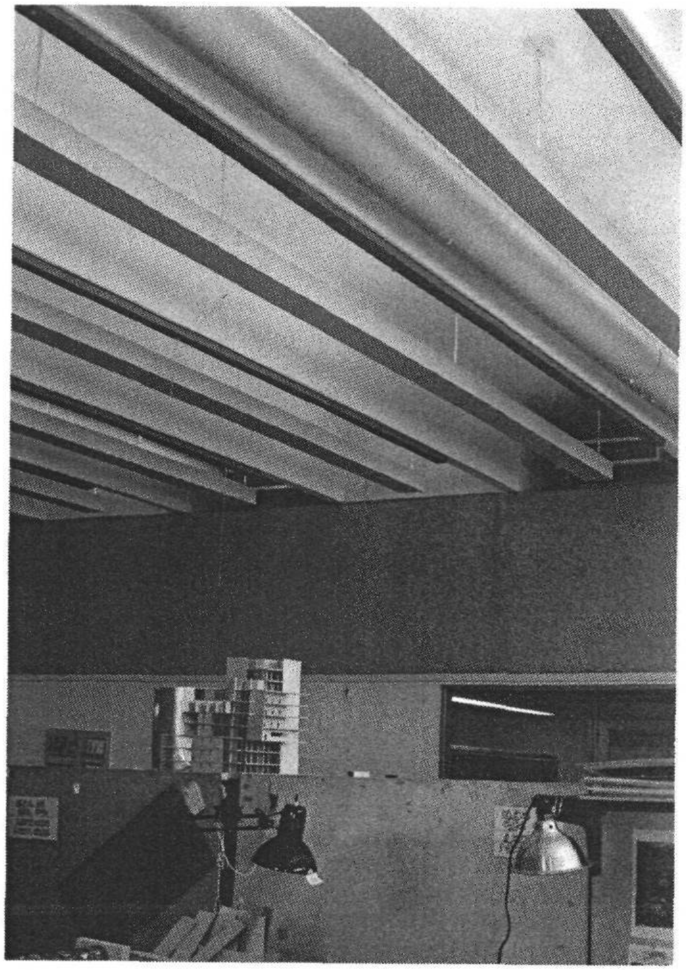


FIGURE 1. SUSPENDED LIGHT FIXTURES IN THE STUDIOS IN BUILDING A

III.1.2. Computer labs

a. Illuminance levels and lighting power density

The lighting fixtures in the computer labs are similar to the ones in the studios. The EDS lab, the computer lab in room 119 and the Visualization lab only have 55% of the available lights turned on (Figure 2). The measured illuminance levels were only about 16 to 24 fc, but the occupants were satisfied with the current lighting condition. The computer labs in rooms 107A, B, and C have all the available lights turned on; however, the illuminance levels were only about 24 to 44 fc. The average lighting power density of these computer labs was 2 Watt/sq.ft.

b. Delamping potential

Based on the measurement and observation results in the Visualization and 119 computer labs, it would be possible to reduce the lighting in the 107 A, B, and C computer labs by 45%. This could be accomplished by turning off (or delamp) the lights in every other row.

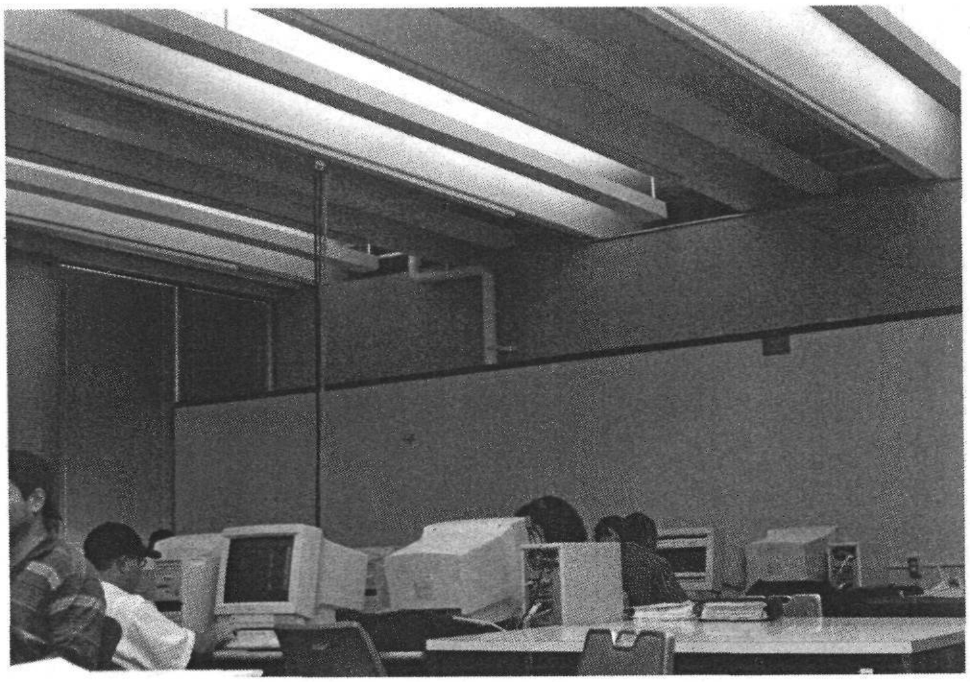


FIGURE 2. TURNING OFF HALF OF THE LIGHTS IN THE 119 COMPUTER LAB

III.1.3. Perimeter offices

a. Illuminanace levels and lighting power density

Lighting fixtures in most perimeter offices generally provide direct illumination using lamps which are 3-40 Watt, covered with prismatic lens. Each office usually has four fixtures, resulting in a very high lighting power density (around 4 Watt/sq.ft.). However, the illuminance levels are about 60 to 90 fc, which is almost twice the IES recommended values for office lighting. Many faculty members indicated that they would like to have the lights delamped and bring their own task lighting. Some faculty members indicated that they needed more lights even though their current illuminance level was about 50 to 80 fc and the power density was 4 W/sq.ft. In this case, it seems that the problem is an inefficient fixture combined with other problems such as the lighting **quality** (i.e. the current color of light -- cool white), the color of the walls and carpets, and in some cases extensive glare from exterior windows.

b. Delamping potential

Some professors completely turned off the general lighting and utilized only daylighting. In these rooms, the illuminance levels was about 10-20 fc, which they felt were satisfactory. Dean Wendler and Dean Wells have provided a good example by turning off the general lighting in their offices and only turning on their task lighting and some accent lights. They felt their space was more comfortable, visually, while on the task the illuminance level was adequate (around 40 fc). Therefore, it is also possible that 50% of the lighting in the perimeter offices could be delamped, and task lighting would be used instead.

To increase the effectiveness of the delamping strategy, it is also possible that the current fixture covers be replaced with the more efficient reflectors/louvers. This type of reflector has been used in some of the offices that have been delamped (Figure 3).

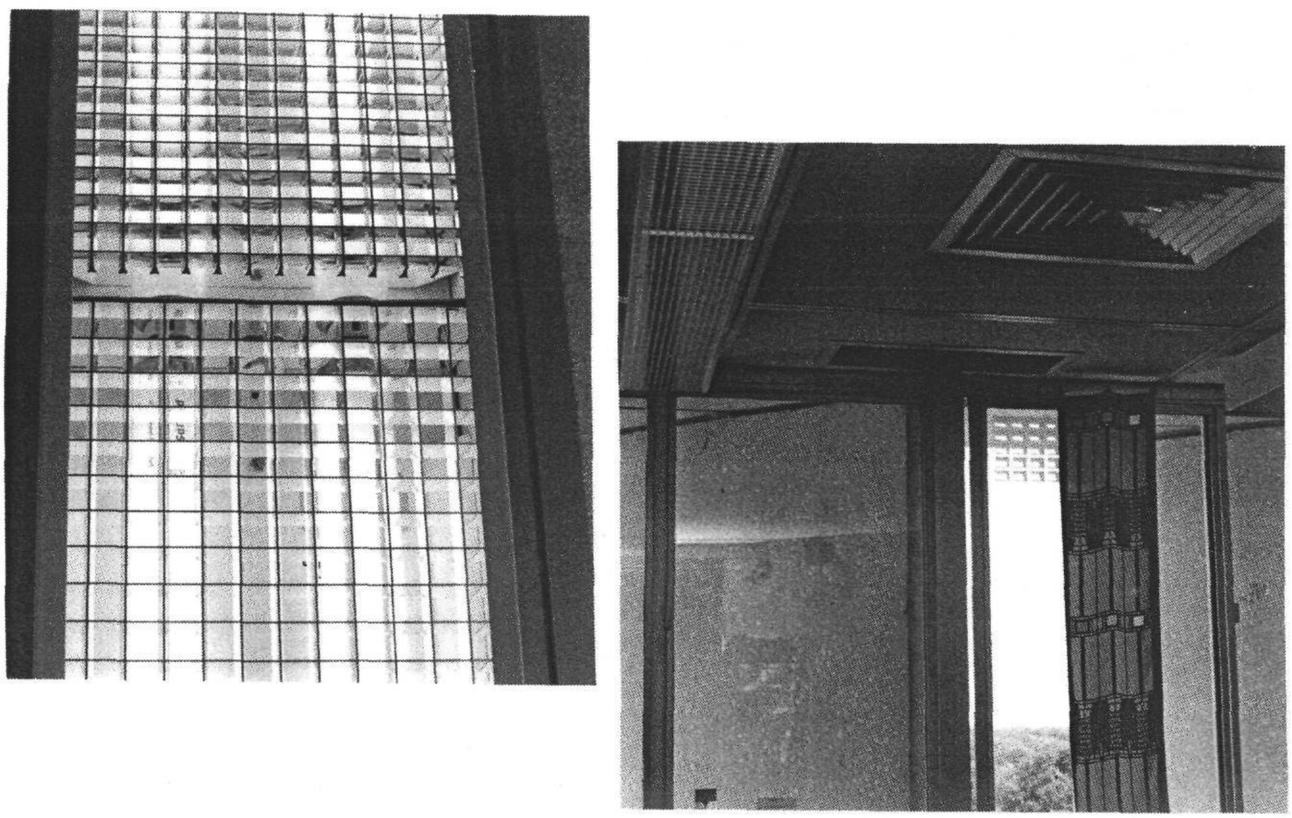


FIGURE 3. REFLECTORS USED IN AN OFFICE IN BUILDING A

III.1.4. Offices around the atrium

a. Illuminanace levels and lighting power density

The lighting systems of most of the offices around the atrium are similar to the ones in the studio (indirect, suspended high from the task), except that each fixture has three fluorescent lamps. In each of these rooms there are four fixtures. The illuminance levels of the offices around the atrium were about 24 to 40 fc. Several faculty members who were interviewed indicated that the illuminance levels were "enough" although they felt that their space was rather dim. Unfortunately, the power density was estimated to be 4.5 Watt/sq.ft. In a similar fashion to the other offices, these offices suffer from inefficient fixtures and other problems such as the glazing that is shared with the atrium that allows a considerable portion of the light to "leak" out into the atrium (Figure 4).

b. Delamping potential

Based on these results, it is possible that these offices could be delamped by taking out at least one lamp per fixture, resulting in at least 30% reduction. Task lighting should then be used in addition to the "borrowed" light from the atrium.

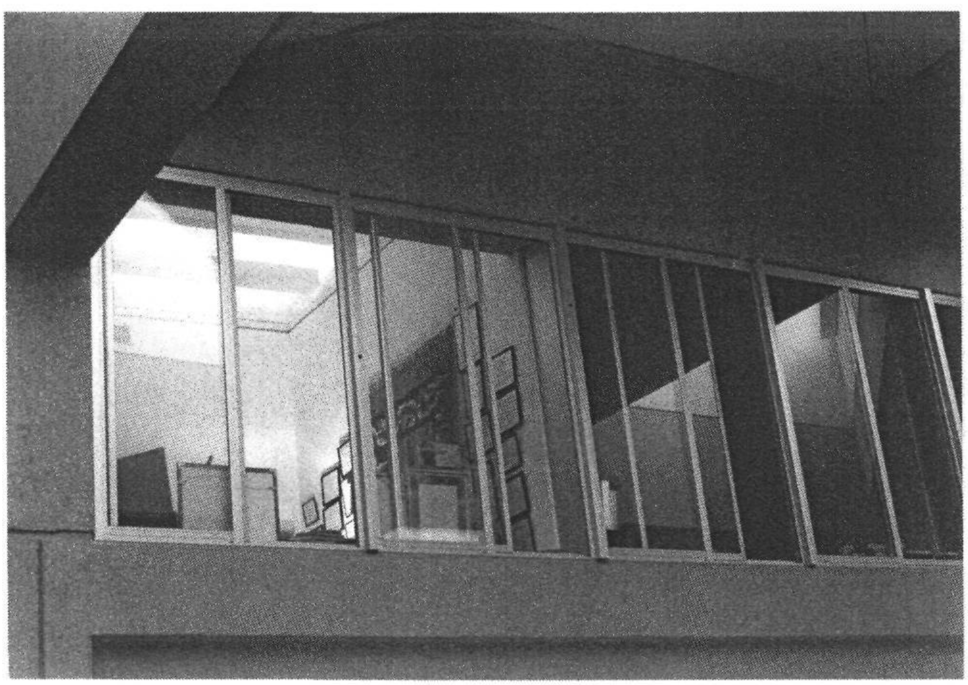


FIGURE 4. THE LIGHT "LEAKING OUT" TO THE ATRIUM

III.1.5. Corridors and hallways

The illuminance levels in the corridors under the direct fluorescent lights were between 10 to 30 fc. The levels under the indirect lights and spot lights were between 4 to 6 fc. While these levels seem to be low and delamping may is not necessary, replacing the current lamps (40-Watt fluorescent and incandescent) with more energy-efficient lamps will certainly reduce the electricity use.

III.2. Building C

III.2.1. Studios and classrooms

a. Illuminanace levels and lighting power density

The illuminance levels in the studios were about between 33 to 60 fc. In the classrooms, the illuminance levels were about 20 to 50 fc. Both spaces actually had the same lighting system; however, the levels in the studios were higher because of the existence of daylight. The lighting power density was about 2 to 2.5 Watt/sq.ft. These high lighting power densities were due to type of the light fixtures (32W or 40W fluorescent covered with prismatic lens that cuts much of the light to reach the task). Several students in the studio of the second floor use their own task lighting.

b. Delamping potential

The fact that the students use their own task lighting in the studio while the general lighting is never turned off indicates several potential problems: (1) the current illuminance level provided by the general lighting is not adequate for drawing purposes, (2) the electricity use during occupied periods increases due to the electricity used for the task lighting; thus, the power density is most likely higher than 2 Watt/ sq.ft. In summary, the current lighting system in the studios and classrooms is inefficient because while the its power density is quite high (2 to 2.5 Watt/sq.ft.), it does not provide adequate illumination (i.e. 33 - 60 fc whereas the IES recommends 50 - 100 fc), forcing the students to bring their own task lighting which then results in even higher power densities.

Therefore, it is possible to delamp the studios in building C. Taking out 50% of the current lighting would reduce the illuminance levels to about 20 to 35 fc (which was tested by turning off about 50% of the current general lighting and measuring the illuminance levels). In order for this to be effective, students will need to bring their own task lighting; thus, additional power outlets should be provided. Using task lighting should reduce the total electricity use because they will only be turned on when the working space is occupied. In addition, to increase the effectiveness of the delamping strategy, it is also suggested that the current lamps be replaced with energy-efficient lamps and the fixture covers be replaced with the more efficient parabolic reflectors.

Because all classrooms in this building do not have access to daylight and it is impractical for students to bring their own lights, we do not recommend delamping in these rooms. However, the current electricity used in these rooms could be reduced by: (1) replacing the current fixture lens and housing with parabolic reflectors, (2) using energy-efficient lamps and ballasts, (3) installing motion sensors to automatically turn off the lights when people leave the rooms.

III.2.2. Offices

a. Illuminanace levels and lighting power density

The illuminance levels in the perimeter offices varied from 14 to 26 fc (Rm. 109), 25 to 48 fc (Rm. 102 and 107), 38 to 46 fc (Rm. 308), to 51 to 70 fc (Rm. 106). In Rm. 106, the occupants felt that the lighting was "too bright", while in the other rooms the occupants felt that the lighting was "too cold". The power lighting density of all these rooms was about 3.5 Watt/sq.ft. No survey was conducted in the offices in the fourth floor of this building.

b. Delamping potential

Because the lighting system in the offices was similar to that of the studios and classrooms, the same solutions as discussed in Section II.1.2. above are also applicable to the offices.

III.2.3. Corridors

a. Illuminanace levels and lighting power density

The illuminance levels in the inside corridors (with no daylight) were about 13 to 22 fc, while they varied from 37 to 45 fc for the corridors with access to daylight. The average lighting power density for all corridors/hallways was about 1.5 to 2 Watt/sq.ft.

b. Delamping potential

It is possible to reduce the illuminance levels in the corridors since the IES recommended values for hallways with simple orientation is about 5 to 10 fc, and between 10 and 20 fc for hallways with occasional visual task. Delamping can be applied by any of the combination of the following strategies: (1) only turn on 50% of the current lights in the corridors, (2) replace the cover with parabolic reflector, (3) use energy-efficient lamps and ballasts. It should also be noted that, at times, the corridors are used for class displays and therefore there may be times when the additional lighting is useful. However, this should be a switched option so it would only be turned on when the corridors are being used for displays.

III.3. Summary of survey results

Based on the above results, it can be concluded that there are other related issues that have to be discussed before the delamping strategy can be applied. The issues include:

- the design of the current light fixtures: the type (direct/indirect), position, type of lamp and ballast, type of the cover,
- the color of the interior surfaces,
- the access to daylight,
- the availability of the power outlets in the studios, and
- the dual use of corridors as occasional display areas.

The measured illuminance levels and estimated power densities are presented in the Tables 1 to 8. These tables also summarize the suggested number of lights to be delamped. Appendix A presents the measured illuminance levels and estimated lighting power densities for all the rooms surveyed. The estimated hourly electricity use reduction from delamping is 33.41 kW for building A and 17 kW for building C. Thus, the total estimated reduction is 50 kW, which is about 12.5% of the current peak electricity use for lighting and receptacles. In section IV estimated savings are presented from the current delamping recommendations.

TABLE 1. SURVEY RESULTS AND SUGGESTED REDUCTION
IN BUILDING A, FIRST FLOOR

Room	Current[1]		Proposed Reduction	Target[2]		Note / suggestions
	foot-candle	Total kW		foot-candle	Total kW	
Computer Labs: • Lab A, B, C	24 - 44	2.4	50%	12 - 22	1.2	
Cons. Sci. Comp. Lab	16 - 24	1.8	-	same	1.8	Lighting is on at every other row.
Gallery	21 - 33	3	-	21 - 33	3	
Media Lab	19.6	uk[3]	-	19.6	uk	
Offices 136 (+ possibly 128 - 135)	54 - 64 (id[4]) 80 (d[5])	8.4	30%	37 - 45	5.6	Take out one bulb per fixture. Add task lighting
Graduate Office 126	24 - 36 (id) 60 (d)	2.8	-	same	2.5	
Undergraduate Office 102	25 - 35 (id)	2.8	-	same	2.8	
Office 105 (+ possibly 103, 104)	43 - 50 (id) 60 (d)	3.5	30%	30 - 35	2.5	Take out one bulb per fixture. Add task lighting
Hallways: • near offices • under atrium • main	 10 - 29 13 - 17 4 - 5	 uk uk uk	 - - -	 same same same	 uk uk uk	
TOTAL	-	**24.7**	-	-	**19.4**	

Estimated savings on first floor building A = 5.3 kW (21.5%)

[1] Current levels are based on survey. Current kW's are estimated from the drawings.
[2] Target foot-candles are estimated for the minimum values (When the number of fixtures is reduced by 50%, the illuminance level does not automatically become 50% -- it depends on the new C.U. Thus, this estimation is only for the worst case). Target foot-candles are based on the IES recommended illuminance levels (see Appendix). "Same" target means delamping is not suggested.
[3] uk = unknown
[4] id = indirect, aside from the light source
[5] d = directly under the light source

TABLE 2. SURVEY RESULTS AND SUGGESTED REDUCTION IN BUILDING A, SECOND FLOOR[6]

Room	Current		Proposed Reduction	Target		Note / suggestions
	foot-candle	Total kW		foot-candle	Total kW	
TRC:						
• Stacks area	24 - 44	3	-	same	3	
• Study area	32, 52 - 61	1.6	-	same	1.6	
• Slide area	48, 60 - 67	1.7	50%	24 - 35	0.8	The slide-viewing desks already have lights. General lighting is not essential.
• Office	28	1.5	-	same	1.5	
Dean's Offices:						
• Conference 205	39 - 42	uk	-	same	-	
• Business	27 - 36	2.1	-	same	2.1	
• Inside hall	48	uk	-	same	uk	
• R. Ulrich	58 - 60	0.8	30%	35 - 45	0.6	
• Communication	76 - 80	1	50%	38 - 45	0.5	Take out one bulb per fixture. Add task lighting.
• (V. Paul & J. Baker)	76 - 80	1.6	30%	35 - 45	1.2	
• Ward Wells	12	uk	-	same	uk	
• Walter Wendler	9 - 17	uk	-	same	uk	
• Sue Wade	36	uk	-	same	uk	
• Lobby	11 - 18	uk	-	same	uk	
Viz Lab	13 - 24	5.5	-	same	5.5	
Main Hall	5 - 6.5, 28	uk	-	same	uk	
TOTAL	**-**	**18.8**	**-**	**-**	**16.8**	

Estimated savings on second floor building A = **2 kW**

[6] Please see footnote from TABLE 1.

TABLE 3. SURVEY RESULTS AND SUGGESTED REDUCTION IN BUILDING A, THIRD FLOOR[7]

Room	Current		Proposed Reduction	Target		Note / suggestions
	foot-candle	Total kW		foot-candle	Total kW	
Dept. Office 311	28- 57	2.4	30%	40	1.68	
Meeting Room 308	uk	0.8	30%	uk	0.6	
Offices 304 - 307 (no survey)	uk (?60)	2.3	30%	42	1.6	Take out one bulb per fixture.
Classroom 303 & 304	60.7 dim	2.8 dim	?	?	2.8 dim	Room feels gloomy because of the wall color and type of fixture. The power density= 4.5 W/sq.ft.
STUDIOS:						Power density =
• Near dept. office	23 - 33	5	45%	15 - 18	2.75 (add 0.9 to take into account the task lighting for 15 students)	2 W/sq.ft. Delamp every other row. Ask student to bring task lights. Low the existing lamps. Add more outlets. Install timers to turn off studio lights at midnight.
• Near classroom	30 - 76	5	45%	17 - 40	same as above	same as above
• Center	27 - 94	5	45%	17 - 50	same as above	same as above
• End	21 - 91	5	45%	17 - 50	same as above	same as above
Offices 341 - 344	60 - 90	2.3	50%	30 - 45	1.15	
Offices 346, 345	24 - 56	2.8 dim	?	?	2.8 dim (?)	The level is within rec. values, but the power density is 4.5 W/sq.ft. Perhaps: delamp 40%, lower the fixture, add task lighting.
Office 337 (+ possibly 328 - 336)	24.1	0.6 (total = 6 kW)	?	?	6 kW (?)	Same comments as above.
Offices 327, 324 (+ possibly 321 - 326)	42 - 55	1.7 (total = 7.7 kW)	?	?	7.7 kW (?)	Same comments as above.
TOTAL	-	**47**	-	-	**35.33**	

Estimated savings on third floor building A = 11.67 kW (25%)

[7] Please see footnote from TABLE 1.

TABLE 4. SURVEY RESULTS AND SUGGESTED REDUCTION IN BUILDING A, FOURTH FLOOR[8]

Room	Current		Proposed Reduction	Target		Note / suggestions
	foot-candle	Total kW		foot-candle	Total kW	
Dept. Office 410. 411	38 - 50	3.3	30%	35	2.4	
Meeting Room 408	70 - 92	0.864	50%	35 - 45	0.43	Current = 3.4 W/sf
Office 407	43 - 56	uk	-	same	uk	Has been delamped
Office 405	67	0.58	40%	40	0.35	
Office 404	80 - 106	0.58	40%	50	0.35	
Classrooms 403, 404	28 - 64	2.8 dim	?	?	2.8 dim (?)	Room feels gloomy because of the wall surface. The power density is about 4.5 W/sq.ft.(!)
STUDIOS:						Power density = 2 W/sq.ft.
• Near dept. office	17 - 35	5	45%	10 - 18	2.75 (add 0.9 to take into account the task lighting for 15 students)	Delamp every other row. Ask student to bring task lights. Low the existing lamps. Add more outlets. Install timers to turn off studio lights at midnight.
• Near classroom	22 - 68	5	45%	12 - 38	same	same as above
• Center	22 - 60	5	45%	12 - 33	same	same as above
• End	26 - 57	5	45%	14 - 32	same	same as above
EDS	11 - 28	2.5	-	same	2.5	In every other row.
Offices / lab 446, 445	18 - 45	2.8 dim	?	?	2.8 dim (?)	Room feels gloomy because of the wall surface. The power density is about 4.5 W/sq.ft.(!)
Office 443	10 - 20 65 - 70	uk	-	same	uk	Has been delamped. 10-20fc w/out lights.
Offices 441, 442, 444	60 - 90	1.7	50%	30 - 45	0.85	Current = 4 W/sf
Offices 435, 437 (+ possibly 428 - 437)	28 - 40	1.2 (total = 6 kW)	?	?	6 kW (?)	Same comments as above.
Office 426 (+ possibly 422 - 427)	36	0.8 (total = 7.7 kW)	?	?	7.7 kW (?)	Same comments as above.
TOTAL	-	**48.82**	-	-	**34.38**	

Estimated savings on fourth floor building A = 14.44 kW (29%)

[8] Please see footnote from TABLE 1.

TABLE 5. SURVEY RESULTS AND SUGGESTED REDUCTION IN BUILDING C, FIRST FLOOR[9]

Room	Current		Proposed Reduction	Target		Note / suggestions
	foot-candle	Total kW		foot-candle	Total kW	
Hallways	19 - 22 37.5 - 44.5	5.2	50%	10 - 23	2.6	
Classroom 111	32 - 52	3.6	?	?	?	current = 3.5 W/sf
Hazard - office 109	14 - 26	2.4	?	?	?	current = 3 W/sf
CHUD - office 102	25 - 48	4.3	?	?	?	current = 3.5 W/sf
Research Lab - 107	28.4	1.8	?	?	?	current = 3.5 W/sf
Hazard - office 106	51 - 70	2	40%	30 - 42	1.2	occupant said it was too bright.
TOTAL	-	**19.3**	-	-	**3.8**	

Estimated savings on first floor building C = 3.4 kW

[9] Please see footnote from TABLE 1.

TABLE 6. SURVEY RESULTS AND SUGGESTED REDUCTION
IN BUILDING C, SECOND FLOOR[10]

Room	Current		Proposed Reduction	Target		Note / suggestions
	foot-candle	Total kW		foot-candle	Total kW	
STUDIO 204	33 - 58 (under light) 20 - 28 (no light above)	6.8	50%	16 - 30	3.4	Add power outlets for task lighting. The additional electricity use for task lighting should be added.
STUDIO 206	43 - 49 (under light) 21 - 28 (no light above)	6.8	50%	16 - 30	3.4	Same comments as above.
Classroom 205	19 - 26	1.8	-	same	1.8	current = 2.3 W/sf
Classroom 207	18	1.8	-	same	1.8	current = 2.5 W/sf
Classroom 208	50	1.1	?	?	1.1	current = 2.5 W/sf.
Historic Imaging Lab - 209	26 - 38	uk	?	same	?	
TOTAL	**-**	**18.3**	**-**	**-**	**11.5**	

Estimated savings on second floor building C = **6.8 kW**

[10] Please see footnote from TABLE 1.

TABLE 7. SURVEY RESULTS AND SUGGESTED REDUCTION IN BUILDING C, THIRD FLOOR[11]

Room	Current		Proposed Reduction	Target		Note / suggestions
	foot-candle	Total kW		foot-candle	Total kW	
STUDIO 304	46 - 62 (under light) 32 (no light above)	6.8	50%	23 - 31	3.4	Add power outlets for task lighting. The additional electricity use for task lighting should be added.
STUDIO 206	42 - 58 (under light) 17.9 (no light above)	6.8	50%	21 - 29	3.4	Same comments as above.
Classroom 307	19.6	1.8	-	same	1.8	current = 2.0 W/sf
Office 308	37.8 - 46	1.1	?	?	1.1	current = 2.7 W/sf.
Hallway	38 - 47 4 (center)	uk	50%	19 - 24	?	
TOTAL	-	**16.5**	-	-	**9.7**	

Estimated savings on third floor building C = **6.8 kW**

TABLE 8. SURVEY RESULTS AND SUGGESTED REDUCTION IN BUILDING C, FOURTH FLOOR

Room	Current		Proposed Reduction	Target		Note / suggestions
	foot-candle	Total kW		foot-candle	Total kW	
Hallway	13.6 - 33	uk	-	same	uk	
Lab / class 412	42	uk	-	same	uk	

[11] Please see footnote from TABLE 1.

IV. ESTIMATED SAVINGS

IV.1. Building A

Estimated savings in Building A by delamping the studios, computer labs on the ground floors, and the offices that have direct lights, without delamping many of the offices:

- Working hours:
  - Electricity savings per-hour:
    = (5.3 + 2 + 11.67 + 14.44) kW
    = 33.41 kW
  - Additional task lighting in studios:
    = approx. 120 students x 60 Watt/student
    = 7.2 kW
  - Net electricity savings per-hour:
    = (33.41 - 7.2) kW
    = 26.21 kW
  - Total annual electricity savings during working hours (8 a.m. to 6 p.m.):
    = 26.21 kW x 10 hours/day x 261 days/year
    = 68,408 kWh/year

- After working hours (only labs and studios):
  - Electricity savings per-hour when labs and studios are occupied:
    = 1.2 kW (labs) + 18 kW (studios)
    = 19.2 kW
  - Additional task lighting in studios:
    = approx. 60 students x 60 Watt/student
    = 3.6 kW
  - Net electricity savings in the studios per-hour:
    = (18 - 3.6) kW
    = 14.4 kW

- Total annual electricity savings after working hours (6 p.m. to 8 p.m. for the studios and 6 p.m. to midnight for the labs):

= (14.4 kW x 14 hours/day + 1.2 kW x 6 hours/day) x 365 days/yr

= 76,212 kWh/year

- Total annual electricity savings by delamping in Building A:

= 68,408 + 76,212

= 144,620 kWh/year

- **Total electricity cost savings by delamping in Building A:**

= 144,620 kWh x $0.03/kWh

= $4,338 per year

IV.2. Building C

Estimated savings in Building C by **delamping the studios only**, without delamping the offices, are as follow:

- During and after working hours:

  - Electricity savings per-hour:

  = (3.4 + 6.8 + 6.8) kW

  = 17 kW

  - Additional task lighting in studios:

  = approx. 60 students x 60 Watt/student

  = 3.6 kW

  - Net electricity savings per-hour:

  = (17 - 3.6) kW

  = 13.4 kW

  - Total annual electricity savings (24 hours/day):

  = 13.4 kW x 24 hours/day x 365 days/year

  = 117,384 kWh

- **Total electricity cost savings by delamping in Building C:**

= 117,384 kWh x $0.03/kWh

= $3,522 per year

IV.3. Total estimated savings

Based on the estimated delamping as described above, the estimated cost savings are estimated as follow:

Estimated annual electricity cost savings (building A & C):

= $4,338 + $3,522

= $7,860 per year

Estimated annual chilled water savings (8 months/year):

= 8/12 x (144,620 + 117,384) kWh x 3,413 Btu/kWh

= 596 MMBtu

Estimated annual chilled water cost savings:

= 596 MMBtu x $4.67/MMBtu

= **$2,783**

Estimated increase in hot water use (4 months/year):

= 4/12 x (144,620 + 117,384) kWh x 3,413 Btu/kWh

= 298 MMBtu

Estimated annual hot water cost increase:

= 298 MMBtu x $4.67/MMBtu

= **$1,392**

Estimated total annual cost savings:

= $ 7,860 + $2,783 - $1,392

= $ 9,251

Note:
*Previous estimated annual cost savings by turning off unnecessary lights during unoccupied periods was **$8,632.***

V. SUMMARY AND RECOMMENDATIONS

V.1. Estimated savings

Results from this survey have shown that there is a potential savings by delamping many of the rooms, especially the **studios, computer labs on the first floor of building A, and some offices located at the perimeter of building A.** The estimated annual savings by delamping these rooms is **$9,251**. This is close to the previous estimated net savings by turning off all unnecessary lights during unoccupied periods, which is **$8,632**. This savings of $9,251, however, does not include the cost to delamp the existing light fixtures and install more power outlets in the studios for the task lighting.

V.2. Other recommended strategies.

To achieve the best results, especially in the rooms where the lighting power densities are high while the illuminance levels are low, we recommend that the following strategies be integrated:

1. Change the current lamps and ballasts to the more energy-efficient one
2. Lower the suspended lights in the studios and some offices in Building A and modify the fixtures to provide more efficient lighting.
3. Add power outlets in the studios.
4. Turn off all unnecessary lights during unoccupied periods (using timers and/or occupancy sensors).

VI. REFERENCES

ASHRAE. 1985. *ANSI/ASHRAE/IES Standard 100.3-1985. Energy Conservation in Existing Buildings -- Commercials.* Atlanta: American Society of Heating Refrigerating and Air-Conditioning Engineers, Inc. and Illuminating Engineering Society.

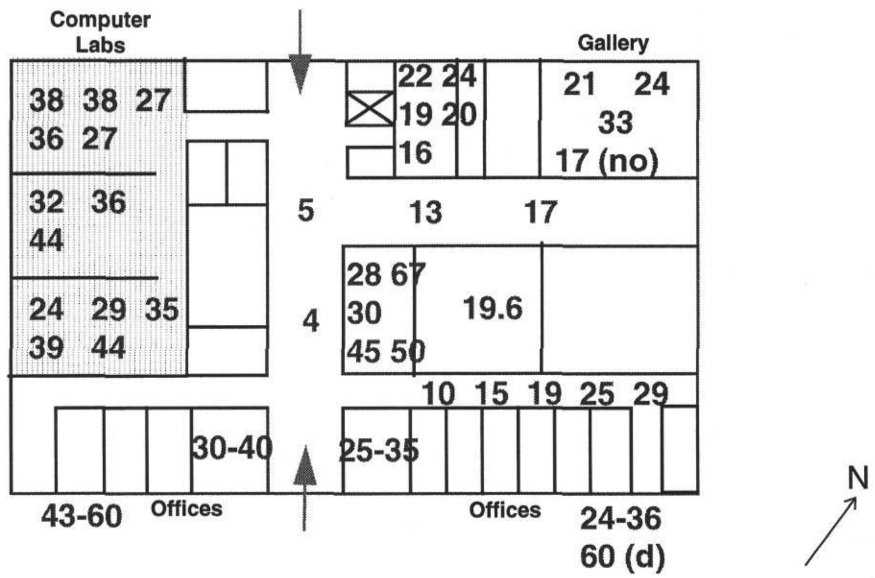
IES. 1987. *IES Lighting Handbook 1987. Application Volume.* New York, NY: Illuminating Engineering Society.

Soebarto, V.I., J.S. Haberl, and L.O. Degelman. 1996. Estimated savings from turning off unnecessary electrical loads during unoccupied periods at the Langford Architecture Center. *Report ESL-TR-96/10-02*, Energy Systems Laboratory, Texas Engineering Experiment Station, Texas A&M University System, October.

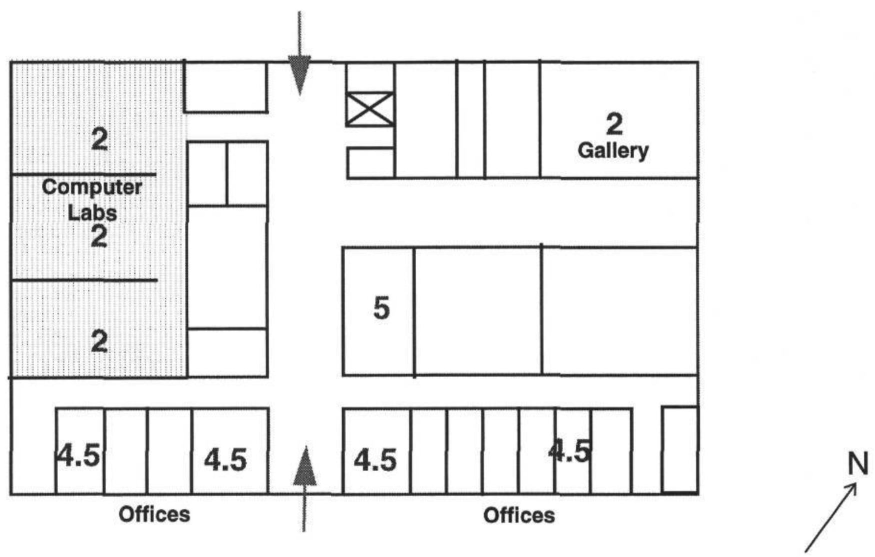
Soebarto, V.I., J.S. Haberl, and L.O. Degelman. 1997. Estimated savings from turning off unnecessary lights at the Langford Architecture Center during the 1996 Christmas Holidays. *Report ESL-TR-97/01-01*, Energy Systems Laboratory, Texas Engineering Experiment Station, Texas A&M University System, January.

APPENDIX A

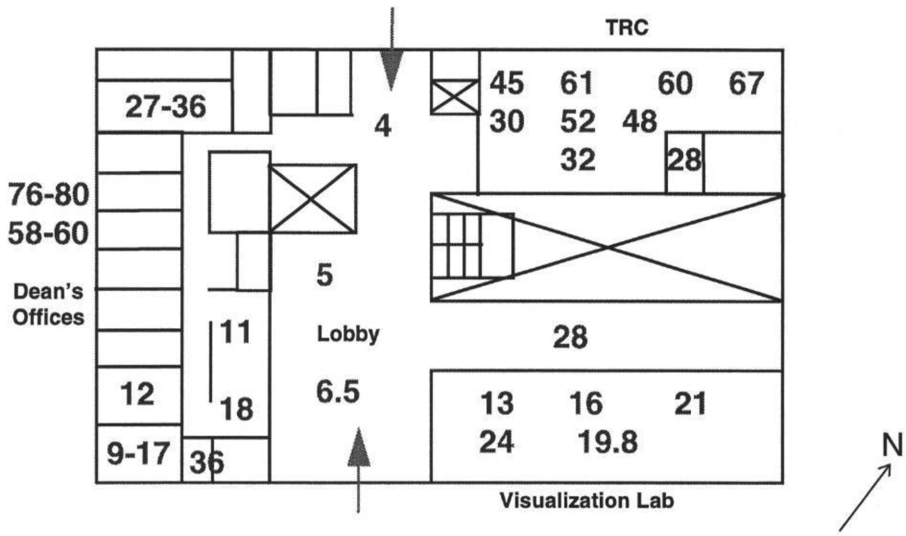
MEASURED ILLUMINANCE LEVELS
AND ESTIMATED LIGHTING POWER DENSITIES



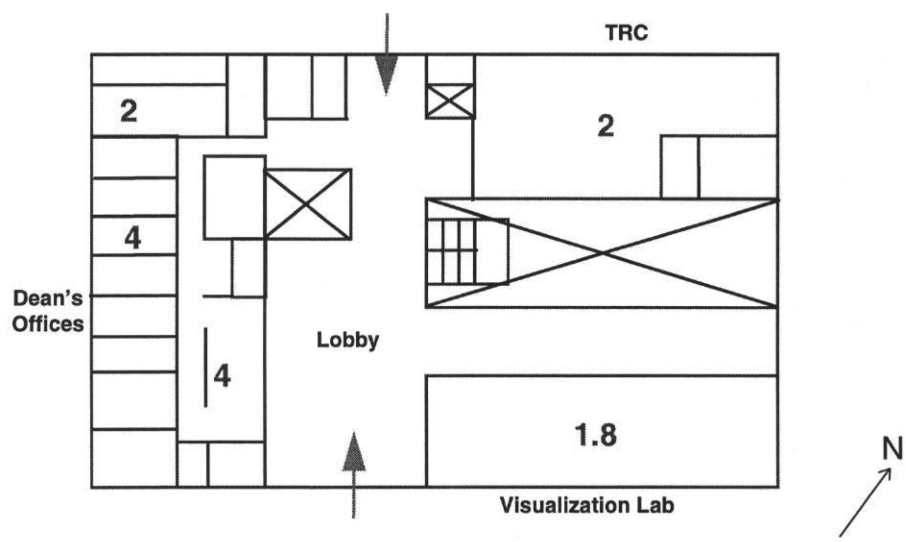
Illuminance Levels (in footcandles), First Floor Building A



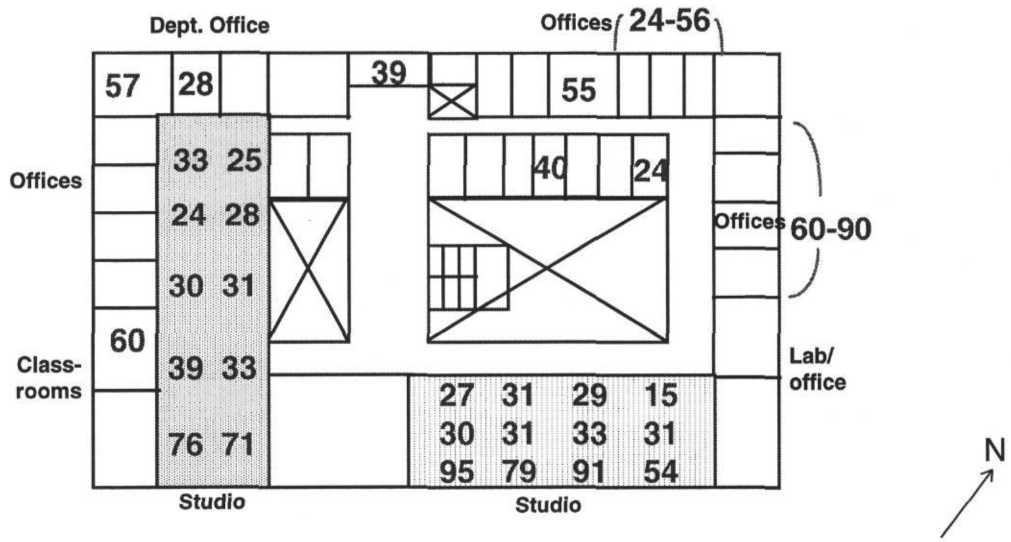
Lighting power density (in Watt/sq.ft.), First Floor Building A



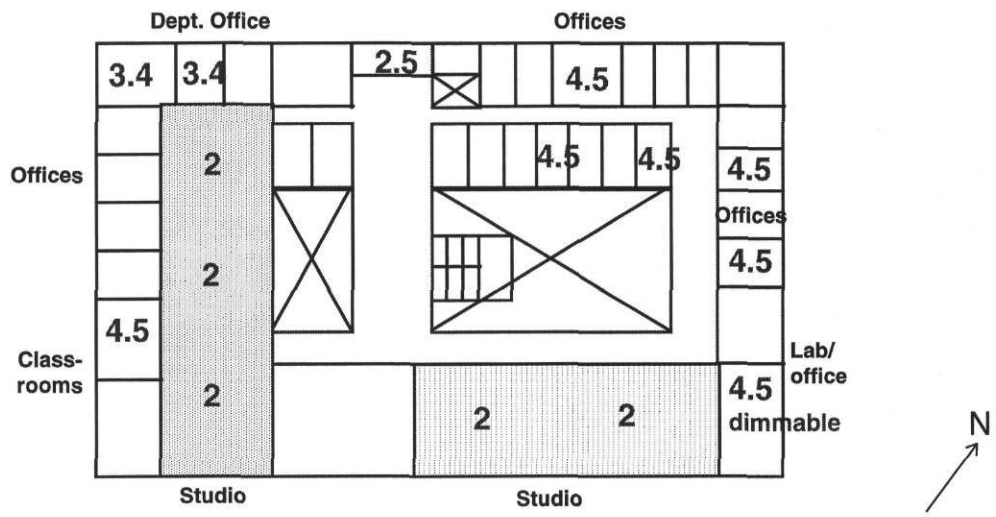
Illuminance Levels (in footcandles), Second Floor Building A



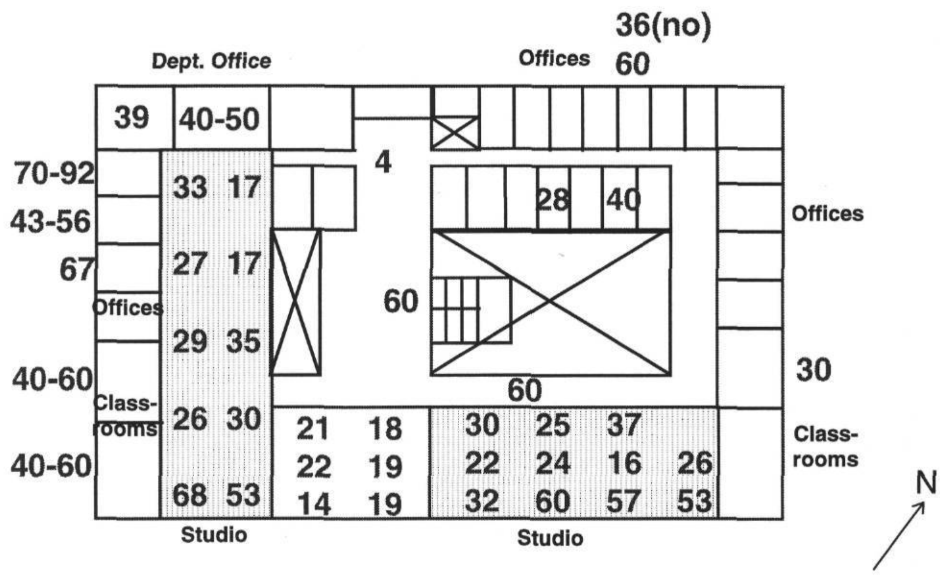
Lighting power density (in Watt/sq.ft.), Second Floor Building A



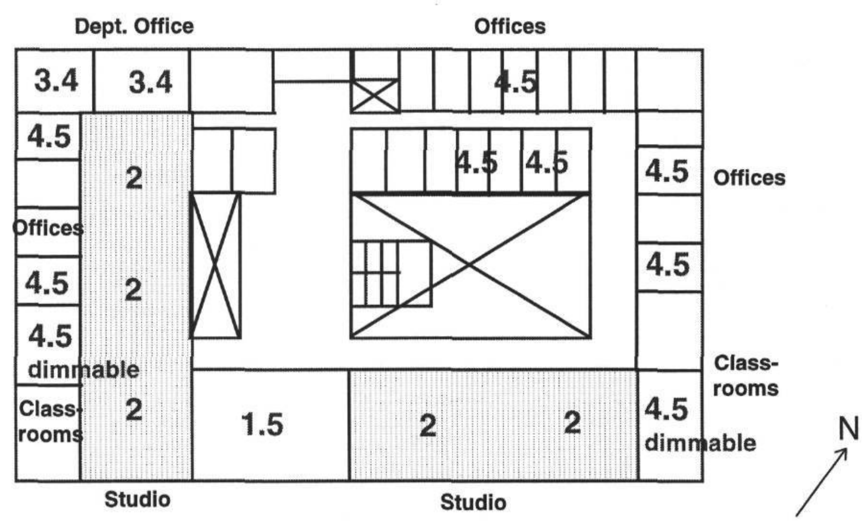
Illuminance Levels (in footcandles), Third Floor Building A



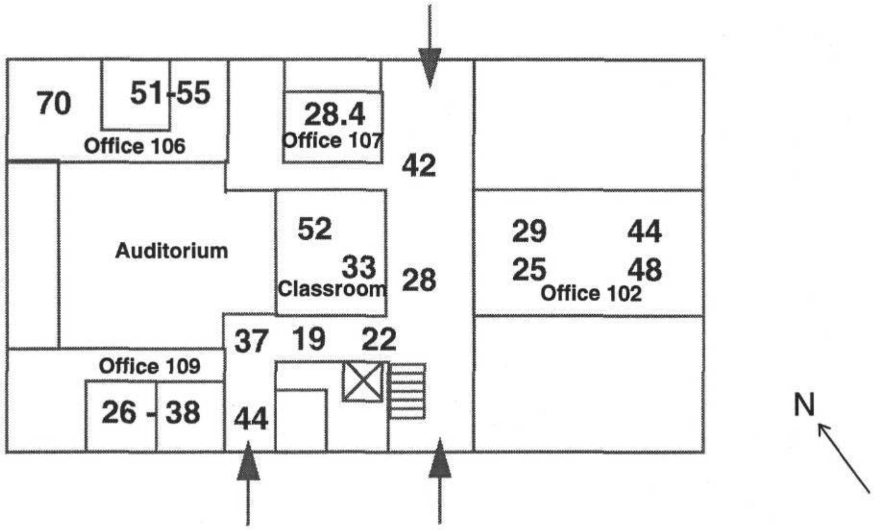
Lighting power density (in Watt/sq.ft.), Third Floor Building A



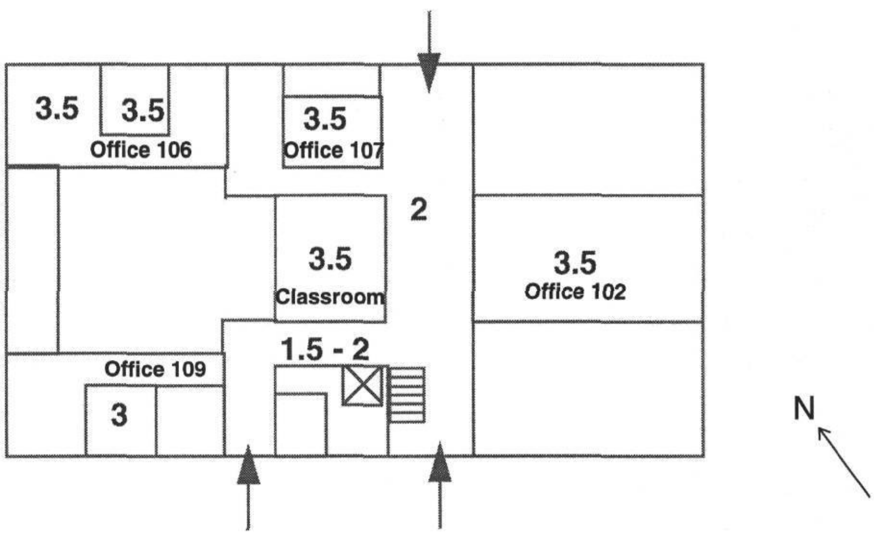
Illuminance Levels (in footcandles), Fourth Floor Building A



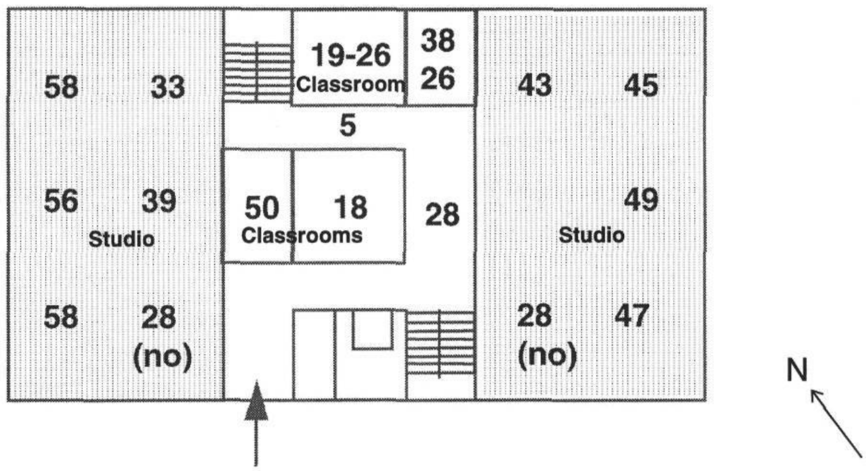
Lighting power density (in Watt/sq.ft.), Fourth Floor Building A



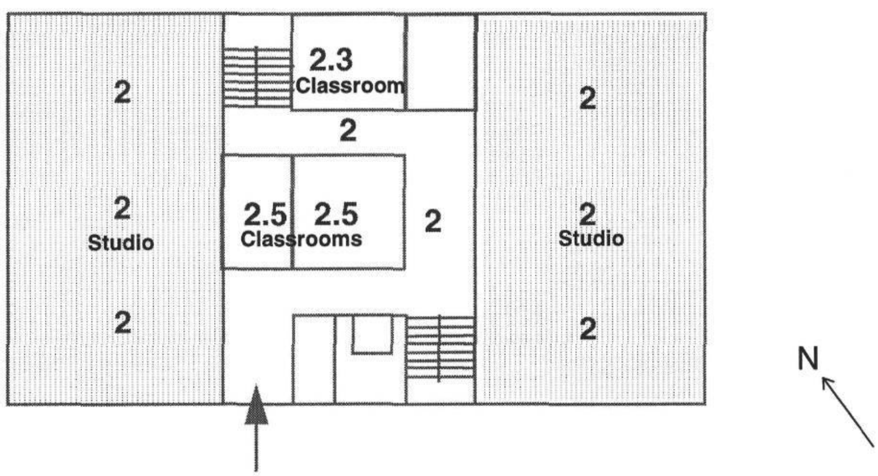
Illuminance Levels (in footcandles), First Floor Building C



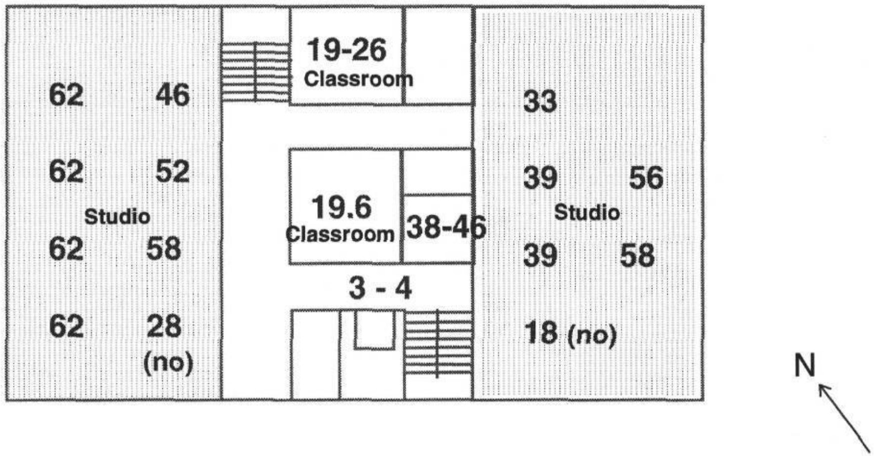
Lighting power density (in Watt/sq.ft.), First Floor Building C



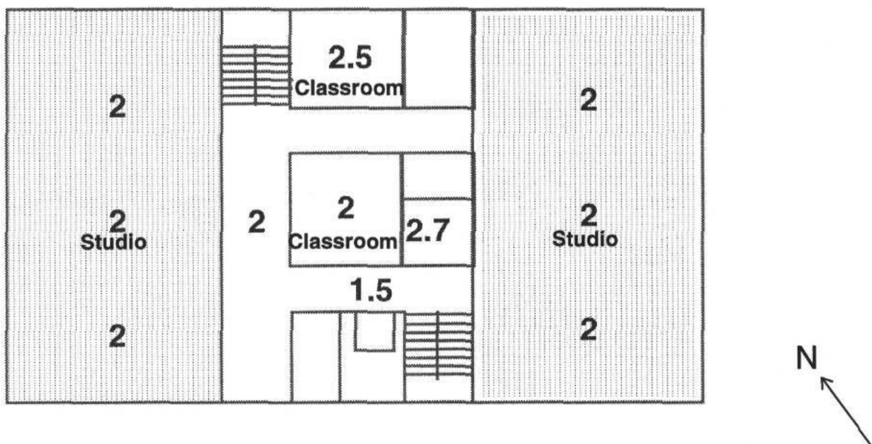
Illuminance Levels (in footcandles), Second Floor Building C



Lighting power density (in Watt/sq.ft.), Second Floor Building C



Illuminance Levels (in footcandles), Third Floor Building C



Lighting power density (in Watt/sq.ft.), Third Floor Building C

APPENDIX B

IES RECOMMENDED ILLUMINANCE LEVELS

Space / Function	Foot-candles
Hallway - simple orientation	5 - 10
Hallway - occasional visual task	10 - 20
Office - handwriting & computer tasks	20 - 50
Office - conference	20 - 50
Library - book stack	20 - 50
cataloging	20 - 50
reading	20 - 50
audio	20 - 50
Classroom	20 - 50
Studio - drafting	50 - 100